Appendix O: Evolution of MetroLink Alignment, System Capacity and Design

MetroLink Scheme – Evolution Summary

The Fingal / North Dublin Transport Study (2015) identified Optimised Metro North (LR7) as the preferred modal solution to address public transport needs on the Swords to City Centre corridor.

The current MetroLink scheme has evolved and changed considerably from LR7 envisioned in the Fingal / North Dublin Transport Study (2015). The evolution of the scheme is summarised and set out in chronological order in Table 1.

Evolution of MetroLink			
	Study	Relevance	Key Findings / Recommendations
2015	The Fingal / North Dublin Transport Study.	Determines LR7 is the preferred public transport solution for the corridor.	Recommends a route which runs from Swords to St Stephens Green. LR7 has smaller and fewer stations than Old Metro North. The alignment includes a reduced amount of tunnelling with sections through Ballymun and Swords running at-grade with high-level of priority over other vehicles at all junctions. LR7 is a light rail / Luas solution.
2016	Transport Strategy for the Greater Dublin Area - 2016-2035.	Endorses the findings of the Fingal / North Dublin Transport Study. LR7 is renamed New Metro North (NMN).	The strategy defines NMN as a high speed, high capacity, high frequency public transport link from Dublin City Centre to Dublin Airport and Swords, with the city centre section underground. The strategy proposes the upgrade of the existing Luas Green Line to Metro standard, through the extension of NMN southwards, via a tunnel, enabling the through running of Metro trams from Swords to Brides Glen.
2017	GreenLine Tie In Study (2018).	Identifies the preferred location for the tie- in of NMN to the exiting GreenLine.	Preferred tie-in location identified at Charlemont.
2018	NMN Alignment Options Report	Identifies the emerging preferred route for NMN.	Identifies the emerging preferred route from Swords to St Stephens Green. Interchange with Irish Rail Line moved from Drumcondra to Whitworth Road. (Renamed Glasnevin)

			Scheme renamed MetroLink.
2018	Green Line Metro Upgrade Study	Assesses infrastructure requirement in upgrading the Green Line to Metro Standard	Route further extended to encompass Metro south / upgrade of Luas Green Line for through running metro services to Sandyford.
2018	National Development Plan 2018- 2027.	Includes for the delivery of MetroLink.	Makes provision for the delivery of MetroLink. Swords, via Dublin Airport to Dublin's south city centre (operating in tunnel under the city centre) and onwards to Sandyford using the existing LUAS Green Line to ensure that growth along this corridor can be accommodated.
2018	MetroLink Emerging Preferred Route, Non-Statutory Public Consultation..	Introduces MetroLink to the Public as a scheme which runs from Estuary (North of Swords) to Sandyford. Leaves open the options of twin to single bore tunnel and propose an alternative alignment along the R132.	Significant local opposition to proposals for the upgrade of the Green Line to Metro services. Significant opposition to proposed tunnel drive site at Mobhi Road and elevated alignment on R132.
2019	MetroLink Preferred Route, Non-Statutory Public Consultation.	Emerging preferred route revised to take account of stakeholder concerns and feedback. Revised MetroLink Preferred Route incorporating these changes introduced.	Route changes included removal of Metro south / Green Line upgrade works, turnback infrastructure at Charlemont station, R132 elevated structure in central reservation changed to open cut in Western Verge. Depot location changed to Dardistown, change to single bore configuration, removal of tunnel launch site at Moby Road and its replacement with a tunnel launch site at Northwood.
2021	MetroLink Preliminary Business Case.	Preliminary Business Case prepared for the MetroLink Preferred Route.	Preliminary Business Case approval process underway Aug 2021.

Table 2 – Evolution of the MetroLink Scheme.

Infrastructure Difference between LR7 and MetroLink

The MetroLink scheme has evolved and changed significantly from the original LR7 scheme first published in 2015. The differences between the two schemes are comprehensively set out in the “MetroLink Rough Order of Magnitude Scheme Estimates” June 2021 report. The more significant changes to the scheme are summarised in Table 2.

Description	2015 FNDTSS2 LR7 Kilometres (km)	2020 Prelim. Design Kilometres (km)
Tunnel Twin Bore	7.46	-
Tunnel Single Bore	-	10.18
Track at-grade	5.12	1.11
Track retained cut	Included in at-grade length	2.98
Track cut & cover	1.20	1.73
Track elevated	2.87	0.36
Stations & Portals	Assumed to be included	1.81
Sub-total Main Route	**16.65**	**18.18**
Other surface level (Access to Depot)	-	2.39
Other tunnel (South of Charlemont)	-	0.39
Total Length	**16.65**	**20.95**

Description	2015 FNDTSS2 LR7 No	2020 Prelim. Design No
Stations underground	6	11
Stations at-grade	6	1
Stations retained cut	-	3
Stations elevated	2	-
Station’s future provision	-	1*
Total	**14**	**16**
Portals	3	3

Table 3 – Key Infrastructure Changes

Other Characteristics – Differences between LR7 and MetroLink

The characteristics of the two schemes differ considerably. The differences between the two schemes are comprehensively set out in the “MetroLink Rough Order of Magnitude Scheme Estimates” June 2021 report and are summarised in Table 3.

Description	2015 FNDTSS2 LR7	2020 Prelim. Design
Route start	Estuary	Estuary
Route finish	St Stephens Green	Charlemont
Main route length (km)	16.65	18.18
Degrees of automation	GoA1	GoA4
Green Luas line connection	No	No
Design capacity (PPHPD)	9,900	20,000
Vehicle frequency (TPH)	30	40
Station platform length (m)	60	65
No. of passenger vehicles (no.)	30	26
Vehicle length (m)	60	64
Passengers per vehicle	330	500
Tunnel type	Twin bore	Single bore
Depot location	Dardistown	Dardistown
Park & ride facilities	Estuary, Fosterstown and Dardistown	Estuary 3,000 spaces
Opening year	2025	2031

Table 4 - Characteristic Difference between LR7 and MetroLink

Costs Comparison – LR7 and MetroLink

The "MetroLink Rough Order of Magnitude Scheme Estimates" June 2021 report also compares the overall costs of the MetroLink and LR7 scheme in 2018. The methodology and assumptions underlying the estimates are also provided in the document

The capital cost estimate for the direct costs of each scheme and the total scheme capital costs (baselined to 2019) are summarised in Table 4 and 5. The overall difference in the comparative costs of the MetroLink scheme and the original LR7 scheme is estimated €2.5bn.

Description	2015 LR7 ROM Estimate € million	2020 Prelim. Design € million
Tunnelling, Portals & Shafts	860	731
Track work	397	651
Stations	1,220	2,079
Park & Ride	30	91
Depot	142	142
Rolling Stock	271	237
Systemwide	367	434
Enabling / Advance Works	115	83
Total	**3,402**	**4,448**

Table 5 - Direct Cost Summary

Description	2015 LR7 ROM Estimate € million	2020 Prelim. Design € million
Direct Costs	3,402	4,448
Indirect Costs	463	605
Property Costs	311	415
Contingency / Risk	2,314	3,030
Inflation	1,484	1,943
Value Added Tax	Excluded	Excluded
Total	**7,975**	**10,442**

Table 6 - Total Project Estimate Summary

MetroLink Evolution from LR7

This section is set out in more detail, the evolution of MetroLink and seeks to explain the evolution of the scheme from the original LR7 original concept, through the route options section phased and eventual adoption of the current preferred MetroLink scheme.

The Fingal/North Dublin Transport Study (2015)

The Fingal / North Dublin Transport Study (2015) identified Optimised Metro North (LR7) as the preferred modal solution to address public transport needs on the corridor. As part of the study 25 alternative modal options were assessed through a multi-stage, multi criteria analysis.

LR7 differs significantly from the current MetroLink scheme. It has smaller and fewer stations than MetroLink. This alignment also includes a reduced amount of tunnelling (7.5km) with sections through Ballymun and Swords running at-grade. LR7 was envisioned to run in twin bore tunnels between St Stephens Green to just south of Collins Avenue where it emerged from tunnel to run predominantly at surface road level to Dardistown station. From Dardistown station the route enters a second section of tunnel running beneath Airport station and emerging from the tunnel just south of Fosterstown station. The route runs at grade along the centre median of the R132 to Estuary, with priority over other vehicles at all junctions. LR7 has smaller and fewer stations than Metro North.

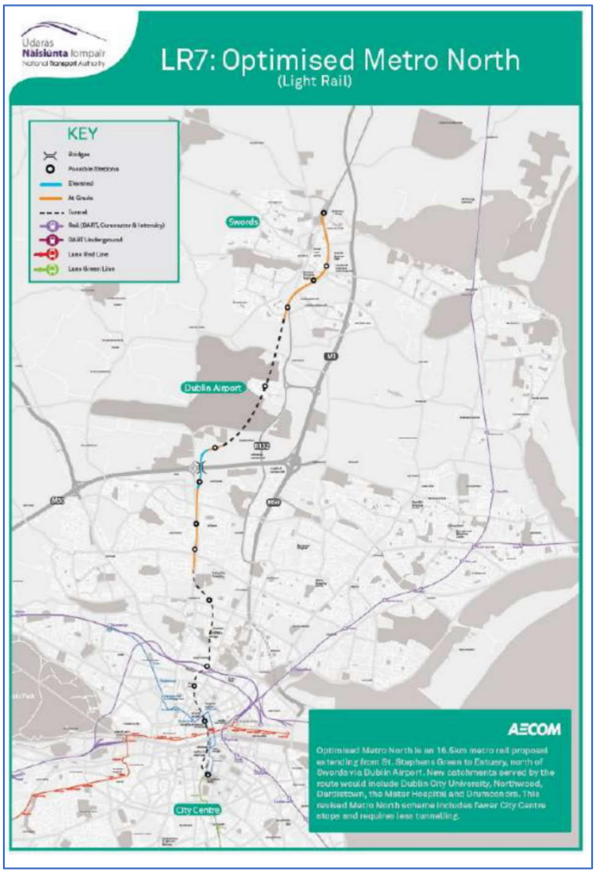

Figure 1 – LR7 Route

The MetroLink scheme by comparison has more tunnelling (11.7km) than LR7. Its runs in single bore tunnel between Charlemont station and Northwood station avoiding major traffic disruption during construction, permanent road realignment and bridge works between Collins Avenue and Northwood. The north portal for the city centre tunnel has been moved from just south of Collins Avenue to a brown field site in Northwood. North of Dublin Airport, the scheme runs on a segregated line prominently in the east verge of the R132. Constructed in open cut, the line is segregated for other transport modes unlike LR7 which requires a high degree of priority running at all R132 junctions.

LR7 would provide capacity to carry 9,900 passengers per direction per hour in line with peak hour passenger demand forecasts along the corridor at the time of the study. LR7 envisioned 60m long, light rail vehicles capable of operating at 30 trains per hr or two minutes headway. LR7 was based on a dual operational concept. In the completely segregated sections trains would operate under a basic block signalling system. This is defined as GoA1 in terms of level of automation. In sections with intersection with traffic at grade, the system would operate on Line of Sight principles similar to the Luas and other Light Rail Transit. This is defined as GoA0 in terms of automation. The level of automation constrains the maximum frequency that the service can achieve and thus the overall capacity. The LR7 alignment is shown in Figure 1.

Transport Strategy for the Greater Dublin Area - 2016-2035

The Transport Strategy for the Greater Dublin Area 2016-2035 was adopted by the Government in 2016 and is an essential component, along with investment programmes in other sectors, for the development of the Greater Dublin Area, which cover Dublin, Meath, Kildare, and Wicklow.

The Fingal / North Dublin Transport Study's recommendations were adopted by the National Transport Authority (NTA) in the Transport Strategy for the Greater Dublin Area 2016-2035 (the strategy). The strategy 'provides a framework for the planning and delivery of transport infrastructure and services in the Greater Dublin Area (GDA) over the next two decades.

During the development of the strategy, LR7 the preferred public transport solution for the corridor from Swords to the City Centre as identified in the Fingal / North Dublin Transport Study, was renamed New Metro North (NMN). NMN is one of a number of Light Rail Infrastructure projects that were proposed to be delivered within the lifetime of the strategy. The strategy defines NMN as a high speed, high capacity, high frequency public transport link from Dublin City Centre to Dublin Airport and Swords, with the city centre section underground.

The strategy also proposed the upgrade of the existing Luas Green Line to Metro standard, through the extension of NMN southwards, via a tunnel, enabling the through running of Metro trams from Swords to Brides Glen.

The recommendation of the Fingal / North Dublin Study regarding the preferred public transport solution for the corridor, did not mean de facto acceptance that the LR7 the definitive scheme on which the preliminary design was to be taken forward. The strategy signalled the intention to move to the route assessment stage. The next stage would require a more detailed assessment of the available route options in the narrow corridor within which LR7 is located and would include LR7 as an assessed option within that corridor. The assessment would be undertaken as part of a Route Options Assessment Study.

GreenLine Tie In Study (2018)

Though providing for the future connection of NMN to an upgraded Luas Green Line, the strategy did not determine the precise location at which NMN would connect to the Luas Green Line. To determine the optimum location for this connection, the NTA commissioned the Green Line Tie In Study.

The objective of this Luas Green Line Tie In Study (LGLTS) was to identify the preferred location for the future tie-in of NMN to the existing Luas Green Line. In April 2016, Transport Infrastructure Ireland (TII), using an internal multi-disciplinary team, commenced work on the LGLTS. A two-stage appraisal methodology was adopted for the study.

The first stage appraisal (stage 1) identified a long list of feasible options between St Stephens Green and Milltown. Following an initial sift of ten options, a long list of seven feasible options were brought forward for preliminary appraisal.

A preliminary appraisal using multi-criteria analysis (MCA) against the criteria of Economy, Environment and Integration was carried out on these options. The preliminary appraisal identified a shortlist of four possible tie-in options, for detailed appraisal (stage 2). During the stage 2 appraisal, designs for the four shortlisted options were further developed to a sufficient level of detail which enabled a more detailed MCA to be carried out on the options, against the criteria of Economy, Environment, Accessibility and Social Inclusion, and Integration.

The LGLTS identified Option 4(B) at Charlemont as the preferred location for the connection of NMN to the Luas Green Line. The LGLTS was published in March 2017.

Emerging Preferred Route and Preferred Route

Following the Fingal / North Dublin Transport Study, NTA / TII commissioned Arup Consulting Engineers to carry out a route options assessment to identify the preferred route for NMN. Building on the work completed as part of the Fingal / North Dublin Transport Study, the "New Metro North Alignment Options Report" published in March 2018 identified an emerging preferred route for New Metro North. The study carried out a comprehensive and robust route option selection process and a total of 34 feasible routes were identified over the length of the corridor. Following an initial assessment, ten of these routes were selected for further detailed assessment, which included a full multi-criteria analysis demand and Cost-Benefit analysis formed part of the assessment. Through this process a single option was identified as the "Emerging Preferred Route."

Figure 4 – MetroLink Preferred Route

The 2018 Emerging Preferred Route for NNM was determined following the conclusion of the NMN Alignment Options study and the Green Line Tie In Study. The overall route for NMN was extended consistent with the objectives of the strategy to include for its connection to the Luas Green Line at Charlemont (Option 4) as per the Green Line Tie In Study (2017). In addition, the upgrade of the Luas Green Line to Metro Standard was included as part of the NMM Emerging Preferred Route enabling through running metro services from Estuary to Brides Glen as envisioned in the strategy.

In advance of a non-statutory public consultation on the Emerging Preferred Route, the scheme was rebranded "MetroLink" and public consultation on the Emerging Preferred took place in March 2018.

The Emerging Preferred Route for MetroLink was announced in March 2018. NTA / TII sought the views of stakeholders through a non-statutory public consultation on the 22nd March 2018.

During the public consultation there was significant public opposition to the upgrade of the Luas Green Line to Metro Standard. The main focus of the opposition to these plans was centred around the significant disruption to existing Green Line services during its upgrade. There was also significant opposition to some of the infrastructure proposed for the upgraded Luas Green Line.

Arising from the public consultation a new strategy was developed for the eventual upgrade of the Luas Greenline to metro standard. The ongoing the Luas Green Line Capacity Enhancement project has potential to provide additional passenger capacity on the line up to 2046, after which demand (11,000ppdh) would exceed capacity on the line. The need therefore to upgrade the line to Metro Standard was not immediate and could therefore be delivered as part of a separate future metro project in or around 2046. In making this decision, NTA / TII were conscious that whilst a significant cohort of stakeholders along the Luas Green Line corridor would welcome this change, other stakeholders not immediately affected by the infrastructure works, but reliant on the line for community from other areas would not welcome the postponement of the upgrade to metro standard.

The upgrade of the Green Line to metro standard was therefore removed from the MetroLink scheme with provision for its future connection at the preferred tie-in location preserved through the continuance of the MetroLink tunnel 200m south of Charlemont station.

The MetroLink Preferred Route

The preferred route for MetroLink was published in 2019. The route incorporated changes arising from the public feedback received on the 2018 Emerging Preferred Route and ongoing design development. Significant changes included the termination of the route just south of Charlemont station, a change from twin bore tunnel to single bore configuration, the replacement of the R132 elevated section to cut and cover running on the eastern verge of the R132.

The preferred route also provided for a change of rolling stock from light rail vehicles (Luas Type vehicles) to Light metro vehicle and then introduction of automated trains to Grade of Automation 4 (GoA4).

Preferred Route compared to LR7

The key differences between the MetroLink and LR7 scheme are summarised in Section 1. Further detail and rationale for these differences are set out in this section.

Extension to Charlemont Tie In Location Retained.

As noted earlier, the Transport Strategy for the Greater Dublin Area 2016 – 2035 requires the upgrading of the existing Green Line to metro standard through the extension of Metro southwards, via a tunnel, to join the Green Line in the Ranelagh area. This would enable the through running of metro trains from Swords to Brides Glen in response to long term demand growth on the Green Line that could not be accommodated through the operation of the Luas extended trams.

Unlike LR7, the MetroLink preferred route makes provision for this possible future upgrade by extending the tunnel from St Stephens Green to Charlemont station. After the commencement of passenger services on MetroLink, Luas trams operating on the Green Line and will provide sufficient capacity in the medium term. At some point in the future, demand will exceed the levels that can be catered for by a light rail service like Luas. It is then envisioned that following completion of the upgrade of the Green Line to metro standard, a short section of tunnel from the Green Line connection point to Charlemont station would be completed to provide through running metro services from Estuary to Brides Glen.

The alternative of terminating the MetroLink at St Stephens Green such that any future connection to the Green Line would be constructed from that point was considered and ruled out, given the sensitive nature of the area surrounding St Stephens Green. The need to construct a large underground turnback facility at this location and the construction impacts and difficulties associated to launching or receiving a new TBM drive south from that location to tie into the existing Green Line were assessed and the conclusion was that locating the southern terminus at Charlemont is the preferred option.

A New Interchange Station at Whitworth Rd (Glasnevin Station)

The “New Metro North Alignment Options Report” identified city centre route “A4” as part of the preferred city centre alignment for MetroLink. This route provided a new integrated rail and metro station at Whitworth Road (Glasnevin Station). LR7 by comparison envisioned the interchange with the heavy rail taking place at Drumcondra close to the existing Irish Rail station. Most importantly the proposed station at Glasnevin due primarily to the closer physical proximity of the GSWR / MGWR[54] line at this location, offers significantly shorter and more efficient passenger transfer between Irish Rail and MetroLink services when compared to Drumcondra.

The proposed Glasnevin MetroLink station is considered to better complement the GDA strategy than one located at Drumcondra, facilitating a seamless transfer / interchange between public transport modes. Drumcondra is and will remain highly accessible by public transport even without a metro station as it is served by the heavy rail and bus network. Furthermore, a metro station located at Glasnevin provides a better opportunity for interchanging with the Maynooth and Kildare lines than at Drumcondra because the Phoenix Park Tunnel and Maynooth lines are at their closest point horizontally and vertically at Whitworth, thereby providing the opportunity for a MetroLink station to capture transfer to and from these lines more effectively than at Drumcondra, due to their proximity.

The proposed Glasnevin MetroLink station also facilitates the construction of an integrated metro station as the two heavy rail lines are beneath the existing ground level, making it possible to connect via an underground concourse to all three rail lines in a short distance. A further advantage of the proposed Glasnevin station is that it is located approximately 1km to the west of Drumcondra. This saves over two minutes in journey time by offering the opportunity for rail passengers travelling to Dublin to transfer sooner from heavy rail to metro at Whitworth to access city centre locations to the south or to the Airport / Swords to the north. The impact of this is that there is an additional 600 transfer boarding's from rail at Whitworth over Drumcondra in the AM peak (equivalent to a 33% increase – in the year of opening).

Designed for Fully Segregated Operations

The LR7 route envisioned the rail service running at grade within the central median of the R132. The existing roundabouts along the central reserve are converted to signalised junctions with high priority given to metro services over other traffic. Whilst a high level of priority would be given to metro services over other traffic, the need to provide a level of priority for pedestrians affects the ultimate head and capacity that can be achieved. The projected demand associated with LR7 could be cater for with this level of service.

Transport modelling which informed the Emerging Preferred Route in 2018 indicated line flows would reach up to peak 18,000 pphpd, during peak hour at city centre stations. Typically, light rail and metro systems are designed to cater for peak hour flows on the route. In deciding on the appropriate design peak hour capacity for MetroLink, a Peak Hour Factor (PHF) is used to convert the hourly traffic volume into the flow rate that represents the busiest 15 minutes of the peak hour. For Luas cross city a PHF of 0.9 has traditionally been agreed with the NTA based on observer traffic analysis. For Metrolink a PHF of 0.9 has been agreed with NTA servicing the required demand of 18,000ppdph.

The International Association of Public Transport (UITP) guidance with respect to the carrying capacity of different modes advises that unsegregated light rail systems have an ability to carry a maximum capacity of 7,000 pphpd increasing to 11,000 pphpd with high level of segregation as intended for LR7. Above those peak hour levels, Transport Authorities tend towards implementing metro / light metro systems, which have a capability of carrying up to 20,000 pphpd and more[55].

NTA / TII do not believe it is desirable to compromise the overall carrying capacity of the line by designing a system constrained by the lower capacity requirements on the northern end of the scheme. For this reason, the Emerging Preferred Route allowed for full segregation also along the R132 corridor. This was to be achieved through the provision of a fully segregated elevated structure along the central median of the R132.

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[54] GSWR - Great Southern and Western Railway / MGWR - Midland Great Western *Railway*

[55] By means of reference the Green Line route on Dublin's Light Rail network has a maximum carrying capacity of 8,800 pphpd. The system, which will be upgraded to provide greater segregation in the coming years, however with segregation it is estimated that the system will provide a maximum carrying capacity of 11,000 pphpd

It is intended that a highest level of service will be delivered during peak hour along the entirety of the MetroLink route. The degree to which the level of services can be delivered is affected by the extent of segregation from other transport modes. Where a route is fully segregated the potential to minimise operating headway and maximise service frequency's is limited only by the signalling system deployed. By contrast line segregation as envisioned for the LR7 with high priority at junctions only, can significantly impact the level of service that can be provided. As is the case with Luas lines the headway and frequency required is dependent on priority at junctions being guaranteed which is not often the case. It is also dependent on there being no encroachment onto the tracks by pedestrians and / or other vehicles which is a regular occurrence. This is a frequent issue for Luas services operating on the Ballyogan Road which is comparable to the LR7 configuration envisioned for the R132.

For the above reasons the MetroLink service has been designed as a segregated system capabile of offering a high frequency service offering reliable headways from 3 minutes on opening down to 90 seconds when required.

R132 An Open Cut - Fully Segregated Solution

During public consultation on the Emerging Preferred Route, the concept of an elevated structure providing the required segregation along the R132 faced opposition from local stakeholders. The elevated structure (Figure 3) would place the MetroLink rail line approximately 8 metres above the existing road surface. The poles and overhead contact wires would extend a further 5 metres vertically. At station locations, the canopy for the stations on the elevated line would be over 13 metres above road level. All of which created significant landscape and visual impacts that concerned local residents of Ashley Avenue, Estuary Court, Seatown Villas, Carlton Court Road and Foxwood estates.

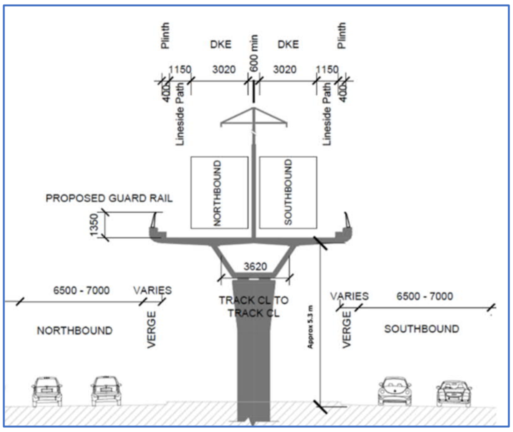


Figure 3 - Elevated Structure

In order to mitigate these impacts NTA / TII considered and ultimately approved a proposal to move the MetroLink alignment along the R132 from the central median into verge on the eastern side of the R132. The new alignment would be placed predominantly in a retained cut structure with discrete sections covered over to facilitate integration and permeability to existing and future planned developments along the R132. The new retained cut proposal removed the visual impact impacts associated with the elevated structure and was estimated to generate a potential significant savings against the elevated route option at that time.

The revised alignment now presents a metro solution which facilitates permeability, connectivity and cycling provision across both sides of the rail line and removes the concept of potential perceived community severance associated to LR7 and trains running in the central median of the R132. The revised alignment enables Fingal County Council to deliver on its strategy to connect the town's urban environment across the R132 by changing the character of the road to a more urban boulevard. The revised station designs associated to the new alignment also provide a more accessible and sheltered environment for customers.

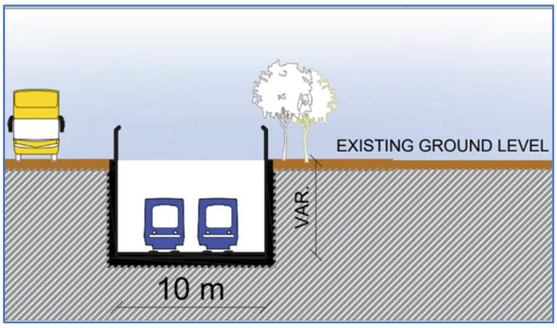


Figure 5 Segregated Running in Retained Cut

The revised proposal to place the alignment in retained cut (Figure 4) on the R132 corridor were received positively during the 2019 non-statutory public consultation and the preliminary design for the scheme was updated accordingly.

Increased Tunnelling

As noted earlier, LR7 had a total tunnelled section of 7.5km consisting of the tunnel drive from St Stephens Green to the southern boundary of Hampstead Park and the tunnel section beneath Dublin Airport between Dardistown and the northern boundary of the Airport. LR7 included for at grade running from the boundary of Hampstead Park on the surface along the R108 Ballymun Road, rising over busy signal-controlled junctions at Santry and Collins Avenue.

MetroLink has more tunnelling than LR7 (11.7km) with additional tunnelling (3.2km) provided beneath R108 (Ballymun Road) in order to avoid the adverse construction, traffic management logistic and environmental impacts associated to running on the surface along the R108. The alternative of at grade running along the R108 was assessed as part of the Arup's Route Options Assessment study and in subsequent studies by NTA / TII. These studies concluded that an at grade option performed poorly against the relevant assessment criteria. In particular the need to construct large underpass / overbridge structures at existing junctions at Collins Avenue, Shangan Road and Santry Avenue, the costs of those structures and the associated impact on local traffic and the wider environment were considered significant when compared to placing the entirety of the route in tunnel beneath the R108.

The extension of the route south to Charlemont to provide for the future connect to the GreenLineadded an extra 1km of tunnelling to the scheme.

The change to Single Bore Tunnel Configuration.

As well as having a shorter section of tunnel, the LR7 tunnel section was intended to be constructed as a twin bore solution with a separate dedicated tunnel for the north and southbound rail lines. The 2018 Emerging Preferred Route also proposed the use of twin bored tunnel for its tunnelled section but left open the possibility that a single bore tunnel could be considered further during the development of the preferred route and preliminary design. In 2018 new consultants appointed to develop the preferred route and preliminary design for the scheme advanced proposals to implement a single bore tunnel solution with the north and southbound rail lines running side by side within the single bore tunnel. Significant advantages associated to single bore were outlined, the "Preferred Route Design Development report (2019), with the specific advantages in relation to Tunnel Fire safety is detailed in the Tunnel Fire Safety: Pros and Cons of a Single Bore Tunnel Arrangement (2021).

Significant advantages associated to implementing a single bore tunnel solution are outlined in this section.

Cost and Programme Savings:

A cost comparison was undertaken to compare the estimated cost of the current single bore tunnel solution against a comparable twin bore tunnel solution. The twin bore tunnel solution was costed based on having an identical number of stations, a slightly shallower tunnel alignment, smaller stations, and tunnel cross passages (for access between each tunnel) at every 250m. The twin bore tunnel solution is currently estimated to cost over €0.6 billion more than the single bore tunnel solution.

The single bore tunnel offered increased service flexibility because it is easier to introduce rail crossovers within the single tunnel configuration allowing trains to turn back or change between the two rail lines if operation on one track is disrupted, accommodating crossovers in a twin bore tunnel solution requires the mining of large cavern spaces, with associated increases in cost, risk, and complexity.

A single bore tunnel can be constructed at lower cost and within a faster timeline than a twin bore solution, primarily due to the fact that there is no requirement to construct cross passages at every 250m as is the case with the twin bore solution and to construct large caverns for the purposes of installing crossover facilities.

Fire Safety and Evacuation

The single bore tunnel facilitates faster train evacuation. Evacuating passengers can exit the train on to the neighbouring rail track area and availing of the entire tunnel floor area passengers can leave the scene in larger numbers, thereby increasing the efficiency and speed of evacuation in the unlikely event of an incident. By comparison twin bore tunnel solutions generally require passengers to exit onto a narrow side walkway in single file until the passengers clear the train length. This can affect the speed with which passengers can evacuate from the incident area.

The benefits of the single bore tunnel from a fire safety perspective are summarised as follows:

- Fast train evacuation. It maximises emergency egress path widths along the trackway, avoiding blockage when alighting from the train and not imposing the speed of the slowest ones to the rest of passengers.
- Provides more space for smoke stratification, which is particularly relevant when the fire is located inside the train.
- Provides a wider side space near and around an incident train for emergency services to deploy and execute their tasks, including assisting passengers evacuating and the access to Fire Hose Connections.
- It improves evacuation guiding in scenarios of fire outside the passenger compartment.
- It avoids the risk of falls from heights from a side passageway and minimizes the psychological sensation of confinement.

For the above reasons the proposal to adopt a single bore tunnel solution for MetroLink was accepted by NTA / TII and the Preliminary Design proceeded on that basis. The full rational for the adoption of the single bore solution is provided in the 2019 Design Development Report.

Additional Underground Stations

MetroLink has a greater section of the route running through tunnels in lieu of the surface level running envisioned for LR7. This has increased the number of underground stations from 6 No (LR7) to 11 No. The change to retained cut running has resulted in 4 of the 5 at grade stations envisioned for LR7 to changing to deep retained cut type stations.

Projected Demand, System Capacity and GoA4 Running

At the time of the Fingal / North Dublin Study (2013) forecasted peak hour demand for the LR7 scheme was predicted to reach 6,245ppdph at peak time (2033) and provided a design capacity of 9,900ppdph. As noted earlier, the LR7 was not a fully segregated system along the entire corridor, it operated at grade on the R132 median with a high level of priority at traffic junctions, operated at maximum two minute headways and provided for a maximum design capacity of 9,900 pphpd.

Subsequently modelling carried out on the route between the publication of the Emerging Preferred Route and Preferred Route, forecast AM southbound line flows in excess of 18,000 pphpd and forecast PM northbound line flows of 13,500ppdph. This increased transport demand is attributed to the fact that demographic, housing density, employment patterns have all changed since the modelling work to support LR7.

Based on the updated transport demand figures NTA / TII agreed that the baseline design capacity should be increased to 20,000pphpd. This (includes circa +10% on model year peak forecast demand in 2057). On this basis NTA / TII defined the appropriate type and level of service for MetroLink.

A Light Metro or Light rail solution?

The capacity of a rail system is the result of the unit capacity delivered by a single vehicle multiplied by the service frequency measured in Trains Per Hour (TPH). The International Association of Public Transport (UITP) published in 2009 a guidance paper with respect to the carrying capacity of different modes. The indication from UITP is that unsegregated rail-based systems have an ability to carry a maximum capacity of 7,000 pphpd increasing to 11,000 pphpd where a high level of segregation can be achieved. This is the operational concept that was used for LR7. Where demand exceeds this levels, Transport Authorities tend towards implementing metro / light metro systems, which have a capability of carrying up to 20,000 pphpd and more.

Metro / Light metro systems (Figure 5) differ significantly from light rail systems vehicles, system design and operational concepts are different. Typically, light rail vehicles are low-floor or partially low-floor: elements of the suspension system occupy some space in the saloon, thus preventing passengers from standing in those locations, where seats are installed to make some use of the space.

Figure 6 – Typical Light Metro System

Metro / Light metro vehicles are typically high floor vehicles, and the saloon is designed to facilitate increased passenger loading. Metros operate on fully segregated tracks and use a signalling system, thus they can provide a more reliable, faster, and higher capacity service

In consideration of the demand and the characteristics of the alignment, the preferred scheme for MetroLink is designed as a high floor light metro system.

Level of Service and Automation.

Standard IEC 62267 defined four Grades of Automation to describe metro operations (Figure 6). A light rail system like Luas, which is based on Line Of Sight would be at the lowest grade, which is GoA0 and is not used by metro systems. The previously mentioned optimised Metro North (LR7) was based on GoA1 operation in segregated sections and GoA0 in sections with traffic junctions at grade.

The highest Grade of Automation is GoA4. In this type of metro, a computerised command and control system controls the operation of the trains, including opening and closing the doors, setting the vehicle in motion, and stopping it and operating trains in case of disruption.

This type of system allows for Unmanned Train Operation (UTO) and in most operations stewards and roving staff are deployed to support customers, protect revenue, and perform maintenance activities. MetroLink is designed an automated metro system (GoA4).

Grade of Automation	Type of train operation	Setting train in motion	Stopping train	Door closure	Operation in event of disruption
GoA1	ATP* with driver	Driver	Driver	Driver	Driver
GoA2	ATP and ATO* with driver	Automatic	Automatic	Driver	Driver
GoA3	Driverless	Automatic	Automatic	Train attendant	Train attendant
GoA4	UTO	Automatic	Automatic	Automatic	Automatic

*ATP - Automatic Train Protection; ATO - Automatic Train Operation

Figure 7 - Grades of Automation

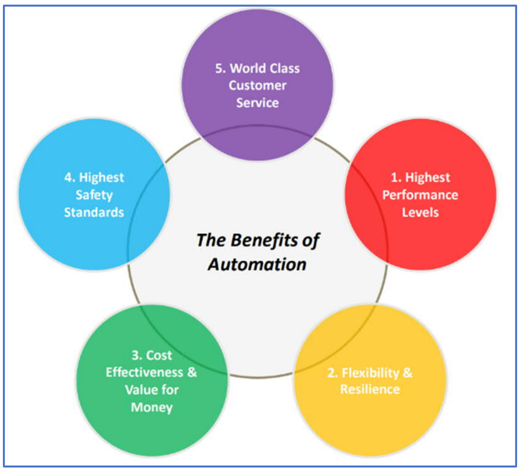
The decision to pursue this grade of automation was driven primarily by the need to provide the required 20,000 pphpd capacity, though high frequency service. As previously outlined, the capacity of a rail system is the result of the unit capacity delivered by a single vehicle multiplied by the service frequency measured in Trains Per Hour (TPH). MetroLink is designed to achieve the required capacity by operating 65m long trains at high frequency up to 40 TPHs or a train every 90s. This results in relatively compact stations[56].

The alternative approach was to build larger stations and longer rolling stock to cater for this future demand. Given the spatial challenges associated with locating stations in a historic medieval city it was felt that station sizes should be kept as compact as possible to minimise the impact on the built environment during construction and reduce the overall all capital cost of the scheme. GoA4 operations would also deliver operational and maintenance savings over the whole life of the project and GoA4 would offer a more efficient service to customers and a better work environment for staff delivering the service.

The first automated metro started passenger service in 1981. In 2018 1000km of automated metros were in operation worldwide and full automation is becoming the mainstream choice for cities that are delivering their first metro. By 2023 over 3000km of automated metros will be operational and the growth is accelerating.

In 75% of the cities with metro networks at least one fully automated line is in operation. Cities with established networks are increasingly choosing automation when they are renewing existing lines. In Europe Brussels, Glasgow, London, Lyon, Marseille, Paris, and Vienna, this is despite the challenges associated with the retrofit and the rationale for the choice is in the benefits that automation deliver.

The benefits of automation are well established. They are described in detailed in Appendix G of the Preliminary Business Case summarised are illustrated in the diagram and explained below[57].



High Performance Levels

To operate the frequent service that Dublin will need, automatic operation (GoA2+) is required. With good discipline, manual driving (GoA1) can be used up to 28tph, but beyond that, delays in response times and lack of driving consistency will cause service instability and recurrent, irrecoverable delays. This allows for a better use of the theoretical frequency that a signalling system can deliver, thus maximising the passenger services that can be delivered in one hour.

GoA3 and GoA4 operation increase capacity further by reducing the time taken to reverse trains in a siding as there is no longer a requirement for a driver to walk from one end of the train to the other for it to change direction. This means that an intensive service can be reversed off fewer sidings, reducing the cost and disruption of operating at high service frequencies, while enhancing reliability (fewer point machines and a less complex track layout) and sustainability (less embodied carbon and smaller construction sites). GoA4 means that no additional platforms are required at termini stations to allow crew changes, comfort breaks and cope with the variability that humans introduce to a system (staff being 30s late for a shift can have significant consequences on the capacity of a high intensity service). A GoA4 system does not require these extra platforms as there are no on-train staff to consider. “MetroLink will be a GoA4 metro, which will allow for Unmanned Train Operation. Staff will be deployed to provide customer support, revenue protection and maintenance of the system.

In the operational start-up phase and during the first introduction of the passenger service, it will be possible to allocate a staff member per train as temporary measure. This will not involve the provision of extra platforms or staff facilities as the system will not be operating at or near the highest frequency that is designed for.

[57] The Benefits of Automation Transport Infrastructure Ireland – SNC 2019

Flexibility and resilience

Fully automated operation enables MetroLink to operate a demand-based rather than a timetable-based service (as traincrew management is no longer a constraint) and enables service levels to be dynamically adjusted to meet the real-time (or predicted) demand or in response to external events.

Cost effectiveness and Value for Money

Automation enables precise optimisation of railway operations, whether in the operation of an individual train, the optimisation of a train service, or the ability to minimise the amount of infrastructure to meet a required level of capacity. Automatic driving will make most efficient use of coasting while maintaining journey time and capacity requirements, and therefore reduce the use of traction power. Automated driving will also co-ordinate train movements to make the most effective use of traction power savings through maximising the opportunities for regenerative braking. The smoother operation and reduced use of braking will reduce wear on system components, reducing the embodied carbon in replacement parts and maintenance activities. As fully automated trains do not require human drivers, train moves to locate drivers (e.g., bringing them back to a depot for the end of a shift or a meal relief) are eliminated, and the ability to change the service pattern to reflect actual demand eliminates energy wastage due to over-provision of train services.

Station automation promotes energy efficiency through the switching of station facilities (e.g., lighting, heating, escalators) in response to measured light levels, temperatures, and customer demand, rather than to a fixed schedule, or when a station supervisor notices that action is required. Stations and the depot may include microgeneration (solar and wind power) where possible, and this will be monitored by the same automation system to ensure peak performance is maintained, and to synchronise the use of energy while it is most abundant.

Highest Safety Standards

During normal operation, automated systems will be undertaking the basic functions of routing trains and supervising the service to identify the first signs of an anomaly. These systems can do this faster and with a lower error rate than a human operator, and without the risk of distraction. This significantly reduces the risk of incidents being initiated by staff error and gives the control centre staff the ability to take a wider view of the service and the infrastructure, potentially identifying issues that an automated system would be less likely to detect and being able to intervene before they threaten the safety of the railway. As detailed in Appendix G, Automated systems also offer significant advantages when operating in degraded and emergency modes. Passenger safety at platforms is greatly enhanced by the platform screen door, generally adopted in most GoA4 systems.

World Class customer service

Railway systems are complex, and like all complex systems, do suffer from performance degradation and breakdowns that have a direct impact on passengers. These failures may be the result of equipment suffering a breakdown, perhaps from a failed component; or may be due to external factors such as a grid power outage or a flooding event. However, failures are frequently a result of human error, a lack of human responsiveness, or staff unavailability. By allowing to focus on supervising the operation and assisting customer, automated systems can largely avoid failures resulting from human errors and shortcomings.

They also remove the variability of human response times and personal preferences, leading to a higher capacity, more consistent railway operation, using analysed and agreed best-practice for every decision. Automated systems are better equipped to deal with equipment failures, and some forms of external influences, through automatically switching to redundant systems with instant service reconfiguration. This enables component failures to be dealt with at times when the customer service will not be disrupted (e.g., overnight) and with less time pressure on the maintenance technician, leading to more in-depth diagnostics and higher-quality corrective work, significantly reducing the risk of a future repeat failure.

By utilising the highest levels of automation on monitoring, detection and control, the passenger benefits from the very highest levels of performance, resilience, and responsiveness. In addition, passengers benefit from the additional flexibility to be gained from releasing train services from staff shift patterns, and safety-related working time limits, that result from the need for train crew. If staff are late, it delays the train service, and the human operators (whether driving a preceding train or using a train to get into position for their next duty) will also be delayed; clearly this can form a vicious circle that causes minor delays to propagate into major disruption. Automated driving will be smoother than traditional manual train operation as hard brake applications will be reduced by the intelligent use of coasting; this will generate customer perception of improved ride quality. The train service reliability will be improved by removing the delays and the vicious cycle of service degradation caused by human operators not being in position. The automated train regulation system will ensure that small service perturbations are managed before they can grow into larger service disruptions; customers will perceive that trains will reliably arrive at regular intervals, and customer load will be evenly spaced between trains.

Finally, Transport Authorities that have adopted automated operation observe a higher degree of job satisfaction among staff than those working on GoA4 automated metros. This primarily due to the fact the driver is required to be present in the cab of the train, with the sole function of opening and closing the train doors. Occasionally the driver may be required to move the train manually during and emergency and therefore the role is perceived as being unskilled, repetitive, and routine leading to high levels of employee boredom and dissatisfaction. This compares with the more customer focused role required of personnel on a GoA4 system. Staff on GoA4 systems are freed of the responsibility of driving the train and are expected to carry out a more varied role which includes engaging with passengers on the train and the stations providing customer service and advice as required. They are also trained to drive the train in manual mode during emergencies. This modal provides for greater employee satisfaction and career advancement within the metro operations company.

For all of the reasons stated above, NTA / TII decided to develop MetroLink as fully automated Metro System.

Why not terminate the route at Tara Street?

The option to terminate the route at Tara Street station offers a significant cost saving. It would reduce the overall tunnel length by 2km and negate the need for two significant stations at St Stephens Green and Charlemont. This would result in an overall saving to the scheme currently assessed at approximately €1.1 billion However, truncating the alignment would result in a number of negative consequences for achieving the full benefits of the scheme including loss of patronage, St Stephens Green and Charlemont stations are amongst some of the busiest MetroLink stations, accounting for 16% of total boarding and over 18% of all alighting. To put that in context, of over 90 million trips estimated in 2060, over 14 million will start at Charlemont and St Stephens Green, and almost 17 million trips have these stations as their destinations. Losing access to these stations will increase journey times and reduce accessibility to these major destination areas. Overall, it is estimated that overall passenger volumes on MetroLink would reduce by 11%. This is considered to reduce the degree to which MetroLink would achieve its stated Intervention Objectives.

Access to key attractors would also be negatively. The proposed St Stephens Green station not only provides direct access to one of Dublin's most cherished and iconic City Centre areas, but it also provides easy access to one of Dublin's busiest shopping and business districts, servicing retail, commercial and cultural trip attractors in the vicinity. St Stephens Green station is also located in area that is particularly important from an employment perspective, providing direct access to one of the largest retail and commercial employment catchment areas in Dublin. If the route were to truncate at Tara Street station direct access to these key areas which include National Gallery of Ireland, National Museum, St Stephens Green and other shopping, leisure and cultural amenities would not be provided.

To assess the impacts on the overall benefits of the scheme associated to truncating the route at Tara Street, NTA / TII carried out a transport model run which considered the reduced overall demand on the system arising from the loss of patronage at St Stephens Green and Charlemont stations. Overall, it is estimated that overall passenger volumes on MetroLink would reduce by 15.64%, with a corresponding reduction in public transport benefits in the range of €1.5 billion (net present value basis).

Airport to Estuary – A Fundamental Part of MetroLink

The main stated objective of MetroLink is *"to provide a sustainable, safe, efficient, integrated and accessible public transport service between Swords, Dublin Airport and Dublin City Centre".* This objective can also be applied to its predecessor Metro North.

Aligned with this objective MetroLink is vital for the transformation of Swords town and County Fingal as a whole, by providing a high-speed, high-capacity, high-frequency public transport link from the city centre to Dublin Airport and Swords.

Fingal is the fastest growing county in Ireland with a population of 296,214 as of Census 2016. The population increased by 77% between 1996 and 2011, and by 22,223 since 2011. This 8.1% increase is the highest of any county or city in the last five years and is over twice the national rate of increase.

Fingal County Council recognises that MetroLink is a key piece of infrastructure to shape and unlock the long-term development of Swords and Fingal. This will be to the benefit of all living and working in Swords and environs. The alignment of the metro service alongside the R132, will influence the built environment along the linear transport corridor. The metro will connect local population and create mixed use development opportunities for large tracts of zoned lands along the metro link route. The metro service will serve as an economic activity corridor. This will provide the local population with vital connectivity and access to jobs, services, accommodation, and local amenities all within close proximity of each other. However, the urban design will need to provide high-quality public spaces with particular attention to urban elevations along road frontages. Focus on character of the built environment, will help create a sense of place.

It is important also to note that the Airport Sword link is a significant contributor to the overall benefits of the MetroLink scheme. In the Opening Year of the scheme over 30,000 (32%) of the 12-hour passenger boarding are from the Airport to Estuary section of the scheme. This increases to 58,000 in 2060 significantly to the overall benefits of the scheme[58].

In summary the development Metrolink and in particular the section between Airport and Estuary will explicitly support:

- The development of high-tech research and development opportunities at Lissenhall East.
- The reduction of car dependency and support sustainable modes of transport / smarter travel.
- Long-term development of Swords and Fingal.
- The role of Dublin Airport as a Global Gateway.
- The role of Dublin Airport as County Fingal's largest employer.

For all of the above reasons providing metro service between Airport and Estuary remains a key component of the MetroLink scheme.

[58] NTA Value for Money exercise, Variant 1 is the route stopping at the Airport 2021 Modelling.