DART+ South West

Technical Optioneering - Introduction

Iarnród Éireann

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Glossary of Terms

Reference	Description
ABP	An Bord Pleanála
ACA	Architectural Conservation Area
APIS	Authorisation for Placing in Service
ASA	Application for Safety Approval
AsBo	Assessment Body
ASPSC	Application Specific Project Safety Case
ATP	Automatic Train Protection
CAF	Common Appraisal Framework
Cantilever	OHLE structure comprising horizontal or near horizontal members supporting the catenary projecting from a single mast on one side of the track.
Catenary	The longitudinal wire that supports the contact wire.
CAWS	Continuous Automatic Warning System
CBI	Computer-Based Interlocking
CCE	Chief Civils Engineers Department of IE
CCRP	City Centre Re-signalling Project
CCTV	Closed Circuit Television
CDP	County Development Plan
CIE	Córas Iompair Éireann
Contact wire	Carriers the electricity which is supplied to the train by its pantograph.
CPO	Compulsory Purchase Order
Cross overs	A set of railway parts at the crossing of several tracks which helps trains change tracks to other directions.
CRR	Commission for Rail Regulation (formerly RSC – Railway Safety Commission)
CSM RA	Common Safety Method for Risk Evaluation and Assessment
CTC	Central Traffic Control
Cutting	A railway in cutting means the rail level is below the surrounding ground level.
D&B	Design & Build (contractor)
DART	Dublin Area Rapid Transit (IÉ's Electrified Network)
DART+	DART Expansion Programme
DeBo	Designated Body
Direct Current (DC)	Electrical current that flows in one direction, like that from a battery.
DCC	Dublin City Council
DRR	Design Review Report
DSR	Design Statement Report
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EIS	Environmental Impact Statement
Electrification	Electrification is the term used in supplying electric power to the train fleet without the use of an on-board prime mover or local fuel supply.
EMC	Electromagnetic Compatibility
EMU	Electric Multiple Unit (DART train)
EN	European Engineering Standard

Reference	Description
EPA	Environmental Protection Agency
EPO	Emerging Preferred Option
ERTMS	European Rail Traffic Management System
ESB	Electricity Supply Board
Four-tracking	Four-tracking is a railway line consisting of four parallel tracks with two tracks used in each direction. Four track railways can handle large amounts of traffic and are often used on busy routes.
FRS	Functional Requirements Specification
FSP	Final Supply Points
GDA	Greater Dublin Area
GI	Ground Investigation
HAZID	Hazard Identification
Horizontal Clearance	The horizontal distance between a bridge support and the nearest railway track is referred to as horizontal clearance. Bridge supports include abutments (at the ends of the bridge) and piers (at intermediate locations).
HV	High Voltage
IA	Independent Assessor
IÉ	Iarnród Éireann
IM	Infrastructure Manager (IÉ)
IMSAP	Infrastructure Manager Safety Approval Panel
Insulators	Components that separate electricity live parts of the OHLE from other structural elements and the earth. Traditionally ceramic, today they are often synthetic materials.
KCC	Kildare County Council
Lateral Clearance	Clearances between trains and structures.
LCA	Landscape Character Area
Mast	Trackside column, normally steel that supports the OHLE.
MCA	Multi-criteria Analysis
MDC	Multi-disciplinary Consultant
MEP	Mechanical electrical and plumbing
MFD	Major Feeding Diagram
MMDC	Maynooth Multi-disciplinary Consultant
MV	Medium Voltage
NDC	National Biodiversity Data Centre
NIAH	National Inventory of Architectural Heritage
NoBo	Notified Body
NTA	National Transport Authority
OHLE	Overhead Line Equipment
Overbridge (OB)	A bridge that allows traffic to pass over a road, river, railway etc.
P&C	Points and Crossings
Pantograph	The device on top of the train that collects electric current from the contact wire to power the train.
PC	Public Consultation
Permanent Way	A term used to describe the track or railway corridor and includes all ancillary installations such as rails, sleepers, ballast as well as lineside retaining walls, fencing and signage.
POAP	Plan-On-A-Page, high-level emerging programme
PPT	Phoenix Park Tunnel
PRS	Project Requirement Specification
PSCS	Project Supervisor Construction Stage

Reference	Description
PSDP	Project Supervisor Design Process
PSP	Primary Supply Points
QA/QC	Quality Assurance/Quality Control
RAM	Reliability, Availability, Maintainability
RC	Reinforced Concrete
Re-signalling	Re-signalling of train lines will regulate the sage movement of trains and increase the capacity of train services along the route.
RMP	Record of Monuments and Places
RO	Railway Order
RPS	Record of Protected Structures
RSC-G	Railway Safety Commission Guideline
RU	Railway Undertaking (IÉ)
SAM	Safety Assurance Manager
SAP	Safety Approval Panel
SDCC	South Dublin County Council
SDZ	Strategic Development Zone
SET	Signalling, Electrical and Telecommunications
Sidings	A siding is a short stretch of railway track used to store rolling stock or enable trains on the same line to pass
SMR	Sites and Monuments Records
SMS	IÉ Safety Management System
TII	Transport Infrastructure Ireland
TMS	Train Management System
TPH	Trains per Hour
TPHPD	Trains per Hour per Direction
TPS	Train Protection System
Track Alignment	Refers to the direction and position given to the centre line of the railway track on the ground in the horizontal and vertical planes. Horizontal alignment means the direction of the railway track in the plan including the straight path and the curves it follows.
TSI	Technical Specifications for Interoperability
TSS	Train Service Specification
TTAJV	TYPSA, TUC RAIL and ATKINS Design Joint Venture (also referred to as TTA)
Underbridge (UB)	A bridge that allows traffic to pass under a road, river, railway etc. The underneath of a bridge.
VDC	Direct Current Voltage
Vertical Clearance	For overbridges, an adequate vertical distance between railway tracks and the underside of the bridge deck (soffit) must be provided in order to safely accommodate the rail vehicles and the OHLE. This distance is known as vertical clearance and it is measured from the highest rail level.
WFD	Water Framework Directive

1. Introduction

1.1. Purpose of the Report

This report presents information that is applicable to the Technical Optioneering Reports.

1.2. DART+ Programme Overview

The DART+ Programme is a transformative railway investment programme that will modernise and improve the existing rail services in the Greater Dublin Area. It will provide a sustainable, electrified, reliable and more frequent rail service, improving capacity on rail corridors serving Dublin.

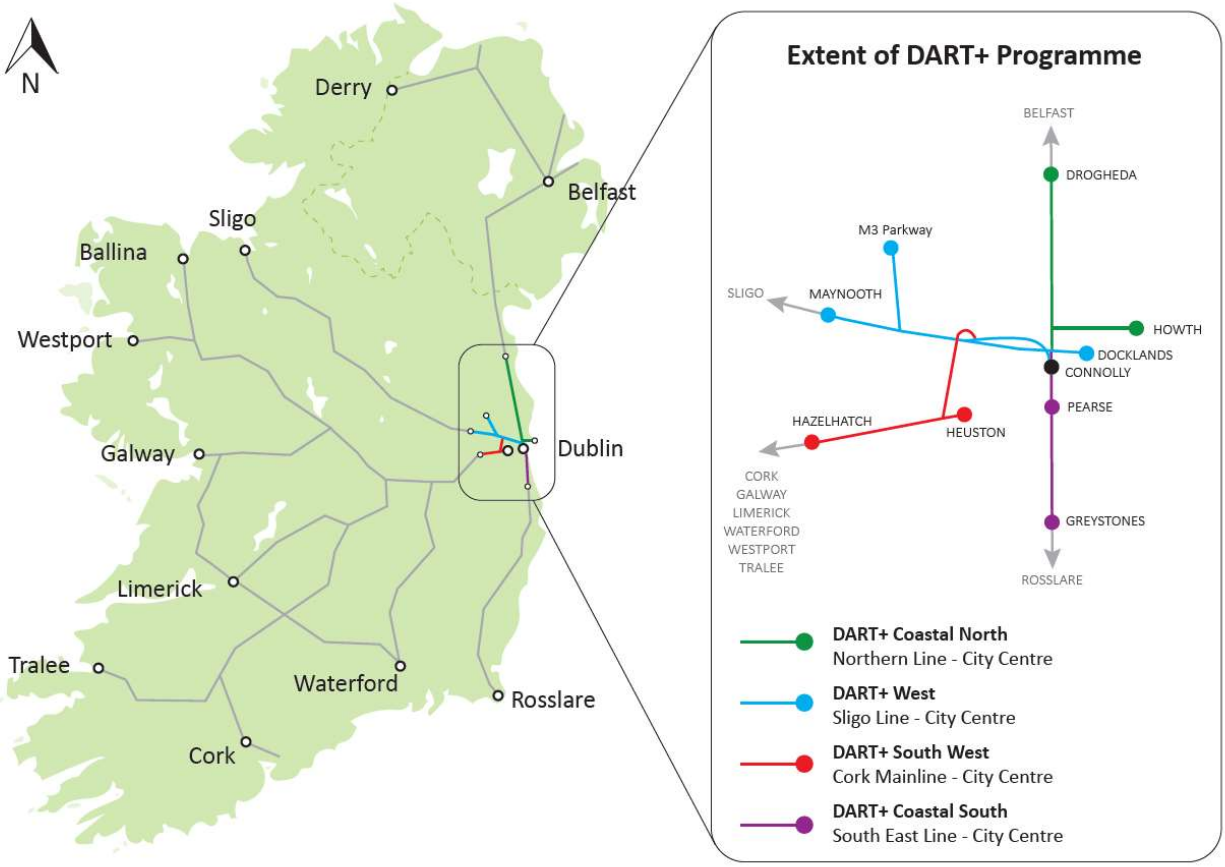

Figure 1-1 - DART+ Programme

The current electrified DART network is 50km long, extending from Malahide / Howth to Bray / Greystones. The DART+ Programme seeks to increase the network to 150km. The DART+ Programme is required to facilitate increased train capacity to meet current and future demands, which will be achieved through a modernisation of the existing railway corridors. This modernisation includes the electrification, re-signalling, and certain interventions to remove constraints across the four main rail corridors within the Greater Dublin Area, as per below:

- DART+ South West (this Project) – circa 16km between Hazelhatch & Celbridge Station to Heuston Station and also circa 4km between Heuston Station to Glasnevin, via the Phoenix Park Tunnel Branch Line.
- DART+ West – circa 40km from Maynooth & M3 Parkway Stations to the City Centre.
- DART+ Coastal North – circa 50km from Drogheda to the City Centre.
- DART+ Coastal South – circa 30km from Greystones to the City Centre.

The DART+ Programme also includes the purchase of new electrified fleet to serve new and existing routes.

The DART+ Programme is a key element to the national public transportation network, as it will provide a high-capacity transit system for the Greater Dublin Area and better connectivity to outer regional cities and towns. This will benefit all public transport users.

The Programme has also been prioritised as part of Project Ireland 2040 and the National Development Plan 2018-2027 as it is integral to the provision of an integrated, high-quality public transport system.

Delivery of the Programme will also promote transport migration away from the private car and to public transport. This transition will be achieved through a more frequent and accessible electrified service, which will result in reduced road congestion, especially during peak commuter periods.

Ultimately, the DART+ Programme will provide enhanced, greener public transport to communities along the DART+ Programme routes, delivering economic and societal benefits for current and future generations.

1.3. DART+ South West Project

The DART+ South West Project will deliver an electrified network, with increased passenger capacity and enhanced train service between Hazelhatch & Celbridge Station to Heuston Station (circa 16km) on the Cork Mainline, and Heuston Station to Glasnevin via Phoenix Park Tunnel Branch Line (circa 4km).

DART+ South West will complete four tracking between Park West & Cherry Orchard Station and Heuston Station, in addition to re-signalling and electrification of the entire route. The completion of the four tracking will remove a significant existing constraint on the line (i.e., where four tracks reduce to two), which is currently limiting the number of train services that can operate on this route. DART+ South West will also deliver track improvements along the Phoenix Park Tunnel Branch Line, which will allow a greater number of trains to access the city centre.

Upon completion of DART+ South West electrification, new DART trains will be used on this railway corridor, similar to those currently operating on the Malahide / Howth to Bray / Greystones Line.

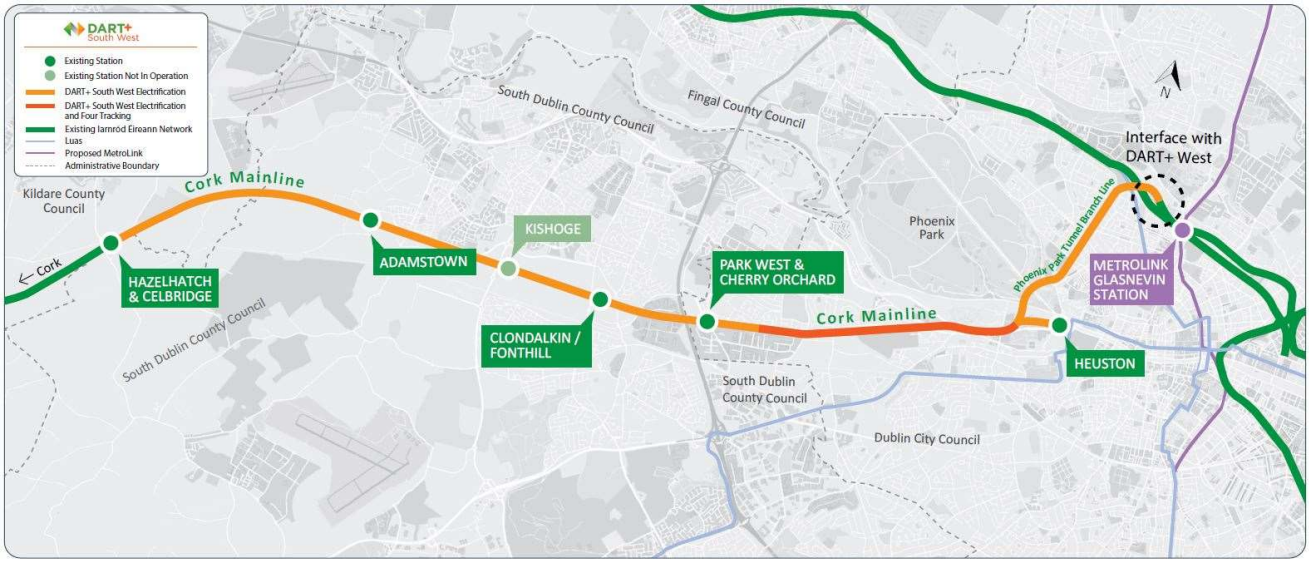

Figure 1-2 DART+ South West Route Map

1.4. Capacity increases associated with DART+ South West

DART+ South West will improve performance and increase train and passenger capacity on the route between Hazelhatch & Celbridge Station to Heuston Station and through the Phoenix Park Tunnel Branch Line to the City Centre, covering a distance of circa 20km. It will significantly increase train capacity from the current 12 trains per hour per direction to 23 trains per hour per direction (i.e. maintain the existing 12 services, with an additional 11 train services provided by DART+ South West). This will increase passenger capacity from the current peak capacity of approximately 5,000 passengers per hour per direction to approximately 20,000 passengers per hour per direction. Upon completion of the DART+ South West Project, train services will be increased according to passenger demand.

1.5. Key infrastructural elements of DART+ South West Project

The key elements of DART+ South West include:

- Completion of four-tracking from Park West & Cherry Orchard Station to Heuston Station, extending the works completed on the route in 2009.
- Electrification of the line from Hazelhatch & Celbridge Station to Heuston Station and also from Heuston Station to Glasnevin, via the Phoenix Park Tunnel Branch Line, where it will link with proposed DART+ West.
- Undertaking improvements / reconstructions of bridges to achieve vertical and horizontal clearances.
- Remove rail constraints along the Phoenix Park Tunnel Branch Line.
- Feasibility report and concept design for a potential new Heuston West Station.

The 'Emerging Preferred Option' will be compatible with the future stations at Kylemore and Cabra, although the construction of these stations is not part of the DART+ South West Project.

2. Design Standards

2.1. Design Codes, Standards, and Guidelines

2.1.1. Structural Design Standards

For the purposes of this report, an overbridge is defined as a bridge that allows vehicular traffic, pedestrians and / or cyclists, to pass over railway lines. An underbridge allows vehicular traffic, pedestrians and / or cyclists, to pass under railway lines. All bridges need to be designed in accordance with the codes and standards included in **Bridge Design Standards**.

Table 2-1 Bridge Design Standards

Document Number	Document Title	Version	Year
CCE-TMS-345	Engineering Requirements for Passenger Platforms and Barrow Paths	1.1	2019
CCE-TMS-389	Drawings Certification Process	1.0	2013
CCE-TMS-390	Preparation of Drawings	1.0	2013
CCE-TMS-399	Glossary of Civil and Permanent Way Engineering Terms	1.2	2013
CCE-TMS-410	Civil Engineering Structures Design Standard	1.1	2019
CCE-STR-PSD-005	Technical Approval for Civil Engineering Structures	1.0	2015
CME-TMS-327	Vehicle Gauging	1.0	2014
I-PWY-1101	Requirements for Track and Structures Clearances	1.1	2010
I-PWY-1136	Requirements for Design, Installation and Maintenance of Lineside Drainage	1.1	2010
PW1	Technical Standard PW1 Introduction to clearances	.03	2000
PW2	Technical Standard PW2 Platform clearances and clearances to bridge girders in the 'Platform Gauge Area'	.03	2000
PW3	Technical Standard PW3 Spacing of Lines - Lineside clearances (excluding platforms)	.04	2000
PW39	Technical Standard PW39 Passenger Platforms (including barrow paths)	.04	2000
PW4	Technical Standard PW4 Underclearances	.03	2000
PW5	Technical Standard PW5 Overhead Clearances	.03	2000
PW6	Technical Standard PW6 Line Loading and Construction Gauges. The Standard Structure Gauge	.03	2000
PW7	Technical Standard PW7 Electrification Clearances	.03	2000
PW80	Technical Standard PW80 Preparation of Drawings	.03	2000
Eurocode Design Suite	The Structural Eurocode suite and associated Irish National Annexes current in June 2020.	Various	
TII	TII Publications (Technical) - supersede previous DRMB standards	Various	

2.1.2. Rail Design Standards

All track modifications will be designed in accordance with the codes and standards included in **Table 2-2**.

Table 2-2 Rail Design Standards

Document Number	Document Title	Version	Year
CCE-TMS-340	Horizontal Curvature Design	1.0	2013
CCE-TMS-341	Vertical Curvature Design	1.0	2011
EN 13803-1	Track Alignment Design		2018
EN 13803-2	Abrupt Changes Curvature		2008
CCE-TMS-300	Track Construction Requirements and Tolerances	1.8	2020
CCE-TMS-321	Track Maintenance Requirements and Tolerances	2.10	2019
I-PWY-1101	Requirements for Track and Structures Clearances	1.1	2010
CME-TMS-327	Vehicle gauging	1.0	2014
CCE-TMS-345	Engineering Requirements for Passengers Platforms	1.1	2019
ITS-INF	Interoperability Technical Specification – Infrastructure		2019

2.1.3. Electrification Standards

The OHLE on the route is intended to comply with European Standards. The existing Irish Rail OHLE standards are undergoing an update process and in some cases are not yet aligned with the European Standards or the current project requirements. These requirements are captured in the draft Functional Requirements Specification for OHLE, which is being developed by the DART+ West designer (MDC).

Table 2-3 Electrification Standards

Document Number	Document Title	Version	Year
EN 50119	Railway applications — Fixed installations — Electric traction overhead contact lines	2020	2020
EN 50122-1	Railway applications — Fixed installations — Electrical safety, earthing and the return circuit Part 1: Protective provisions against electric shock	2011+A4:2017	2017
EN 50123-1	Railway applications - Fixed installations. D.C. switchgear. General	2003	2003
EN 50124-1	Railway applications - Insulation coordination Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment	2017	2017
EN 50124-2	Railway applications. Insulation coordination. Overvoltages and related protection	2017	2017
EN 50149	Railway applications. Fixed installations. Electric traction. Copper and copper alloy grooved contact wires.	2012	2012
EN 50182	Conductors for overhead lines. Round wire concentric lay stranded conductors.	2001	2001
EN 50317	Railway applications - Current collection systems - Requirements for and validation of measurements	2012	2012

Document Number	Document Title	Version	Year
	of the dynamic interaction between pantograph and overhead contact line.		
EN 50318	Railway applications - Current collection systems - Validation of simulation of the dynamic interaction between pantograph and overhead contact line	2018	2018
EN 50341-1	Overhead electrical lines exceeding AC 1 kV - Part 1: General requirements - Common specifications	2012	2012
EN 50345	Railway applications - Fixed installations - Electric traction - Insulating synthetic rope assemblies for support of overhead contact lines.	2009	2009
EN 50367	Railway applications. Current collection systems. Technical criteria for the interaction between pantograph and overhead line.	2020	2020
EN 50388	Railway Applications. Power supply and rolling stock. Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability.	2012	2012
ENE-TSI	Technical Specifications of Interoperability – Energy	2019	2019

2.1.4. Geotechnical Design Standards

Geotechnical design requirements for proposed or changes to existing assets such as embankments and cuttings, retaining walls and foundations, OHLE foundations etc shall be undertaken in accordance with Eurocode 7, as stated within CCE-TMS-410 Civil Engineering Structures Design Standard Version 1.1 (2019). Other aspects geotechnical design not covered by this design document or in Table 3 such as track bed investigation, design and formation treatments will be undertaken using the most current Network Rail Standards. The proposed standards to be used are outlined in **Table 2-4**.

Table 2-4 Geotechnical Design Standards

Document Number	Document Title	Version	Year
CCE-TMS-410	Civil Engineering Structures Design Standard	1.1	2019
IS EN 1997-1:2005:2015	Eurocode 7: Geotechnical Design Part 1	N/A	2005
IS EN 1997-1:2004/NA:2015	Irish Annex to Eurocode 7: Geotechnical Design	N/A	2015
NR/L2/TRK/4239	Track Bed Investigation, Design and Installation	N/A	2020
NR/SP/TRK/9039	Formation Treatments	N/A	2005

2.1.5. Road Design Standards

Historically the NRA Design Manual for Roads and Bridges were used for both Urban, Rural and National Roads. Since 2010 these have all been superseded by the Transport Infrastructure Ireland (TII) suite of Publications/Standards. As of 2019, 3No. key publications have become the main design reference documents for urban roads (incl. pedestrian and cycle infrastructure). Where the transport routes are classified as regional in nature (Con Colbert Road), a combination of TII and DMURS (Design Manual for Urban Roads and Streets) Standards will be used. The proposed standards to be used are outlined in **Table 2-5.**

Table 2-5 Roads Design Standards

Document Number	Document Title	Version	Year
N/A	Design Manual for Urban Roads and Streets - DMURS (DTTAS)	1.1	2019
Various Volumes	Traffic Signs Manual - TSM (TII)	August	2019
N/A	National Cycle Manual - NCM (NTA)	N/A	2011

Document Number	Document Title	Version	Year
Various	TII Publications (Technical) - Roads, Lighting, Drainage, Safety	Various	

2.2. Design Life

The design life of new civil engineering structures shall be in accordance with the requirements of I.S. EN 1990 or as otherwise detailed in Iarnród Éireann (IE) Infrastructure Technical Management Standards CCE-TMS-410 Civil Engineering Structures Design Standard, and replicated in **Table 2.6** for completeness.

The design life of existing civil engineering structure works shall be agreed with the Principal Engineer Structures.

Table 2-6 Design Life for new civil engineering structures (IE Standard CCE-TMS-410 version 1.1)

Structure	Design Working Life
Bridges	120 years
Un-reinforced embankments and cuttings	120 years
Embankments and cuttings incorporating gabions	60 years
Soil nails and anchors	120 years
Retaining walls	120 years
Lighting columns	60 years
OHLE structures	60 years
Platforms and loading banks	60 years
Gantries	60 years
Masts and towers	60 years

2.3. Horizontal Clearance

For overbridges, an adequate horizontal distance between railway tracks and bridge supports must be provided in order to control the risk arising from derailment. Bridge supports include abutments (at the ends of the bridge) and piers (at intermediate locations). The horizontal distance between a bridge support and the nearest railway track is referred to as horizontal clearance. The requirements for minimum horizontal clearance are defined in Irish Rail Standard I-PWY-1101 Requirements for Track and Structures Clearances. According to this standard, the minimum horizontal clearance is 4500 mm. However, where this clearance cannot be achieved, a minimum lower clearance of 2500 mm is permitted subject to the support being designed to resist notional impact forces.

Cognisance shall be taken regarding any proposed containment strategy to be included within this clearance envelope.

2.4. Vertical Clearance

For overbridges, an adequate vertical distance between railway tracks and the underside of the bridge deck (soffit) must be provided in order to safely accommodate the rail vehicles and the OHLE. This distance is known as vertical clearance and it is measured from the highest rail level.

The requirements for minimum vertical clearance are defined in Irish Rail Standard I-PWY-1101 Requirements for Track and Structures Clearances. According to this standard, the vertical clearance from the highest rail level to the soffit of all new overbridges must be a minimum of 5.3 m.

Where this vertical clearance cannot be achieved due to constraints imposed by the existing rail and / or road networks and / or existing utilities, and a lower vertical clearance is proposed, a CCE department derogation is required. Existing Irish Rail Technical Standard PW7 Electrification Clearances specifies electrification

clearances standards, but this has been superseded by the OHLE FRS and project requirements. As such, an in-house calculation model has been developed to determine the vertical clearance required for a given contact wire height and OHLE configuration. With this model, a vertical clearance to accommodate a 4.4m contact wire height is required. Where there is no practicable solution available to achieve the 4.4 m contact wire height a derogation will be sought through the IE internal process and agreed.

Additional tolerance will be considered in the design where it is practicable to do so.

2.5. Loading

2.5.1. General

Bridges will be designed to satisfy the requirements of I.S. EN 1990: Eurocode, Basis of structural design, I.S. EN 1991: Eurocode 1, Action on Structures, and the associated Irish National Annexes, together with the requirements set out in TII Standards (AM-STR-06026, AM-STR-06030, etc) and CCE-TMS-410 Civil Engineering Structures Design Standard.

Dead and superimposed dead loads will be based on the densities of materials given in I.S. EN 1991: Eurocode 1, Action on structures, Part 1-1 General actions - Densities, self-weight and imposed loads for buildings, and the associated Irish National Annex. All dead and superimposed dead loads affecting the structure at each stage of erection will be taken into account. The effects of the erection method of permanent materials will be considered and due allowance will be made for locked-in stresses.

The prestressing action acting on the structure will be determined in accordance to I.S. EN 1992-2: Eurocode 2, Design of concrete structures, Part 2 Concrete bridges - Design and detailing rules, and the associated Irish National Annex.

Live Load Surcharge loading will be based on the requirements of I.S. EN 1991: Eurocode 1, Action on structures, Part 2 Traffic loads on bridges, and the associated Irish National Annex.

2.5.2. Climatic Effects

Wind loads on bridge structures will be determined as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 1-4 General actions – Wind actions, and the associated Irish National Annex, or otherwise as detailed in the TII Standards.

Thermal Actions on bridge structures will be determined as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 1-4 General actions – Thermal actions, and the associated Irish National Annex.

Snow load is generally not included in the design of rail structures, however if required, snow loads will be determined in accordance with IS EN 1990: Basis of structural design for details, and the associated Irish National Annex.

2.5.3. Loading for Overbridges

Bridges carrying road traffic will be designed for road traffic loads as set out in I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges, and the associated Irish National Annex, or otherwise as detailed in the TII Standards.

Where overline electric traction passes beneath an overbridge, the load arising from breakage of the overhead lines will be taken into account. The tensile force exerted by a broken catenary will be considered in accordance with CCE-TMS-410 Civil Engineering Structures Design Standard.

Impact actions and derailment loading will be considered as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 1-7 General actions – Accidental actions, I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges, and the associated Irish National Annexes. The requirements for mitigation of risk for Class B structures as identified in I.S. EN 1991: Eurocode 1, Action on structures, Part 1-7 General actions – Accidental actions will be considered as satisfied provided a bridge substructure is located 4.5 m or more from the nearest running edge of a track.

For overbridges carrying loads which are outside the scope of IS EN 1991: Eurocode 1, Action on structures, i.e. light rail loading (LUAS) on Kylemore Road Bridge (OBC5A), advice from relevant authorities will be sought to define the individual requirements for definition and combination of loads. Definition and combination of loads will follow the principles of Eurocodes and will take into account the probability of simultaneous occurrence of different load components.

2.5.4. Loading for Underbridges

All underbridges shall be designed to withstand the effects of Load Model 71, with vertical static loads as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges. Each bridge must be designed for the greatest number of tracks geometrically and structurally possible in the most onerous effects of loading, irrespective of the position of existing tracks. The minimum distance between tracks shall be measured between running edges as detailed in Section 3.2 of I-PWY-1101 Requirements for Track and Structures Clearance.

The requirements for dynamic effects shall be assessed in accordance with I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges Section 6.4 and as amended by the Irish National Annex to Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges.

Centrifugal forces shall be considered as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges Section 6.5. Actions due to traction and braking shall be considered as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges Section 6.5.

Nosing force shall be considered as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges Section 6.5. Derailment actions shall be considered as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 1-7 General actions – Accidental Actions and I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges Section 6.7.

Road vehicle collision loads shall be considered as defined in I.S. EN 1991: Eurocode 1, Action on structures, Part 1-7 General actions – Accidental Actions and I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges or otherwise as detailed in the DMRB

2.5.5. Fatigue

Fatigue assessment will be carried out for all structural elements, which are subject to fluctuation in accordance with I.S. EN 1991: Eurocode 1, Action on structures, Part 2- Traffic loads on bridges and the associated Irish National Annex.

2.5.6. Parapets and Handrails

Parapets will be designed in accordance with the load requirements of TII Standard DN-REQ-03034 – The Design of Road Restraint Systems (Vehicle and Pedestrian) for Road Bridges. The specification and details will be in accordance with TII Standard GE-TBU-01019 - NRA TB 11 NRA TD 19 and Forgiving Roadsides, and IS EN 1317. Parapets will be a minimum of 1.8 m high with no handholds and will have a 45-degree symmetrical steeple coping.

3. Assumptions / Caveats

3.1. Electrification

All OHLE diagrams used in the Technical Reports are for visual information only. Final dimensions, lengths, heights and cantilever types are to be defined in the reference design and subsequent design stages of the project.

OHLE configuration through the overbridges for each track or civils option is being assessed..

3.2. Geotechnical

Geotechnical information on the superficial deposits, bedrock deposits and groundwater regime has been obtained from the following sources of information:

- Geological Survey Ireland (GSI) Online Quaternary and Bedrock Geology 1:100K Maps
- Historical ground investigations from a variety of sources within or close to the existing railway corridor.

In general, historical ground investigation summarised in the Technical Reports has been derived (mainly) from investigations outside the railway boundary. Limited historical ground investigation information is available within the railway boundary. It should be noted that site specific ground conditions within the railway corridor may be different to those encountered and reported outside the railway boundary.

Current geotechnical information within the Technical Reports related to specific Options may be subject to change upon receipt of location specific detailed ground investigation information from the upcoming 2021 ground investigation (between Hazelhatch and Glasnevin Junction) and receipt of detailed topographical survey information.

4. Options Selection Process

4.1. Introduction

A clearly defined appraisal methodology has been used in the selection of the end-to-end Emerging Preferred Route for the Project. Consistent with other NTA projects, it is based on '*Guidelines on a Common Appraisal Framework for Transport Projects and Programmes*' (CAF) published by the Department of Transport, Tourism, and Sport (DTTAS), March 2016 (updated 2020), TII's *Project Management Guidelines* (TII PMG 2019) and Iarnród Éireann's *Project Approval Guidelines*. The process comprises of a two-stage approach (if / as appropriate):

- **Stage 1** – Preliminary Assessment (Sifting); and
- **Stage 2** – Multi-Criteria Analysis (MCA).

While applying the broad principles of the CAF, when it comes to exploring different options to achieve the identified Project objectives and requirements, the methodology has regard to the fact that DART+ South West Project involves an existing operational rail line running in a pre-defined corridor. Unlike other transport projects there are no / limited route options and spatial variables for the improvement works and interventions required to meet the Project objectives and requirements. For this reason, the options are:

a) focused on particular locations, and

b) include technical design considerations.

A summary of the proposed methodology is illustrated in **Figure 4-1**. The focus at this time is on the process up to Public Consultation No. 1.

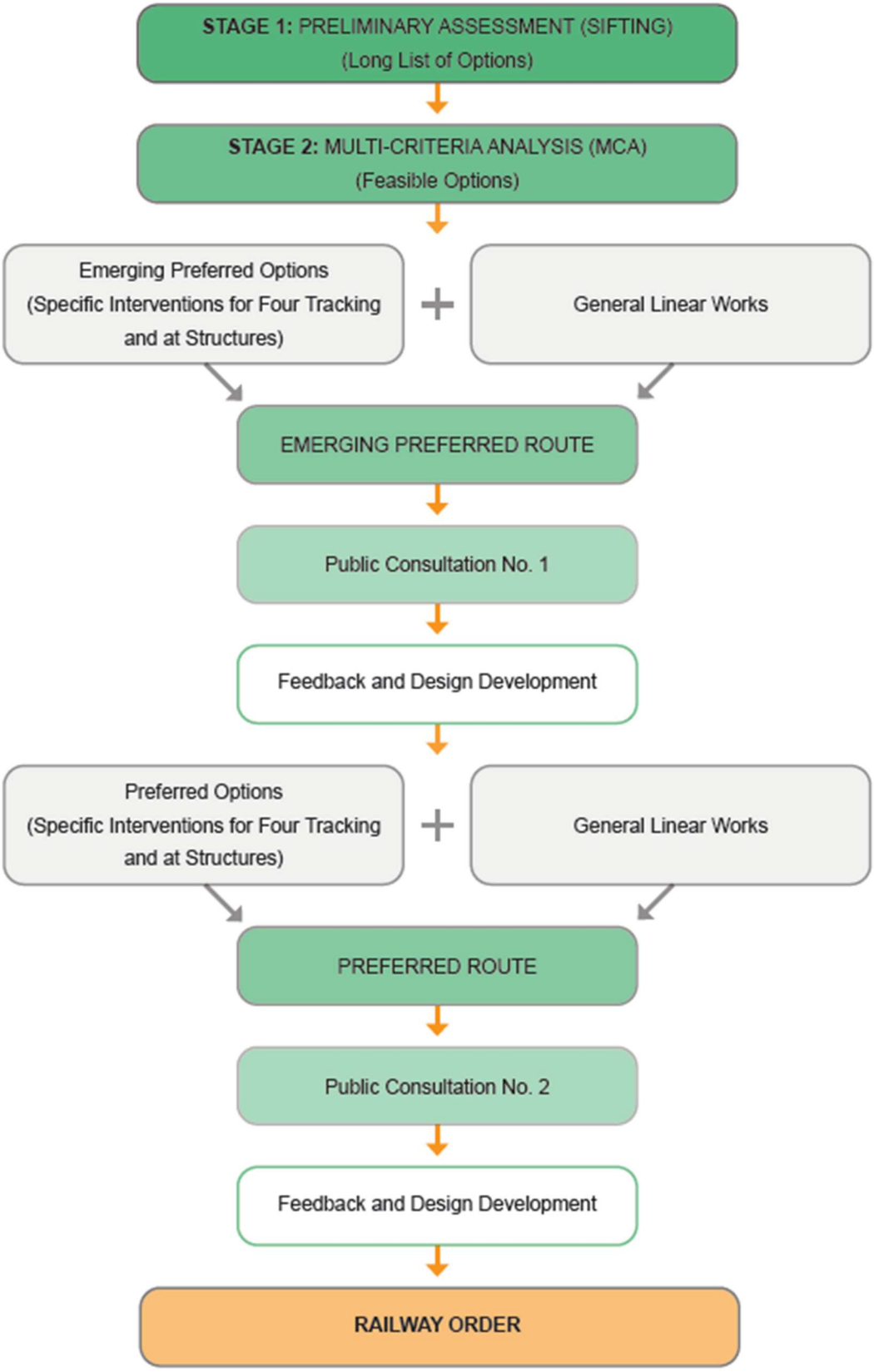

Figure 4-1 Option Selection Methodology

4.2. The Options to be Assessed

Many elements of the Project (or works and interventions needed) require option assessment at a local level prior to incorporation into the end-to-end Emerging Preferred Route for the Project. The options for particular interventions e.g., at a bridge location, need to be considered holistically because of the knock-on implications both within the rail corridor and outside of the rail corridor in terms of track alignment, road levels, other bridges etc.

The options presented for assessment include:

- A Do-Nothing Option. This option describes what is likely to occur in the absence of works and interventions needed to meet the Project objectives and requirements. In the case of the DART+ South West Project, this would include no four-tracking and no electrification.
- A Do-Minimum Option. This option describes the least burdensome option to maintain an intervention. For the DART+ South West Project, it is the option where the works and interventions that are needed to meet the Project objectives and requirements can generally be met within the existing rail corridor, minimising the potential for new or additional impacts on the receiving environment. Do-Minimum in this context is not passive, as some level of works and intervention is necessary to meet the Project objectives and requirements, albeit the least burdensome.
- Do-Something Option(s): These options are available to address the objective of the intervention (i.e., the Project objectives and requirements). In the case of the DART+ South West Project, these options involve interventions and related works that are required beyond the existing railway corridor.

4.3. Starting Principle

The starting principle for the Project is to accommodate the works and interventions needed to meet the Project objectives and requirements within the existing rail corridor. In many cases this 'Do-Minimum Option' is technically feasible and will be the Emerging Preferred Option for the particular element of the Project / intervention required. However, in some cases it is not technically feasible. These cases that are the focus of more extensive options assessment. The methodology is as follows:

- If the 'Do-Minimum' option is feasible and meets the Project objectives / requirements, it is the Emerging Preferred Option in respect of the intervention required. Stage 2 MCA is not necessary.
- If the 'Do-Minimum' option is not feasible and/or does not meet the Project objectives / requirements, other options are brought forward for detailed assessment as part of the Stage 2 MCA in order to identify the Emerging Preferred Option in respect of the intervention required.
- In some instances, while the 'Do-Minimum' option is preferred and considered likely, verification is required, and therefore other options remain open and are presented for information. However, they will not be brought forward for detailed assessment (including Stage 2 MCA, where appropriate) unless the 'Do-Minimum' option is determined not to be feasible.

4.4. Stage 1: Preliminary Assessment (Sifting) Methodology

In keeping with principles of the CAF Preliminary Appraisal approach, the purpose of Stage 1: Preliminary Assessment (Sifting) is to subject a range of options to a preliminary appraisal, before subjecting a smaller number of options to a more detailed Stage 2: Multi-Criteria Analysis (MCA). For the DART+ South West Project,

the key sifting criteria was whether an option was 'Feasible' and met the Project objectives and requirements. Feasibility refers to whether the option can or cannot be done (is technically deliverable or not) and Project objectives / requirements are specific for a particular element or area along the rail corridor.

4.4.1. Long List of Options

Stage 1: Preliminary Assessment (Sifting Process) commenced with the Project Team identifying a long list of high-level options for the key elements of the scheme. This list included: a "Do-Nothing" Option (as described previously); a "Do-Minimum" Option (depending on the specific requirements for the particular element); and "Do-Something" Option(s) where interventions and related works are required beyond the existing railway corridor in order to meet the Project objectives and requirements.

Both the 'Do-Minimum' option and 'Do-Something' options are capable of different technical variations. These variations will be considered in detail as the Project moves towards the Preferred Option (to be presented at Public Consultation No. 2 (PC2)) and Reference Design (which provides the basis of the Railway Order application).

4.4.2. Sifting

Consistent with CAF, the headline criteria which the options were assessed against the criteria of Engineering; Environment; and Economy.

Of these, the key 'pass' or 'fail' criteria was Engineering and whether an option was 'Feasible' and met the Project objectives and requirements.

Given the interventions are constrained geographically, a pass/fail approach for Environment was not considered suitable at sifting stage. Rather the approach applied was to consider and raise key environmental issues during the Stage 1 process but not discount any option solely on environment criteria.

It was also considered unsuitable to apply a pass/fail approach to Economy at Stage 1. The only exception was where the option clearly runs counter to policy goals and objectives set by the political and administrative processes (this is consistent with the CAF objectives-led approach to economic appraisal). Key Economy issues were therefore identified but were not used to discount any option solely on economy criteria.

This approach only brought forward feasible options to be explored at Stage 2 in greater detail.

4.4.2.1. Feasibility

Feasibility refers to whether the option can or cannot be done (is technically deliverable or not). The sub-criteria for determining this, identified by the Design Disciplines within the Project Team, were:

Constructability

Pass/Fail was determined by the fact that the construction process needed to get to the finished stage might not have been feasible or required unacceptable impact, regardless of the capacity of the site to accommodate the option.

Geometrical fitness for intervention

Pass/Fail was determined by the physical capacity of the site to accommodate the finished option or the requirement (for example, a Fail status was declared for an option that intended to accommodate four tracks beneath an existing narrow bridge).

Safety

Pass/Fail was determined by the physical capacity of the site to accommodate the finished option or the requirement (for example, a Fail status was be declared for an option that intended to accommodate four tracks beneath an existing narrow bridge).

4.4.2.2. Project Objectives and Requirements

Project objectives and requirements apply the overarching objectives and scope of the Project to specific elements of the Project and areas along the route. These include:

Four-tracking

This requirement focuses on horizontal clearance for four-tracking both along the rail corridor between Park West & Cherry Orchard and Heuston and under existing bridges (it does not apply to the Phoenix Park Tunnel Branch Line).

Electrification of tracks

It is a project requirement to provide an electrification system that is the same as that to be deployed for the DART+ West Project. A standardised approach to electrification will be adopted. This requirement focuses on vertical clearance for OHLE.

Track alignment and drainage (standards)

Compliance with existing standards for track alignment and drainage (avoidance of low points) is mandatory, which eliminates options that cannot accommodate the requirements of the design standards.

Maintain current functionality of roads

Road design standards (as required by TII and the DMURS) require a maximum of 3% gradient for the first 15m of road at junctions. This constrains the levels that can be used for rail bridges that interact with the road network.

Fundamentally, given the Project is focused on an existing railway line and the interventions required are very localised; detailed design considerations (such as road design standards) have a direct bearing on the feasibility or otherwise of particular options.

4.4.3. Sifting Findings

The sifting of options occurred during a multi-disciplinary workshop. Options which failed to meet the necessary Engineering Feasibility and Project Requirements were discounted. Options which met the necessary Engineering Feasibility and Project Requirements were brought forward to Stage 2: MCA for detailed assessment. In some instances, verification is required, and therefore options remain open.

Following the Phase 1: Sifting, the Design Team developed the feasible options for presentation and consideration by a multi-disciplinary team in the next stage of the optioneering process.

4.5. Stage 2: MCA Methodology

Stage 2 of the optioneering process comprises a detailed multi-disciplinary comparative analysis of those feasible options that passed through Stage 1: Preliminary Sifting. The options are assessed against the criteria of Economy, Safety, Environment, Accessibility and Social Inclusion, Integration and Physical Activity in line with the criteria required for multi-criteria analysis in the CAF guidelines. These parameters were split into a number of sub-criteria considered relevant to the DART+ South West Project.

The CAF parameters, criteria and considerations for comparative analysis are set out in **Table 4-1**. These include qualitative and quantitative indices.

The assessment was informed by general arrangement drawings focusing on detailed design aspects for the feasible options (bridges, roads, and rail corridor / permanent way). The arrangement drawings were used to identify a spatial envelope for each option including the likely extent of permanent and temporary works required. The spatial envelope and GIS software was used to collate, map and analyse information in relation to environmental and other data sets to assist the specialists in undertaking the Stage 2: MCA.

The key environmental data / constraints are available in Technical Appendices Volume 2.2 Environmental Constraints Reporting. This baseline data informed the baseline characteristics of the environmental topic / CAF sub criteria under consideration. It, inter alia, identified areas or sites with specific statutory protection, which are recognised as important and / or sensitive from a planning and environmental perspective e.g., European and National designated sites, Protected Views, Record of Protected Structures etc.

Relevant considerations include:

- The assessment is a comparative analysis between options presented, not an impact assessment of each option. The impact from the Emerging Preferred Option will be assessed in the Environmental Impact Assessment Report in the next phase of the development.
- Not all sub-criteria may be relevant in every case. Those that are relevant to the assessment, i.e., that have differentiated options, are highlighted in the narrative.
- For each option there are potential design variations. In due course design variations will be subject to detailed technical analysis (in respect of the Emerging Preferred Option).
- For each option an indicative envelope was identified for the extent of permanent works required; a worst-case scenario was considered. The extent of temporary works was also considered. Further work including detailed design and technical and construction related solutions will seek to minimise land take in respect of the Emerging Preferred Option.
- The envelope around each option was used to spatially represent environmental constraints within / proximate to the options.
- There are direct and indirect effects associated with either or both the construction and operational activities (including maintenance) associated with the options. These are highlighted where relevant, and in particular where they have differentiated options under particular sub-criteria.
- The changes in land use are considered under the planning policy consideration under the CAF Integration criteria (specifically Land Use Integration).
- The changes in traffic and associated impacts on the 'economy' are addressed under the CAF Economic criteria (specifically Traffic functionality and associated economic activities and opportunities) and are not duplicated as part of the Environment Assessment.

Table 4-1 CAF Parameters, Criteria and Considerations for Comparative Analysis

CAF Parameters	Criteria	Basis for Comparative Analysis	Qualitative and/or Quantitative Considerations (as appropriate)
1. Economy - The impacts of a transport investment on economic growth and competitiveness.	Capital Expenditure (CAPEX): construction, land acquisition, temporary works.	This sub-criterion considered cost of construction, land cost and temporary works cost of each option. A high-level cost estimate was prepared for each option (including potential land acquisitions (permanent and temporary, zoned or un-zoned land). The lowest cost option was preferable to higher cost options.	Estimated high level cost of construction of option. Extent and type of 3rd party lands required permanently. Extent and type of 3rd party lands required temporarily for temporary works during construction (where known).
	OPEX: operational costs (IE or other entities), Technology advancement and future proofing / obsolescence	This sub-criterion considered long term maintenance costs. The option with less risk for long term maintenance issues (and hence cost) was preferable to options with greater risk of long-term maintenance issues.	Estimated risk of maintenance cost associated with the improvement or deterioration of the conditions of the line (OHLE special solutions, track and structures maintenance, flooding management and pumping requirements).c Structure type e.g., steel v concrete structures (concrete structures being preferable to steel in the context of electrified railways as they require less clearance above the catenary infrastructure).

CAF Parameters	Criteria	Basis for Comparative Analysis	Qualitative and/or Quantitative Considerations (as appropriate)
	Train Operations Functionality/Economic Benefit	The option which resulted in a lower risk of interruption was preferable to options with a higher risk on operations.	Potential improvement or deterioration of the operating conditions of the line (reduction or increase of the risk of interruption of service).
	Traffic functionality and associated economic activities and opportunities.	The option with shorter traffic disruption/diversions was preferable to options with longer disruption/diversions.	Potential benefit to vehicular traffic flows in the vicinity of the works during construction and associated economic activities and opportunities in the vicinity. Consideration of duration of traffic disruption and length of diversions.
	Urban regeneration	The option with greater potential to contribute to future urban regeneration was preferable.	Potential contribution to future urban regeneration [i.e. the extent to which an option provides / supports opportunity for regeneration - such as an improved urban environment, better employment opportunity and social facilities."
2. Integration - the extent to which the options being evaluated promotes integration with other transportation	Transport integration	The option which maximised integration with other existing and proposed transportation networks, infrastructure and services was preferable to other options.	Scope for and ease of interchange between modes. New interchange nodes and facilities.

CAF Parameters	Criteria	Basis for Comparative Analysis	Qualitative and/or Quantitative Considerations (as appropriate)
networks and infrastructure and is compatible with Government policies, including national and local planning policy			Reduced walking and wait times associated with interchanges. Integration with the cycle network (existing and proposed). Modal shift figures during construction and operations. Changes to journey times to transport nodes. Impact on the operation of other transport services both during construction and in operation stage.
	Land use integration	The option with greater consistency and compliance with planning policy was preferable to others.	Consistency with land use strategies, regional and local plans including: NPF EMRA RESES / MASP Dublin City Development Plan 2022 Other CDP's where relevant Consistency with local land use policies and objectives (zoning) Changing character of area (future urban regeneration proposals, extant planning permission

CAF Parameters	Criteria	Basis for Comparative Analysis	Qualitative and/or Quantitative Considerations (as appropriate)
			etc).
	Geographical Integration	The option which minimise disruption and accessibility during construction was preferable.	Potential to impact on external links during construction. Potential to impact on external links during operation. Consideration for any community severance impacts.
	Other government policy	The option with greater consistency and compliance with other government policy was preferable to others.	Integration with Government Policy, Smarter Travel, Investment Programmes, Climate Action Plan etc.
	Adaptability in the future (robustness in the solution)	The option with greater adaptability for the future was preferable to others.	Ability to continue to function successfully despite future changes in circumstances
3. Environment - considers impacts, such as emissions to air, noise, and ecological and architectural impacts.	Noise and Vibration	The Option which minimises potential effects on the environmental factor under consideration was preferable to other options.	Based on the professional judgement of specialists qualified in the specialist areas taking into consideration sensitivity of the sub-criteria and the significance of the likely effect, and in
	Air quality and Climate		
	Landscape and Visual		
	Biodiversity (flora and fauna)		
	Cultural Heritage, archaeological and architectural heritage		

CAF Parameters	Criteria	Basis for Comparative Analysis	Qualitative and/or Quantitative Considerations (as appropriate)
	Water resources		general terms whether potential effects can be mitigated.
	Agricultural and non-agricultural		
	Geology and soils (including waste)		
4. Accessibility and Social Inclusion - considers social deprivation, geographic isolation and mobility and sensory deprivation	Impact on Vulnerable Groups / Residents	The option which provided a higher degree of accessibility and safety for vulnerable groups was preferable.	Enhanced facilities for vulnerable road users (enhanced pedestrian facilities) on roadways and across bridges. Improving connectivity between hubs. Avoiding severance to all groups during construction. Minimising length of diversions.
	Accessibility (station) – where relevant	The option which provided the best accessibility to the station was preferable.	
	Accessibility (bridge)	The option which minimised severance across bridges was preferable.	
	Social inclusion	The option which provided a higher degree of accessibility and connectivity for vulnerable groups was preferable.	
5. Safety - Safety is concerned with the impact of the investment on the number of transport related accidents.	Rail Safety	The option which provided the best rail safety solution was preferable.	Improvement of the track alignment Manageable acceptable conditions of the structures above, below and alongside the railway. Manageable acceptable conditions for safe operation of the Inchicore Works area Maximised electrical clearances for OHLE

CAF Parameters	Criteria	Basis for Comparative Analysis	Qualitative and/or Quantitative Considerations (as appropriate)
			to third party neighbours Minimised requirement for vegetation management activities
	Vehicular Traffic Safety	The option which provides the best vehicular safety solution was preferable.	Vertical and Horizontal Alignment within the standard parameters. Improvement of existing road network. Pedestrian safety improvements (inclusion of adequate footpaths, formalised crossing points and desire lines). High quality cycle facilities and connectivity to existing cycle facilities. Safer environment for vulnerable road users (inclusion of tactile paving and other safety elements) Potential to improve personal sense of security
	Pedestrians, cyclists, road users and neighbour's safety	The option which provides the best safety solution for vulnerable road users was preferable. The focus is on operational phase not construction.	
6. Physical Activity - (where applicable) This relates to the health benefits derived from using different transport modes	Connectivity to adjoining cycling and walking facilities	The option that provided better connectivity between trip generators (green areas / key attractions) and that promoted physical activity was preferable. The focus is on operational phase not construction.	Connectivity to adjoining cycling and pedestrian facilities

CAF Parameters	Criteria	Basis for Comparative Analysis	Qualitative and/or Quantitative Considerations (as appropriate)
	Permeability and local connectivity	The option that provided better connectivity between trip generators and that promoted physical activity was preferable. The focus is on operational phase not construction.	Enhanced connectivity between key attractions / trip generators related to active mode (e.g. parks, tourism destinations). Diversions, duration and impact on journey times and potential to create a negative modal shift (e.g., people opt to drive instead of walk or cycle)

The next step involved assessing the performance of each option against relevant quantitative and qualitative indicators. Presented in a matrix format, each specialist included a commentary of their analysis for each option.

All disciplines then came together at a workshop to compare the options relative to each other based on whether an option had 'some' (see note) or 'significant' advantage or disadvantage over other options or whether all options were 'comparable / neutral'. The basis for comparative analysis is identified in the Table 3.2. This basis of comparison is consistent with the CAF Guidelines which uses a five-point ranking scale when comparing options against each other for comparative analysis.

Note: Some or Slight are used interchangeably in supporting documentation.

Table 4-2 Comparison Findings

Comparison Criteria Legend
Significant Comparative Disadvantage over Other Options
Some Comparative Disadvantage over Other Options
Comparable to Other Options / Neutral
Some Comparative Advantage over Other Options
Significant Comparative Advantage over Other Options

Criteria were then considered and aggregated to give a summary finding for each CAF criteria. The summary findings for all five CAF parameters were then considered and aggregated to determine the Emerging Preferred Option in respect of the particular option.

4.5.1. Observations on Optioneering Process

After completing the Stage 1 Preliminary Assessment (Sifting) it was noted that there was a distinct choice in routing and/or spatial variation in the options for around Inchicore and South Circular Road Junction, which would lend themselves well to the MCA process. However, in respect of other areas (i.e. Le Fanu Road Bridge (OBC7), Kylemore Road Bridge (OBC5A) and Memorial Road Bridge (OBC3)) the spatial difference in the feasible options was much less clear. In these cases, only two feasible options progressed through the Stage 1 Preliminary Assessment (Sifting) process and the differences between the options were focused on technical design matters.

Notwithstanding this, the options were reviewed by a range of specialists undertaking the Stage 2: MCA. The observations of the findings of the Stage 1 Preliminary Assessment (Sifting) for Le Fanu Road Bridge (OBC7), Kylemore Road Bridge (OBC5A) and Memorial Road Bridge (OBC3) were confirmed when the specialists could not discern a noticeable difference between the two feasible options across a wide range of sub-criteria and assessed the two options as '*comparable / neutral*'.

In order to streamline and simplify the reporting of results, it was considered appropriate at this stage (i.e., after the Stage 2: MCA process), to combine the two feasible options at each of these locations into a single option which would be the Emerging Preferred Option. The detailed technical design differences between the options remaining a potential design variation and /or comparator to be further explored through the future design process.

Project development and optioneering is an iterative process. The fact that the Stage 2: MCA process could not differentiate between the two feasible options does not undermine the value of the process itself. Rather it reinforces the particular characteristics of the DART+ South West Project that requires, amongst other things, very localised technical interventions along an existing rail corridor.

4.6. Emerging Preferred End-to-End Route

The various Emerging Preferred Options in respect of particular elements or interventions were then combined with general linear works needed to upgrade and modernise the railway to make up the end-to-end 'Emerging Preferred Route'.

End-to-End considerations were factored into the option development and assessment process and will continue to inform the project development process, including:

- The phasing of the bridge replacement works will take into consideration the need to keep reasonable levels of traffic. At this moment, it is not envisaged to work simultaneously on more than one bridge at any one time, however the fundamental principle is that works on specific locations will take into consideration the wider impact in order to keep it at reasonable levels.
- Likewise, a number of utilities ducts and mains are associated with the bridges. When a bridge is reconstructed, due consideration will be given to the need to keep these services in operation during construction, either by ensuring that the timing is compatible with alternative back feeding, or doing the necessary arrangements to make such back feeding work, or by providing temporary diversions as required.
- Electrical connections to electrically feed substations from ESB networks will need to be developed. These are currently being analysed with ESB.

The end-to-end Emerging Preferred Option is presented for the purposes of ongoing technical and environmental analysis, as well as consultation and engagement with the public and potentially affected property owners. In this regard, it will continue to be analysed and recalibrated based on public consultation feedback. This ongoing work will inform the 'Preferred Route' which will be published as part of Public Consultation No.2 (PC2) when additional surveys and assessments have been completed.