DART+ Coastal North

Public Consultation No.2

Annex 3.2E: OHLE Bridge Clearance Works Reports and Drawings

NTA Údarás Náisiúnta Iompair National Transport Authority

Rialtas na hÉireann Government of Ireland | Tionscadal Éireann Project Ireland 2040

Iarnród Éireann Irish Rail

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ABBREVIATIONS

Abbreviation	Definition
CAF	Common assessment framework
CCE	Chief Civil Engineer
CWH	Contact Wire Height
DC	Direct Current
EC	Electrical Case
FRS	Functional Requirements Specification
IÉ	Iarnród Éireann
MCA	Multi-criteria analysis
NIAH	National Inventory of Architectural Heritage
OHLE	Overhead line equipment
OLE	Overhead line electrification
SET	Signalling, electrification and telecoms
SH	Structural Height
ToR	Top of rail
TSS	Train Service Specification

1. INTRODUCTION

This report provides an update to the technical assessment of the overbridges between Malahide and Drogheda that was developed during Phase 2 (Concept, Feasibility and Options) to give a justification for why particular overbridges require clearance improvement works in order to facilitate feasible OHLE arrangements compliant with the minimum contact wire height and required electrical clearances, considering the allowances and tolerances given in the DART+ Electricity Functional Requirement Specification System-Wide (MAY-MDC-ELE-DART-SP-E-0002).

Sufficient clearance must be achieved at overbridges such that overhead wires can be placed at the correct height for future electrified trains' pantographs, along with provision of necessary allowances for tolerance, adjustment and electrical isolation.

From an OHLE point of view, various equipment arrangements exist and are selected based upon a hierarchy of preference from a systems perspective and the current available bridge clearance. Selection of the electrical case is a purely technical exercise and not subject to a multi-criteria analysis (MCA) process. It is deemed that an electrical-only solution is always the most preferable option wherever this is not a derogation from standards due to insufficient bridge soffit height. Should an electrical-only solution not be possible, other design options are explored – see section 6.2.

This document should be read in conjunction with the other reports which describe the electrification package of work - see Table 1-1.

Table 1-1: List of key documents associated with Electrification of the Northern Line from Malahide to Drogheda

Annex	Section	Title
3.2	A	OHLE system
	B	OHLE foundation solutions
	C	OHLE support solutions at underbridges
	D	Bridge parapet modifications for OHLE
	E	OHLE Bridge Clearance works
	E1	OBB39 Option Selection Report
	E2	OBB44 Option Selection Report
	E3	OBB55 Option Selection Report
	E4	OBB78 Option Selection Report
	E5	OBB80/80A/80B Option Selection Report
	E6	OBB81 Option Selection Report
	F	Traction Power Supply
	G	User worked level crossing south of Donabate
	H	Fencing and lineside safety
	I	Drogheda Station Canopies

2. EXISTING SITUATION

2.1 Overview

As part of the DART+ Coastal project, the Northern Line between Malahide and Drogheda is to be electrified with 1.5kV DC overhead line electrification. The OHLE foundation solutions report (Annex 3.2: Section B) provides a general overview of ground conditions. Factors for bridge-specific locations are listed within the relevant sections of this report.

2.2 Structures

There are 30 overbridges along the length of track which is to be electrified between Malahide and Drogheda and one additional proposed overbridge is also planned. The existing overbridges are, generally, historic structures and hence were constructed without cognisance of necessary clearances for OHLE.

For an overview of the bridge locations, please refer to Annex 1: Schematic Drawings.

A summary of the criteria relevant to the bridge clearance works is provided in Table 2-1 below. It should be noted that clearances and widths are shown in bold, where confirmed by survey. Other approximate dimensional information has been provided by IÉ. Clearances stated are measured from top of rail (ToR) to bridge soffit.

Table 2-1: Relevant information for clearance works to existing overbridges between Malahide and Drogheda

Overbridge	Name	Approx. Location		Function	Arch	Station	Clearance (ToR - Soffit) [1] (mm)	Approx. Width (m)
		Miles	Yards					
OBB32A	DONABATE BYPASS (CLONBURRIS BRIDGE)	11	0	Road	No	No	~ 5800	23.0
OBB32B	PEDESTRIAN CYCLE BRIDGE	-	-	Footbridge	No	No	~ 6000	5.6
OBB33	DONABATE STATION ROADBRIDGE	11	727	Road	No	Yes	~5000	12.2
OBB33A	DONABATE FOOTBRIDGE	11	784	Footbridge	No	Yes	~5100	2.2
OBB35	BEAVERSTOWN GOLF CLUB	12	445	Road	No	No	**4740**	4.5
OBB38	ROGERSTOWN LANE	13	999	Road	Yes	No	~5020	4.6
OBB38A	RUSH & LUSK FOOTBRIDGE	13	1564	Footbridge	No	Yes	~5200	3.0
OBB39	RUSH & LUSK ROADBRIDGE	13	1644	Road	No	Yes	**4775**	10.7
OBB41	KINGSTOWN/PUBLIC ROAD	14	438	Road	No	No	**4700**	6.9
OBB44	TYRRELSTOWN/PUBLIC ROAD	14	1437	Road	No	No	**4585**	7.4

Overbridge	Name	Approx. Location		Function	Arch	Station	Clearance (ToR - Soffit) [1] (mm)	Approx. Width (m)
		Miles	Yards					
OBB45	HJ2DA	15	856	Road	No	No	**4715**	4.8
OBB46	BALDONGAN	16	172	Road	No	No	~4860	7.1
OBB47	SKERRIES GOLF CLUB	16	1038	Road	Yes	No	**4900**	5.1
OBB49	GOLF LINKS RD SKERRIES	17	524	Road	No	No	**4690**	8.1
OBB51A	SKERRIES FOOTBRIDGE	17	1708	Footbridge	No	Yes	**4815**	2.6
OBB54	LADIES STAIRS	19	1440	Footbridge	No	No	~5100	2.5
OBB55	COUNTY BRIDGE/PUBLIC ROAD	21	304	Road	No	No	**4590**	11.5
OBB57A	BALBRIGGAN FOOTBRIDGE	21	1328	Footbridge	No	Yes	**4775**	2.4
OBB62	FRANKINS/OCCUPATION ROAD	22	1573	Road	No	No	~4880	7.9
OBB63	FILGATE'S/OCCUPATION ROAD	23	866	Road	No	No	**4735**	4.9
OBB66	GORMANSTON STATION ROADBRIDGE	24	19	Road	No	Yes	**4880**	4.5

Overbridge	Name	Approx. Location		Function	Arch	Station	Clearance (ToR - Soffit) [1] (mm)	Approx. Width (m)
		Miles	Yards					
OBB66A (TBC)	GORMANSTON STATION NEW FOOTBRIDGE						~5270	2.5
OBB68	IRISHTOWN/PUBLIC ROAD	24	1757	Road	No	No	**4920**	6.6
OBB74A	LAYTOWN FOOTBRIDGE	27	186	Footbridge	No	Yes	~5100	2.8
OBB77	PILTOWN/COLP EAST	29	1452	Road	No	No	~4850	8.2
OBB78	COLPE BRIDGE/PUBLIC ROAD	30	233	Road	No	No	**4680**	17.5
OBB80A	MCGRATH'S LANE DROGHEDA	31	758	Road	Yes	No	**4205**	6.9
OBB80	MCGRATH'S LANE DROGHEDA	31	869	Road	Yes	No	**4300**	6.6
OBB80B	MCGRATH'S LANE DROGHEDA	31	871	Road	No	No	**4910**	7.2
OBB81	MacBRIDE STATION	31	1259	Footbridge	No	Yes	**4465**	2.8
OBB81C	MacBRIDE STATION	31	1262	Footbridge	No	Yes	**5800**	4.4

Notes:

1) Vertical clearance heights were initially based on information received from IÉ, based on field measurements. The heights based on this information include an approximate sign (~) in front of them in the table. Bridge specific topographical surveys were undertaken on bridges identified as having a low clearance. The results from these surveys are shown in bold.

2) Bridge specific topographical surveys were undertaken on bridges identified as having a low clearance, therefore lateral clearance has been determined from that survey for these bridges. In these cases, pantograph gauge and OHLE wire and supports (where applicable) have been included in the overbridge cross sections obtained from the survey to check the lateral clearance for OHLE wires. For flat overbridges, the lateral clearance is not a limiting factor for the OHLE solution (contact wire and catenary wires) through the bridges, so it is considered that it will also not be a limiting factor for the overbridges which do not have the survey currently available. Furthermore, assessment of installation of parallel feeder wires through the overbridges is being developed. According to the DART+ Electricity Functional Specifications System-Wide document they are preferably installed aerially supported on the OHLE structures. However, when this is not possible because of the available clearance of the overbridge, it will be passed to an isolated cable and clamped to the structure or by any other means or buried.

2.3 Permanent Way

Generally, at all overbridge locations there are two tracks which are continuous welded rail on ballast. The exception is at Drogheda Depot and OBB80 at Drogheda Station.

2.4 Other Railway Facilities

Seven stations exist along the route to be electrified. These are as follows:

- Donabate: Platforms 1 and 2
- Rush & Lusk: Platforms 1 and 2
- Skerries: Platforms 1 and 2
- Balbriggan: Platforms 1 and 2
- Gormanston: Platforms 1 and 2
- Laytown: Platforms 1 and 2
- Drogheda MacBride: Platforms 1,2 and 3

Where overbridges are adjacent to or within station platforms, the OHLE wire height needs to be cognisant of the requirements to have increased separation between the public and electrical equipment.

2.5 Utilities

There are extensive utility networks in the area surrounding the railway, particularly in the urban areas through which it passes. Service providers with network assets in the area, from whom records have been obtained, include:

- Gas Networks Ireland;
- Irish Water (Water Supply);
- Irish Water (Foul Water Sewers);

- Dublin City Council (Storm Water Sewers);
- Fingal County Council (Storm Water Sewers);
- ESB Networks – Low, Medium and High Voltage Networks;
- EirGrid
- Eir;
- BT Ireland;
- Irish Rail - Lineside cables parallel to the railway line.

Utility service records have been obtained from all providers in the area. Most services are located within the existing road network surrounding the railway, and in bridge and underpass crossings of the railway. There are also lineside services running parallel to the railway and some major utilities crossing perpendicularly under the railway. All records should be considered indicative only and must be verified prior to any intrusive works occurring.

The records indicate that there are services at track level or within the railway corridor. These include Irish Rail lineside cables, Eir telecoms cables and BT telecoms cables running parallel to the railway from Malahide to Drogheda.

There are several railway overbridges that have utilities located within them. These are as follows:

- OBB33 at Donabate Station contains underground telecommunications.
- OBB39 at Rush & Lusk Station contains underground telecommunications.
- OBB55 at the R127 road contains underground medium voltage electrical, telecommunications and a 125mm diameter medium pressure gas main.
- OBB78 at the L1611 road contains underground telecommunications and a 180mm diameter medium pressure gas main.

3. REQUIREMENTS

The main project requirements relevant to this report subsection are as follows:

- Electrification of the line from the end of the current electrified section at Malahide to Drogheda with 1500V DC overhead;
- Undertake necessary infrastructure change to achieve the clearances required for electrification at bridges and structures;
- Undertake safety improvements resulting from the introduction of 1500V DC overhead.

3.1 Specific Requirements

In achieving the clearances required for electrification at bridges and structures, a predefined approach for electrical clearance design has been adopted as per DART+ Electricity Functional Specifications System-Wide (MAY-MDC-ELE-DART-SP-E-0002) Section 5.6.7. This lists relevant electrical equipment configurations and their hierarchy for adoption and is explained further in section 5.1 of this report.

3.2 Systems Infrastructure and Integration

Integration with the signalling system needs to be considered, as well as integration with other electrical cables including OHLE feeder cables though the bridge structure.

3.3 Design Standards

Table 3-1 contains the key applicable standards that will be used to develop the design. Please note that this is not intended as an exhaustive list.

Table 3-1: Relevant design standards for OHLE bridge clearance works

Source	Description	Comments
European Norm	EN50122-1	Protective provisions against electric shock
European Norm	EN50119	Electric traction overhead contact lines
Irish Rail	I-ETR-4101	Maintenance Parameters for 1500Vdc OHLE
Irish Rail	CCE-TMS-300	Track Construction Requirements and Tolerances
Irish Rail	CME-TMS-306	OHLE Interface for IÉ Rolling Stock

Source	Description	Comments
Irish Rail	CCE-TMS-321	Track Maintenance Requirements and Tolerances
Irish Rail	CME-TMS-327	Vehicle gauging
Irish Rail	CCE-TMS-410	Civil Engineering Structures Design Standard
Irish Rail	I-PWY-1101	Requirements for Track and Structures Clearances
Irish Rail	SET-AMS-002-012 Iss1.0	Derogation from SET Technical Standards

4. CONSTRAINTS

4.1 Technical

4.1.1 Electrical system

- The total clear height required at any bridge is a sum of the following:
  - The desired contact wire height;
  - The track maintenance tamping allowance;
  - The track construction tolerance;
  - The track maintenance tolerance;
  - The OHLE construction tolerance;
  - The OHLE maintenance tolerance;
  - The structural construction tolerance if bridge reconstruction/modification is required;
  - An allowance for contact wire and pantograph wear;
  - The OHLE system height or allowance for OHLE support;
  - The uplift caused to wires by a passing train;
  - The required electrical clearances;
  - The survey tolerance.

4.1.1.1 Contact wire height

The height of the contact wire (from which the train pantograph draws its power) is defined by system requirements as having a target height of 4.7m. A number of electrical equipment arrangements exist to achieve this, each compatible with differing bridge soffit heights. This can also be reduced to a height of 4.4m before a derogation from standards is required, with a risk assessment and approval from IÉ SET (and CCE depending on values for allowances, tolerances and clearances). The absolute minimum is 4.27m.

In case of modifications of overbridges or construction of new overbridges, passive provision for 25kV a.c. electrification will be considered. In this case, the minimum nominal contact wire height should be 5 m instead of 4.7 m as per section 5.24.2 of the DART+ Program Electricity FRS MAY-MDC-ELE-DART-SP-E-0002, in order to fulfil with the TSI requirements.

However, according to the TSI (table 4.2.9.1.) the minimum design contact wire height can be lower in accordance with EN 50119 clause 5.10.5 depending on the chosen gauge.

Contact wire height

Description	v ≥ 250 [km/h]	v < 250 [km/h]
Nominal contact wire height [mm]	Between 5 080 and 5 300	Between 5 000 and 5 750
Minimum design contact wire height [mm]	5 080	In accordance with EN 50119:2009, clause 5.10.5 depending on the chosen gauge
Maximum design contact wire height [mm]	5 300	6 200 (1)

(1) Taking into account tolerances and uplift in accordance with EN 50119:2009 figure 1, the maximum contact wire height shall not be greater than 6 500 mm.

Figure 4-1: Table 4.2.9.1. of the Energy Subsystem TSI

Clause 5.10.4.3 of EN 50119 states that the minimum design contact wire height shall be calculated by adding all downwards movements of the contact wire to the minimum height. The minimum contact wire height is calculated by adding the electrical clearance to the swept envelope height of the rolling stock. Consideration is therefore given to:

- Vehicle gauge (IRL2 CME-TMS-327): 4064 mm
- Electrical clearance: 270/150 mm (Static/Passing)
- Vertical tolerance on the track position: TMTA 100/75/50 mm
- Downwards installation tolerance for the contact wire: 50 mm (Construction plus maintenance tolerances as per section 5.6.6. FRS)
- Downwards dynamic movements of the contact wire: 0/110 mm
- Effects of ice load and temperature on the conductors: Depending on the span as per values given by Appendix K of the FRS.

4.1.1.2 Track maintenance tamping allowance

Track tamping is the regular maintenance process of correcting geometry and creating a uniform rail bed via adjustments to the ballast. This is generally achieved by a rail-mounted tamping machine. The target maintenance allowance is 100mm although this can be reduced to a minimum of 50mm for ballasted track. Alternatively, the rails can be mounted directly to a concrete slab (referred to as slab track) to remove the need for tamping (i.e. 0mm allowance).

4.1.1.3 Track maintenance tolerance

Track Maintenance Tolerance of 25mm for ballast track is considered in the required clear height.

4.1.1.4 Track and OHLE construction tolerance

Track and OHLE construction tolerances are 5mm and 20mm respectively.

4.1.1.5 OHLE maintenance tolerance

During the service lifetime of the OHLE, maintenance operations and adjustments require a tolerance of 30mm, regardless of electrical arrangement selected.

4.1.1.6 Contact wire and pantograph wear

An allowance of 25mm is required to account for wear to the pantograph and contact wire affecting the dynamic behaviour of the system.

4.1.1.7 System height

The system height is the distance between the highest point of the catenary wire within the area underneath the bridge soffit and the contact wire. Typically, support is provided to the contact wire from the catenary wire with ‘droppers’ as shown in Figure 4-2. The dropper heights can vary from 500 to 100mm.

It is possible to place the catenary and contact wires at the same height and hence reduce the system height to 0mm. This is referred to as a contenary system and is shown in Figure 4-3. This

system requires reduced support spacing such that the tension in the contact wire is enough to keep it sufficiently level. This is a maximum distance of 12-13m. Since OHLE masts must be a minimum of 2m from the bridge structure, if the bridge deck is wider than 8m then intermediate support arms fixed to the soffit are required. This is referred to as a 'fitted' system, the preferable opposite of which is a 'free running' system.

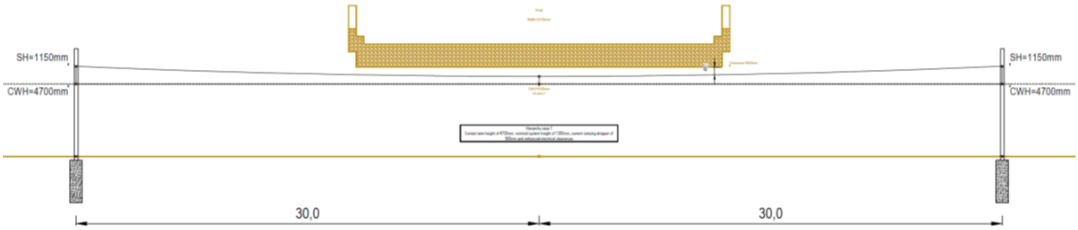


Figure 4-2: Example of typical catenary support to contact wire with 500mm droppers, passing under example bridge

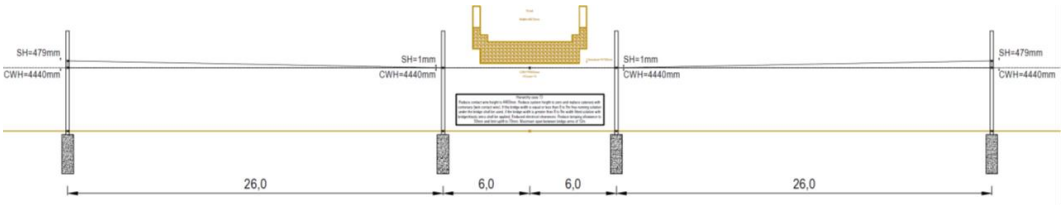


Figure 4-3: Example of typical contenary support showing achievement of a system height of 0mm underneath a reduced clearance bridge

In case of fitted solution, an allowance of 120mm is considered for the installation of the OHLE support arms.

4.1.1.8 Uplift

Passing trains cause movement on the overhead wires. This is relevant when considering dynamic electrical clearance required. For a catenary system, the required dynamic uplift allowance is 110mm. For a contenary system this is typically 70mm but may be reduced to 50mm at reduced clearance overbridges.

4.1.1.9 Electrical clearance

Enhanced electrical clearance (the preferred option) is 150mm under static conditions or 100mm under dynamic for 1.5 kV d.c. Note that the dynamic case governs as this requires the inclusion of uplift allowance. Reduced electrical clearances are 100mm and 80mm under static and dynamic conditions respectively.

In case of modifications of overbridges or construction of new overbridges, passive provision for 25kV a.c. electrification will be considered, so in this case, electrical clearances are 270mm and 150mm under static and dynamic conditions respectively.

4.1.1.10 Surveying

An allowance of 5mm for survey inaccuracies is required.

4.1.2 Gauging

The necessary changes to electric rolling stock on this section of the route requires consideration of gauging (physical clearances) as well as the previously discussed electrical clearances. This is particularly relevant to the pantograph and its interaction with arched bridge profiles. As shown in Figure 4-4 below, this may constrain the track alignment within the bridge cross section and impact on the proposed solution.

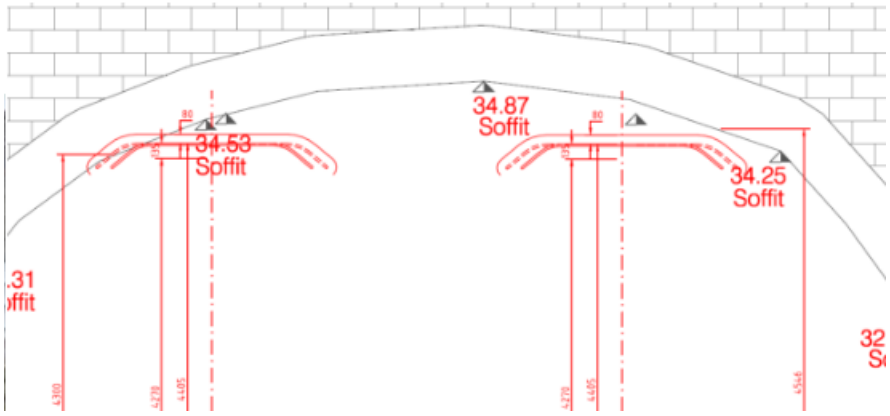


Figure 4-4: Example of pantographs clashing with bridge soffit

4.1.3 Track Level

Track lowering is an option to improve the bridge soffit height and enable a more favourable electrical arrangement. Track lowering can be achieved in two ways:

- Removal of some of the ballast depth – skim dig;
- Adjustment of formation level.

A skim dig can be achieved in some conditions by temporarily supporting rails and digging out some of the ballast from underneath sleepers. This is a relatively simple task with limited construction impact but can only achieve minor reductions to track levels (less than ~ 75mm).

For lowering greater than 75mm, the potential construction operations will be more disruptive. Where enough ballast depth exists, this may be possible via alterations to the overall ballast depth. In cases with minimal ballast depth, the formation may need to be lowered, comprising significantly disruptive construction activities, including removal of track and ballast before the formation can be dug down, followed by reinstatement. It should be noted that further investigation into the existing ballast depth at such locations will be required at subsequent design stages.

Due to gradient limits and vertical curve requirements on track alignment, any lowering operation is likely to impact extensive lengths of rail. Consideration must be given to the interaction with other assets such as station platforms.

Lowering of track is also constrained by impacts on existing drainage, utilities and bridge substructure.

4.1.4 Bridge Modification

As an alternative to track lowering, bridge modification can be considered to achieve additional vertical clearance where alternative solutions prove too constrictive. This can either take the form of raising the bridge superstructure or adopting a more substantial modification/reconstruction of the bridge to achieve the required clearance.

Raising the superstructure is typically achieved by either demolishing and reconstructing the superstructure or jacking up the existing bridge beams and resetting the deck at a higher level. Adjustment to the road level above and tie-in with the road alignment is required. This has a direct impact on the road geometry, particularly the vertical alignment. Many bridges over the existing line have already been raised with noticeably pronounced vertical crest curves and poor intervisibility. Any services carried by the deck above would need to be temporarily diverted or disconnected as part of the works. The existing bridge would need to be structurally assessed to ensure it is suitable for the altered configuration. This type of solution would retain the existing lateral clearance to the abutments.

Similarly, bridge reconstruction would require the structure to be taken out of commission for the duration of the build, while new foundations, abutment walls and deck are constructed. Where a full bridge reconstruction is proposed, it would need to meet the vertical and lateral clearance requirements of the relevant standards (CCE-TMS-410 in particular must be complied to among other standards), considering a passive provision for 25kV a.c. electrification. Where this cannot be achieved, a derogation will be required.

Unless the works can be done offline, any bridge modification option would have an impact on accessibility and would rely on a suitable alternative route to be put in place during construction.

4.2 Environmental

For a more detailed overview of the existing environmental constraints for DART+ Coastal North refer to Annex 3.1 Constraints Report and the individual option selection reports that can be found in Annexes E1 to E6.

5. ELECTRICAL SOLUTION ASSESSMENT

This section reviews whether electrical solutions are possible at each bridge location. The minimum vertical clearance is checked at each bridge and a best fit electrical solution applied based on the hierarchies outlined in the project specification.

5.1 Electrical Case Hierarchy

As detailed in section 4.1, a variety of electrical arrangements exist to cater for different available clearances. These are given a hierarchy of preference as shown in Table 5-1. This is as provided and detailed further in section 5.6.7 of the Electricity Functional Specifications System-Wide document (MAY-MDC-ELE-DART-SP-E-0002).

A nominal contact wire height of at least 4700 mm is preferred at overbridge locations. Where this cannot be achieved, a minimum contact wire height (CWH) of 4400 mm can be considered provided the associated risks are suitably addressed. Contact wire heights less than 4400 mm will require a derogation. This is summarised as follows:

- **Contact wire height ≥ 4700 mm:**
  Represents nominal contact wire height. No risk assessment or derogation required. These are coloured green in the table below.
- **Contact wire height < 4700 mm but ≥ 4400 mm:**
  Electrical solutions with contact wire heights in this range require a risk assessment to be undertaken. These are coloured yellow in the table below.
- **Contact wire height < 4400 mm but >4200 mm:**
  Electrical solutions with contact wire heights less than 4400 mm require a risk assessment and a derogation. These are coloured orange in the table below.

The electrical solution given in the specification favours the contact wire height over the system height. Where possible, the contact wire height is increased, resulting in contenary systems being favoured since increasing the system height typically requires more clearance than that required to increase the system height to a more favourable hierarchy case.

As stated in section 2.2, it should be noted that soffit heights are shown in bold, where confirmed by survey. Other approximate dimensional information has been provided by IÉ.

Table 5-1: Electrical case hierarchy at overbridge structures

		Nominal CW height	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Minimum soffit height (mm)
Case 1 CWH of 4700mm, nominal SH of 1300mm, current carrying dropper of 500mm and enhanced EC.	Static EC	4700	100	5	25	20	30	0	500	0	150	5	5535
	Dynamic EC	4700	100	5	25	20	30	25	500	110	100	5	**5620**
Case 2 CWH of 4700mm, reduced SH with reduced current carrying dropper of 300mm and enhanced EC.	Static EC	4700	100	5	25	20	30	0	300	0	150	5	5335
	Dynamic EC	4700	100	5	25	20	30	25	300	110	100	5	**5420**
Case 3 CWH of 4700mm, reduced SH with reduced current carrying dropper of 100mm and enhanced EC.	Static EC	4700	100	5	25	20	30	0	100	0	150	5	5135
	Dynamic EC	4700	100	5	25	20	30	25	100	110	100	5	**5220**
Case 4 CWH of 4700mm, reduced SH to zero, contenary and enhanced EC. Uplift 70 mm	Static EC	4700	100	5	25	20	30	0	0	0	150	5	5035
	Dynamic EC	4700	100	5	25	20	30	25	0	70	100	5	**5080**
Case 5 CWH of 4600mm, reduced SH with reduced current carrying dropper of 300mm, reduced tamping allowance to 75 mm and enhanced EC.	Static EC	4600	75	5	25	20	30	0	300	0	150	5	5210
	Dynamic EC	4600	75	5	25	20	30	25	300	110	100	5	**5295**
Case 6	Static EC	4600	75	5	25	20	30	0	100	0	150	5	5010

		Nominal CW height	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Minimum soffit height (mm)
CWH of 4600mm, reduced SH with reduced current carrying dropper of 100mm, reduced tamping allowance to 75 mm and enhanced EC.	Dynamic EC	4600	75	5	25	20	30	25	100	110	100	5	**5095**
Case 7 CWH of 4600mm, reduced SH to zero, contenary, reduced tamping allowance to 75 mm and enhanced EC. Uplift 70 mm	Static EC	4600	75	5	25	20	30	0	0	0	150	5	4910
	Dynamic EC	4600	75	5	25	20	30	25	0	70	100	5	**4955**
Case 8 CWH of 4500mm, reduced SH with reduced current carrying dropper of 300mm, reduced tamping allowance to 50 mm and enhanced EC.	Static EC	4500	50	5	25	20	30	0	300	0	150	5	5085
	Dynamic EC	4500	50	5	25	20	30	25	300	110	100	5	**5170**
Case 9 CWH of 4500mm, reduced SH with reduced current carrying dropper of 100mm, reduced tamping allowance to 50 mm and enhanced EC.	Static EC	4500	50	5	25	20	30	0	100	0	150	5	4885
	Dynamic EC	4500	50	5	25	20	30	25	100	110	100	5	**4970**
Case 10 CWH of 4500mm, reduced SH to zero, contenary, reduced tamping allowance to 50 mm and enhanced EC. Uplift 70 mm	Static EC	4500	50	5	25	20	30	0	0	0	150	5	4785
	Dynamic EC	4500	50	5	25	20	30	25	0	70	100	5	**4830**
Case 11 CWH of 4400mm, reduced SH with reduced current carrying dropper of 300mm, reduced tamping allowance to 50 mm and enhanced EC.	Static EC	4400	50	5	25	20	30	0	300	0	150	5	4985
	Dynamic EC	4400	50	5	25	20	30	25	300	110	100	5	**5070**
Case 12	Static EC	4400	50	5	25	20	30	0	100	0	150	5	4785

		Nominal CW height	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Minimum soffit height (mm)
CWH of 4400mm, reduced SH with reduced current carrying dropper of 100mm, reduced tamping allowance to 50 mm and enhanced EC.	Dynamic EC	4400	50	5	25	20	30	25	100	110	100	5	**4870**
Case 13 CWH of 4400mm, reduced SH to zero, contenary, reduced tamping allowance to 50 mm and reduced EC. Uplift 70 mm	Static EC	4400	50	5	25	20	30	0	0	0	100	5	4635
	Dynamic EC	4400	50	5	25	20	30	25	0	70	80	5	**4710**
Case 14 CWH of 4350mm, reduced SH to zero, contenary, reduced tamping allowance to 50 mm and reduced EC. Uplift 50 mm	Static EC	4350	50	5	25	20	30	0	0	0	100	5	4585
	Dynamic EC	4350	50	5	25	20	30	25	0	50	80	5	**4640**
Case 15 CWH of 4270mm, reduced SH to zero, contenary, slab track: tamping allowance 0 mm and maintenance tolerance 5 mm. Reduced EC. Uplift 50 mm	Static EC	4270	0	5	5	20	30	0	0	0	100	5	4435
	Dynamic EC	4270	0	5	5	20	30	25	0	50	80	5	**4490**

5.1.1 Risk Assessments

For bridges where a contact wire height of less than 4.7m is proposed, a risk assessment must be carried out and presented to the IÉ Signalling, Electrification and Telecoms (SET) department. Site specific risks will be evaluated in subsequent design stages however, general risks associated with reduced contact wire heights have been captured.

The figures provided in this section are example extracts from the hazard log and are provided for reference only. 'F' represents the frequency of the hazard event occurring and 'C' the consequence.

5.1.1.1 General risks

The two risks shown in Figure 5 1 are associated with all overbridges where the proposed contact wire height is less than 4.7m. The mitigation measures listed are proposed for each overbridge.

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, lower proposed CWH is 4290 mm considering 10 mm for OHLE maintenance tolerance (as per FRS in crossovers and particular locations) and spans are lower than 10 m, so minimum CWH will be 4193 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS: Maximum Gradient (speed up to 120km/h): 1/250 or 4 ‰ Maximum Change of Gradient (speed up to 120km/h): 1/500 or 2 ‰ These values are according to values indicated in Table 11 of EN50119 for speed up to 120 km/h	3	2	5

Figure 5-1: General hazards associated with reduced contact wire heights at overbridges

5.1.1.2 Station risks

Where an overbridge with reduced contact wire height exists within a station, this introduces further risk as detailed in Figure 5 2.

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	F	C	Result	**Safety Measures - mitigation description**	F	C	Result
Contact wire height < 4700 mm	Live parts of the OHLE or pantograph are closer to platform standing surface than minimum required	Electrocution	4	4	8	In the north side of the overbridge, the spans are lower than 30 m, so considering CWH is 4550 mm, the absolute minimum CWH will be 4376 mm. Pantograph depth is 210 mm and therefore minimum height for live parts is 4166 mm from ToR. Platform height is 9xx mm, so minimum height of live parts from platform standing surface is 3166 mm. Therefore it fulfils the distance required in the EN50122-1 for 1500 V d.c.	2	4	6

Figure 5-2: Hazards within stations associated with reduced contact wire heights at overbridges

5.1.1.3 Public use of legacy overbridges and structures with reduced clearances

Similarly, where an overbridge designated for public use has a reduced contact, this introduces further risk as detailed in Figure 5 3.

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	F	C	Result	**Safety Measures - mitigation description**	F	C	Result
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS.	2	4	6

Figure 5-3: Hazards associated with reduced contact wire heights at overbridges designated for public use

5.2 Classification of Bridge Electrical Solutions

The available vertical clearance at each bridge was assessed and an electrical solution proposed based on the requirements of the Functional Specification. Where the soffit of the bridge varies across the width of the tracks (e.g. arch bridges), the pantograph and electrical clearance envelopes were plotted in elevation to confirm proposed solutions.

The electrical solution also takes into account the extra depth needed to install a bridge-arm connection in the case of fitted systems.

Table 5-2 below summarises the proposed electrical solutions at each overbridge location. As for previous tables, bold clearances are those confirmed by survey.

Table 5-2: Summary of the proposed electrical solutions at each overbridge

Bridge No.	Soffit Form	Clearance (ToR – Soffit) (mm)	Approx. Abut. Width (m)	Fitted (F) / Free-Running (FR) System	Proposed CWH (mm)
OBB32A	Flat	~ 5800	23.0	FR	4700
OBB32B	Flat	~ 6000	5.6	FR	4700
OBB33	Flat	~5000	12.2	F	4550
OBB33A	Flat	~5100	2.2	FR	4600
OBB35	Flat	**4740**	4.5	FR	4400
OBB38	Arch	~5020	4.6	FR	4480
OBB38A	Flat	~5200	3.0	FR	4420
OBB39	Flat	**4775**	10.7	F	4370
OBB41	Flat	**4700**	6.9	FR	4400
OBB44	Flat	**4585**	7.4	FR	4320
OBB45	Flat	**4715**	4.8	FR	4400
OBB46	Flat	~4860	7.1	FR	4500
OBB47	Arch	**4900**	5.1	FR	4500
OBB49	Flat	**4690**	8.1	FR	4400
OBB51A	Flat	**4815**	2.6	FR	4480
OBB54	Flat	~5100	2.5	FR	4700
OBB55	Flat	**4590**	11.5	F	4270
OBB57A	Flat	**4775**	2.4	FR	4440
OBB62	Flat	~4880	7.9	FR	4500
OBB63	Flat	**4735**	4.9	FR	4400

Bridge No.	Soffit Form	Clearance (ToR – Soffit) (mm)	Approx. Abut. Width (m)	Fitted (F) / Free-Running (FR) System	Proposed CWH (mm)
OBB66	Flat	**4880**	4.5	FR	4525
TBC	Flat	~5270	2.5	FR	4645
OBB68	Flat	**4920**	6.6	FR	4540
OBB74A	Flat	~5100	2.8	FR	4700
OBB77	Flat	~4850	8.2	F	4400
OBB78	Flat	**4680**	17.5	F	4290
OBB80	Arch	**4205**	6.9	-	-
OBB80A	Arch	**4300**	6.6	-	-
OBB80B	Flat	**4910**	7.2	FR	4530
OBB81	Flat	**4465**	2.8	FR	4270
OBB81C	Flat	**5800**	4.4	FR	4700

The table above uses various shades of colour to differentiate between the various electrical solutions proposed. These are as follows:

- Green indicates solutions with a nominal contact wire height (CWH ≥ 4700MM) ;
- Yellow indicates solutions which require a risk assessment (4700mm < CWH ≤ 4400MM);
- Blue indicates solutions which would require a derogation and risk assessment (CWH < 4400 mm). These are potential solutions only, refer to section 5.3 for details);
- Orange indicates that no electrical solution is possible at this location.

5.2.1 Electrical solutions adopting a Nominal Contact Wire Height (4700 mm)

The bridges listed in the table below have sufficient vertical clearance to adopt an electrical solution with a contract wire height of 4700 mm.

Table 5-3: Bridges with a proposed contact wire height of 4700 mm

Bridge No.	Clearance (ToR – Soffit) (mm)	Proposed CWH (mm)	Comment
OBB32A	~5800	4700	Road bridge recently constructed as part of the Donabate relief road.

OBB32B	~6000	4700	Proposed future pedestrian cycle bridge at south of Donabate station
OBB54	~5100	4700	Ladies Stairs pedestrian bridge. Bridge arms installed on dedicated OHLE structures each side of the signals on the southern side
OBB74A	~5100	4700	Pedestrian bridge at Laytown Station. Bridge arms installed on dedicated OHLE structures each side of bridge in platform area.
OBB81C	5800	4700	Relatively new footbridge at Drogheda MacBride Station used by maintenance staff to access the depot building.

Please note that distance between the uplifted pantograph and the overbridge soffit for OBB54 and OBB74A is 125 mm.

5.2.2 Electrical Solutions requiring a risk assessment

The proposed electrical solution for bridges where the contact wire height is less than 4700 mm but greater than or equal to 4400 mm is summarised the tables below. A risk assessment has been undertaken for the solutions at each of these bridges and is contained in Appendix A of this report.

Table 5-4: Proposed electrical solution with 4500 mm ≤ CWH < 4700 mm

	OBB33	OBB33A	OBB46	OBB47	OBB62	OBB66	OBB66A (TBC)	OBB68
Current Structure Parameters								
Structure Name	Donabate Station Roadbridge	Donabate Station Footbridge	Baldongan	Skerries Golf Club	Frankins/Occupation Road	Gomrnaston Station Roadbridge	Gormanston St. Footbridge (planned)	Irishtown/Public Road
Chainage	11 miles & 727 yards	11 miles & 784 yards	16 miles & 172 yards	16 miles & 1038 yards	22 miles & 1573 yards	24 miles & 19 yards	24 miles & 120 yards	24 miles & 1757 yards
Bridge Type	Roadbridge	Footbridge	Roadbridge	Roadbridge	Roadbridge	Roadbridge	Footbridge	Roadbridge
Is the Structure Listed	Yes	No	No	No	No	No	No	No
Width of Structure	12.2	2.2	7.1	4.7	7.9	4.5	2.6	6.6
Worst Vertical Clearance - TOR to Soffit	~5000	~5100	~4860	4900	~4880	4880	~5274	4920
Structure type	Flat	Flat	Flat	Arched	Flat	Flat	Flat	Flat
Bridge Constraints	Donabate station	Donabate station, OBB33	None	None	None	Gormanston station, New footbridge	Gormanston station, OBB66	None
Proposed OHLE solution	Contenary with zero encumbrance	OHLE with minimum dropper of 100 mm	Contenary with zero encumbrance	OHLE with minimum dropper of 100 mm	Contenary with zero encumbrance	Contenary with zero encumbrance	OHLE with minimum dropper of 100 mm	Contenary with zero encumbrance

Table 5-5: Proposed electrical solution parameters with 4500 mm ≤ CWH < 4700 mm

	OBB33	OBB33A	OBB46	OBB47	OBB62	OBB66	OBB66A (TBC)	OBB68
Proposed OHLE solution	Contenary with zero encumbrance	OHLE solution with minimum dropper of 100 mm	Contenary with zero encumbrance	OHLE solution with minimum dropper of 100 mm	Contenary with zero encumbrance	Contenary with zero encumbrance	OHLE solution with minimum dropper of 100 mm	Contenary with zero encumbrance
OHLE Arrangement	Fitted with Elastic Bridge Arms	Free Running	Free Running	Free Running	Free Running	Free Running	Free Running	Free Running
Static Clearance (Csc) - 1500Vdc	150	150	150	150	150	150	270	150
Dynamic Clearance (Cdc) - 1500Vdc	100	100	100	100	100	100	150	100
Minimum Position of the Contact Wire (considering tamping)	4411	4352	4336	4223	4311	4361	4421	4351
Actual Design Contact Wire Height (Cdcl) (After Tamping)	4550	4600	4500	4500	4500	4525	4645	4540
Maximum Design Contact Wire Height [Pre-Tamping]	4600	4675	4575	4575	4600	4600	4745	4640
OHLE System Depth (Csd)	0	110	0	0	0	0	150	0

	OBB33	OBB33A	OBB46	OBB47	OBB62	OBB66	OBB66A (TBC)	OBB68
OHLE Uplift (Cwu)	70	110	70	110	70	70	110	70
OHLE Construction/ Installation (Cct) + Maintenance Tolerance (Cmt)	50	50	50	50	50	50	50	50
Structure Construction Tolerance (St)	0	0	0	0	0	0	5	0
Track Maintenance Tamping Allowance (Tla)	50	75	75	75	100	75	100	100
Track Construction Tolerance (Tct)	0	0	0	0	0	0	0	0
Track Maintenance Tolerance (Tmt)	25	25	25	25	25	25	25	25
Considered OHLE span through the overbridge (as per hierarchy cases)	15	40	15	45	15	15	30	15
Sag and Ice Load	39	123	39	152	39	39	74	39
Survey Tolerance	5	5	5	5	5	5	5	5
Loading Gauge	4064	4064	4064	4064	4064	4064	4064	4064
Mechanical Clearance	225	210	110	110	105	105	314	105
Speed through the structure	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph

	OBB33	OBB33A	OBB46	OBB47	OBB62	OBB66	OBB66A (TBC)	OBB68
Acceptance - CCE	TMTA 50 mm	TMTA 75 mm	TMTA 75 mm Mech. clearance 110 mm	TMTA 75 mm Mech. clearance 110 mm	Mech. clearance 105 mm	TMTA 75 mm Mech. clearance 105 mm	No	Mech. clearance 105 mm
Acceptance - SET	CW<4700 mm	CW<4700 mm	CW<4700 mm	CW<4700 mm	CW<4700 mm	CW<4700 mm	CW<4700 mm	CW<4700 mm
Derogation - SET	No	No	No	No	No	No	No	No

Table 5-6: Proposed electrical solution with 4400 ≤ CWH < 4500 mm

	OBB35	OBB38	OBB38A	OBB41	OBB49	OBB51A	OBB57A	OBB63	OBB77
Current Structure Parameters									
Structure Name	Beaverstown Golf Club	Rogerstown Lane	Rush & Lusk Footbridge	Kingstown/ Public Road	Golf Links Road Skerries	Skerries Footbridge	Balbriggan Footbridge	Filgate's/ Occupation Road	Piltown
Chainage	12 miles & 445 yards	13 miles & 999 yards	13 miles & 1564 yards	14 miles & 438 yards	17 miles & 524 yards	17 miles & 1708 yards	21 miles & 1328 yards	23 miles & 866 yards	29 miles & 1452 yards
Bridge Type	Roadbridge	Roadbridge	Footbridge	Roadbridge	Roadbridge	Footbridge	Footbridge	Roadbridge	Roadbridge
Is the Structure Listed	No	No	No	No	No	No (but located in a station which protected)	No (but located in a station which protected)	No	No
Width of Structure	4.5	4.6	3.0	6.7	7.4	2.3	2.4	4.5	8.2
Worst Vertical Clearance - TOR to Soffit	4740	~5020	~5200	4703	4690	4815	4775	4735	~4850
Structure type	Flat	Arched	Flat	Flat	Flat	Flat	Flat	Flat	Flat
Bridge Constraints	-	-	Rush & Lusk station, OBB39	-		Skerries station	Balbriggan station		
Proposed OHLE solution	Contenary with zero encumbrance	Contenary with zero encumbrance	OHLE with minimum dropper of 300 mm	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance

Table 5-7: Proposed electrical solution parameters with 4400 ≤ CWH < 4500 mm

	OBB35	OBB38	OBB38A	OBB41	OBB49	OBB51A	OBB57A	OBB63	OBB77
Proposed OHLE solution	Contenary with zero encumbrance	Contenary with zero encumbrance	OHLE solution with minimum dropper of 300 mm	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance
OHLE Arrangement	Free Running	Free Running	Free Running	Free Running	Free Running	Free Running	Free Running	Free Running	Fitted with Elastic Bridge Arms
Static Clearance (Csc) - 1500Vdc	100	100	150	100	100	100	100	100	100
Dynamic Clearance (Cdc) - 1500Vdc	80	80	100	80	80	80	80	80	80
Minimum Position of the Contact Wire (considering tamping)	4236	4316	4221	4275	4275	4316	4276	4236	4261
Actual Design Contact Wire Height (Cdcl) (After Tamping)	4400	4480	4420	4400	4400	4480	4440	4400	4400
Maximum Design Contact Wire Height [Pre-Tamping]	4475	4555	4495	4450	4450	4555	4515	4475	4450
OHLE System Depth (Csd)	0	0	320	0	0	0	0	0	0

	OBB35	OBB38	OBB38A	OBB41	OBB49	OBB51A	OBB57A	OBB63	OBB77
OHLE Uplift (Cwu)	70	70	110	50	50	70	70	70	70
OHLE Construction/ Installation (Cct) + Maintenance Tolerance (Cmt)	50	50	50	50	50	50	50	50	50
Structure Construction Tolerance (St)	0	0	0	0	0	0	0	0	0
Track Maintenance Tamping Allowance (Tla)	75	75	75	50	50	75	75	75	50
Track Construction Tolerance (Tct)	0	0	0	0	0	0	0	0	0
Track Maintenance Tolerance (Tmt)	25	25	25	25	25	25	25	25	25
Considered OHLE span through the overbridge (as per hierarchy cases)	15	15	30	12	12	15	15	15	15
Sag and Ice Load	39	39	74	25	25	39	39	39	39
Survey Tolerance	5	5	5	5	5	5	5	5	5
Loading Gauge	4064	4064	4064	4064	4064	4064	4064	4064	4064
Mechanical Clearance	90	290	490	98	85	85	85	85	225
Speed through the structure	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph

	OBB35	OBB38	OBB38A	OBB41	OBB49	OBB51A	OBB57A	OBB63	OBB77
Acceptance - CCE	TMTA 75 mm Mech. clearance 90 mm	TMTA 75 mm	TMTA 75 mm	TMTA 50 mm Mech. clearance 98 mm	TMTA 50 mm Mech. clearance 85 mm	TMTA 75 mm Mech. clearance 85 mm	TMTA 75 mm Mech. clearance 85 mm	TMTA 75 mm Mech. clearance 85 mm	TMTA 50 mm
Acceptance - SET	"CW<4700 mm Reduced electrical clearances	"CW<4700 mm Reduced electrical clearances	"CW<4700 mm	"CW<4700 mm Reduced electrical clearances	"CW<4700 mm Reduced electrical clearances	"CW<4700 mm Reduced electrical clearances	"CW<4700 mm Reduced electrical clearances	"CW<4700 mm Reduced electrical clearances	CW<4700 mm Reduced electrical clearances
Derogation - SET	No	No	No	No	No	No	No	No	No

5.2.3 Electrical Solutions requiring a derogation

A potential electrical solution for bridges where the contact wire height is less than 4400 mm but greater than 4200mm is summarised in the tables below. A risk assessment has been undertaken for the solutions at each of these bridges and is contained in Appendix A of this report. In addition to this, a derogation would need to be sought for these bridges as the contact wire height is below minimum.

However, it has been required to develop compliant OHLE solutions with the minimum contact wire height for all the overbridges. Therefore, as indicated in section 6 of this report, further assessment for these bridges has been carried out in order to define the feasible options to improve the existing vertical clearance and to provide a compliant OHLE solution without requiring derogation.

Table 5-8: Potential electrical solution with 4200mm < CWH < 4400 mm (Derogation required)

	OBB39	OBB44	OBB55	OBB78	OBB81
Current Structure Parameters					
Structure Name	Rush & Lusk Roadbridge	Tyrrelstown / Public Road	County Bridge / Public Road	Colpe Bridge / Public Road	MacBride Station
Chainage	13 miles & 1644 yards	14 miles & 1437 yards	21 miles & 304 yards	30 miles & 233 yards	31 miles & 1259 yards
Bridge Type	Roadbridge	Roadbridge	Roadbridge	Roadbridge	Footbridge
Is the Structure Listed	No	No	No	No	No (but located in a station which protected)
Width of Structure	10.08	7.18	11.5	17.46	2.82
Worst Vertical Clearance - TOR to Soffit	4776	4585	4590	4680	4464
Structure type	Flat	Flat	Flat	Flat	Flat
Bridge Constraints	Rush&Lusk station	-			Drogheda MacBride Station
Potential OHLE solution	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance

Table 5-9: Potential electrical solution parameters with CWH < 4400 mm (Derogation required)

	OBB39	OBB44	OBB55	OBB78	OBB81
Potential OHLE solution	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance	Contenary with zero encumbrance
OHLE Arrangement	Fitted with Elastic Bridge Arms	Free Running	Fitted with Elastic Bridge Arms	Fitted with Elastic Bridge Arms	Free Running
Static Clearance (Csc) - 1500Vdc	100	100	100	100	100
Dynamic Clearance (Cdc) - 1500Vdc	80	80	80	80	80
Minimum Position of the Contact Wire (considering tamping)	4245	4215	4215	4193	4223
Actual Design Contact Wire Height (Cdcl) (After Tamping)	4370	4320	4270	4290	4270
Maximum Design Contact Wire Height [Pre-Tamping]	4420	4370	4270	4340	4270
OHLE System Depth (Csd)	0	0	0	0	0
OHLE Uplift (Cwu)	50	50	50	50	25
OHLE Construction/ Installation (Cct) + Maintenance Tolerance (Cmt)	50	30	30	30	30
Structure Construction Tolerance (St)	0	0	0	0	0

	OBB39	OBB44	OBB55	OBB78	OBB81
Track Maintenance Tamping Allowance (Tla)	50	50	0	50	0
Track Construction Tolerance (Tct)	0	0	5	0	5
Track Maintenance Tolerance (Tmt)	25	25	5	25	5
Considered OHLE span through the overbridge (as per hierarchy cases)	12	12	12	10	10
Sag and Ice Load	25	25	25	17	17
Survey Tolerance	5	5	5	5	5
Loading Gauge	4064	4064	4064	4064	4064
Mechanical Clearance	201	80	90	205	104
Speed through the structure	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	160km/h - 100 mph	50km/h - 30 mph
Acceptance - CCE	TMTA 50 mm	TMTA 50 mm Mech. clearance 80 mm	Slab track Mech. clearance 90 mm	TMTA 50 mm	Slab track Mech. clearance 104 mm
Acceptance - SET	CW<4700 mm	CW<4700 mm	CW<4700 mm	CW<4700 mm	CW<4700 mm Reduced electrical clearances OHLE construction + maintenance tolerance 30 mm OHLE Uplift 25 mm

	OBB39	OBB44	OBB55	OBB78	OBB81
Derogation - SET	CWH - 4370 Post tamping	CWH - 4320 Post tamping	CWH -4270	CWH - 4290 Post tamping	CWH - 4270

5.3 No Possible Electrical Solution

The bridges on the approach to Drogheda MacBride Station, namely the masonry arch bridges OBB80, OBB80A and OBB80B which carry McGrath's Lane over the railway line has insufficient clearance to provide an electrical only solution, even with a derogation.

However, it has been required to develop compliant OHLE solutions with the minimum contact wire height for all the overbridges. Therefore, as indicated in section 6 of this report, further assessment for these bridges has been carried out in order to define the feasible options to improve the existing vertical clearance and to provide a compliant OHLE solution without requiring derogation.

6. BRIDGES REQUIRING INTERVENTION

The following section identifies the bridges which have undergone further optioneering since PC1 to identify a preferred solution.

The bridges fall into two categories:

1. Bridges which have a potential electrical solution but would require a derogation.
2. Bridges with no viable electrical solution in the existing arrangement.

To avoid the need to apply for a derogation, options that consider lowering the track or modifying the bridges have been considered, as set out in the following sub-sections.

6.1 Bridges with an electrical solution requiring a derogation

6.1.1 OBB 39

As indicated previously, the current soffit height of this overbridge allows a non-compliant OHLE solution, with contact wire height lower than 4400 mm, as per Table 5-8 and Table 5-9, so additional options have had to be considered in order to achieve an OHLE compliant solution that does not require a derogation. These options are assessed in the Annex E1 Overbridge OBB39 Options Report. The preferred option entails local lowering of the track beneath the bridge to achieve an electrical clearance that does not require a derogation.

6.1.2 OBB 44

As indicated previously, the current soffit height of this overbridge allows a non-compliant OHLE solution, with contact wire height lower than 4400 mm, as per Table 5-8 and Table 5-9, so additional options have to be considered in order to achieve an OHLE compliant solution. These options are assessed in the Annex E2 Overbridge OBB44 Options Report. The preferred option entails local lowering of the track beneath the bridge to achieve an electrical clearance that does not require a derogation.

6.1.3 OBB 55

As indicated previously, the current soffit height of this overbridge allows a non-compliant OHLE solution, adopting the minimum contact wire height of 4270 mm and requiring a slab track, as per Table 5-8 and Table 5-9, so additional options have to be considered in order to achieve an OHLE compliant solution. These options are assessed in the Annex E3 Overbridge OBB55 Options Report. The preferred option entails local lowering of the track beneath the bridge to achieve an electrical clearance that does not require a derogation.

6.1.4 OBB 78

As indicated previously, the current soffit height of this overbridge allows a non-compliant OHLE solution, with contact wire height lower than 4400 mm, as per Table 5-8 and Table 5-9, so additional options have to be considered in order to achieve an OHLE compliant solution. These options are assessed in the Annex E4 Overbridge OBB78 Options Report. The preferred option entails local

lowering of the track beneath the bridge to achieve an electrical clearance that does not require a derogation.

6.1.5 OBB 81

As indicated previously, the current soffit height of this overbridge allows a non-compliant OHLE solution, adopting the minimum contact wire height of 4270 mm and requiring a slab track and a reduced OHLE uplift allowance of 25 mm, as per Table 5-8 and Table 5-9, so additional options have been considered in order to achieve an OHLE compliant solution. These options are assessed in the Annex E6 Overbridge OBB81 Options Report. The preferred option entails replacement of the bridge superstructure.

6.2 Bridges with no viable electrical solution in the existing arrangement

6.2.1 OBB80/80A/80B

As outlined above, the bridges on the approach to Drogheda MacBride Station, namely the masonry arch bridges OBB80, OBB80A and OBB80B which carry McGrath's Lane over the railway line has insufficient clearance to provide an electrical only solution, even with a derogation.

An infrastructure solution has been developed at this location – refer to Annex E5 – technical optioneering report for OBB80/80A/80B. This entails complete replacement of the bridge.

Appendix A

Risk Assessments for Proposed Electrical Solutions where Contact Wire Height is less than 4700mm.

Risk Ranking Matrix

Guidance for RISK RANKING MATRIX	Frequency (F)		Consequence (C)					Risk Classifications
			1	2	3	4	5	
			Negligible	Minor	Major	Critical	Catastrophic	
	5	Frequent	6	7	8	9	10	**2-4 NEGLIGABLE LOW RISK**: Ensure control measures are maintained and reviewed as necessary to control residual risk as far as is reasonably practicable.
	4	Probable	5	6	7	8	9	
	3	Occasional	4	5	6	7	8	**5-6 TOLERABLE RISK**: Control measures to reduce risk rating to a level which is as low as reasonably practicable (ALARP). Add details of residual risk to drawings/docs.
	2	Remote	3	4	5	6	7	
	1	Improbable	2	3	4	5	6	**7-10 INTOLERABLE RISK**: Activity not permitted. Hazard to be avoided or reduced.

Frequency Category	Classification Term	Time Frame	Midpoint Frequency Estimate	Description
5	Frequent	Less than 1	1 in 6 months	The event is likely to occur frequently (probably on a
4	Probable	1 year to 10 years	1 in 5 years	The event will occur several times and is likely to occur often.
3	Occasional	10 years to 100 years	1 in 50 years	The event is likely to occur several times.
2	Remote	100 years to 1000 years	1 in 500 years	The event can be expected to occur during the lifecycle.
1	Improbable	1000 years or greater	1000 years	The event is unlikely to occur, but may by exception occur.

Consequence Category	Classification Term	Ratio	FWI Equivalence	Description
1	Negligable		0,001	Non-reportable injury.
2	Minor	5 negliga	0,005	Minor injury.
3	Major	20 minor	0,1	Major injury or multiple minor injuries.
4	Critical	10 major	1	Single fatality or multiple major injuries, equivalent to 1 Fatality Weighted Injury (FWI).
5	Catastrophic	5 critical		Multiple fatalities.

Risk Ranking Matrix

Guidance for RISK RANKING MATRIX	Frequency (F)		Consequence (C)					Risk Classifications
			1	2	3	4	5	
			Negligible	Minor	Major	Critical	Catastrophic	
	5	Frequent	6	7	8	9	10	**2-4 NEGLIGABLE LOW RISK**: Ensure control measures are maintained and reviewed as necessary to control residual risk as far as is reasonably practicable.
	4	Probable	5	6	7	8	9	
	3	Occasional	4	5	6	7	8	**5-6 TOLERABLE RISK**: Control measures to reduce risk rating to a level which is as low as reasonably practicable (ALARP). Add details of residual risk to drawings/docs.
	2	Remote	3	4	5	6	7	
	1	Improbable	2	3	4	5	6	**7-10 INTOLERABLE RISK**: Activity not permitted. Hazard to be avoided or reduced.

Frequency Category	Classification Term	Time Frame	Midpoint Frequency Estimate	Description
5	Frequent	Less than 1	1 in 6 months	The event is likely to occur frequently (probably on a
4	Probable	1 year to 10 years	1 in 5 years	The event will occur several times and is likely to occur often.
3	Occasional	10 years to 100 years	1 in 50 years	The event is likely to occur several times.
2	Remote	100 years to 1000 years	1 in 500 years	The event can be expected to occur during the lifecycle.
1	Improbable	1000 years or greater	1000 years	The event is unlikely to occur, but may by exception occur.

Consequence Category	Classification Term	Ratio	FWI Equivalence	Description
1	Negligable		0,001	Non-reportable injury.
2	Minor	5 negliga	0,005	Minor injury.
3	Major	20 minor	0,1	Major injury or multiple minor injuries.
4	Critical	10 major	1	Single fatality or multiple major injuries, equivalent to 1 Fatality Weighted Injury (FWI).
5	Catastrophic	5 critical		Multiple fatalities.

OBB33 DONABATE STATION ROADBRIDGE

Approx.	Miles	11
Location	Yards	727
Soffit height		~5000 mm
Width		12,19 m
Station		Y
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Fitted contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 10 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB33	10	Static EC	4550	4411	25	14	50	0	25	20	30	0	0	0	150	5	120	0	4950	~5000
		Dynamic EC	4550	4411	25	14	50	0	25	20	30	25	0	70	100	5	120	0	4995	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4550 mm and spans are lower than 12 m, so minimum CWH will be 4411 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Contact wire height < 4700 mm	Live parts of the OHLE or pantograph are closer to platform standing surface than minimum required	Electrocution	4	4	8	In the north side of the overbridge, the proposed adjacent spans are lower than 30 m, so considering pretamping CWH is 4600 mm, the minimum CWH will be 4453 mm. Pantograph depth is 210 mm and therefore minimum height for live parts is 4243 mm from ToR. Worst envelope situation is considering 60 mm cant towards platform and platform height in this section of 1070 mm from nearest rail, so minimum height of live parts from platform standing surface is 3162 mm. Therefore it fulfils the distance required in the EN50122-1 for 1500 V d.c. Cant and platform height values have been obtained from lidar surveys in Annex C of tender documentation.	2	4	6

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Insufficient load capacity of overbridge structure	Adding additional construction loads to structure	Instability and collapse of existing structure	3	5	8	Capacity of the overbridge will be checked in the following stages of the design	1	5	6

OBB33A DONABATE FOOTBRIDGE

Approx.	Miles	11
Location	Yards	784
Soffit height		~5100 mm
Width		2,18 m
Station		Y
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running solution with 100 mm minimum encumbrance based on tolerances/allowances considered in hierarchy case 6 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB33A	6(*)	Static EC	4600	4352	24	99	75	0	25	20	30	0	110	0	150	5	0	0	5015	~5100
		Dynamic EC	4600	4352	24	99	75	0	25	20	30	25	110	110	100	5	0	0	5100	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4600 mm and spans are lower than 12 m, so minimum CWH will be 4352 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Contact wire height < 4700 mm	Live parts of the OHLE or pantograph are closer to platform standing surface than minimum required	Electrocution	4	4	8	In the north side of the overbridge, the proposed adjacent spans are lower than 40 m, so considering pretamping CWH is 4675 mm, the minimum CWH will be 4502 mm. Pantograph depth is 210 mm and therefore minimum height for live parts is 4292 mm from ToR. Worst envelope situation is considering 60 mm of cant towards platform and platform height of 1060 mm from nearest rail, so minimum height of live parts from platform standing surface is 3221 mm. Therefore it fulfils the distance required in the EN50122-1 for 1500 V d.c. Cant and platform height values have been obtained from lidar surveys in Annex C of tender documentation.	2	4	6

OBB35 BEAVERSTOWN GOLF CLUB

Approx.	Miles	12
Location	Yards	445
Soffit height		4740 mm
Width		4,54 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 13 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB35	13	Static EC	4400	4236	25	14	75	0	25	20	30	0	0	0	100	5	0	0	4655	4740
		Dynamic EC	4400	4236	25	14	75	0	25	20	30	25	0	70	80	5	0	0	4730	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4400 mm and spans are lower than 12 m, so minimum CWH will be 4236 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB38 ROGERSTOWN LANE

Approx.	Miles	13
Location	Yards	999
Soffit height		~5020 mm
Width		4,64 m
Station		N
Flat/arched		Arched

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 13 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB38	13	Static EC	4480	4316	25	14	75	0	25	20	30	0	0	0	100	5	0	200	4935	~5020
		Dynamic EC	4480	4316	25	14	75	0	25	20	30	25	0	70	80	5	0	200	5010	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4480 mm and spans are lower than 12 m, so minimum CWH will be 4316 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB38A RUSH & LUSK FOOTBRIDGE

Approx.	Miles	13
Location	Yards	1564
Soffit height		~5200 mm
Width		3 m
Station		Y
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running solution with 300 mm of minimum encumbrance based on tolerances/allowances considered in hierarchy case 11 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB38A	11(*)	Static EC	4420	4221	18	56	75	0	25	20	30	0	320	0	150	5	0	0	5045	~5200
		Dynamic EC	4420	4221	18	56	75	0	25	20	30	25	320	110	100	5	0	0	5130	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4420 mm and span is lower than 30 m, so minimum CWH will be 4221 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

Hazard Cause	Hazard - The unsafe act or condition.	Hazard Event Description of the Hazard Event (the RISK) and the consequence.	EVALUATION F	EVALUATION C	EVALUATION Result	Safety Measures - mitigation description	EVALUATION F	EVALUATION C	EVALUATION Result
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Contact wire height < 4700 mm	Live parts of the OHLE or pantograph are closer to platform standing surface than minimum required	Electrocution	4	4	8	In the south side of the overbridge, the proposed adjacent span is lower than 46 m, so considering pretamping CWH at the overbridge is 4495 mm and in the adjacent structure would 4575 mm, the minimum CWH will be 4333 mm. Pantograph depth is 210 mm and therefore minimum height for live parts is 4123 mm from ToR. Worst envelope situation is considering 10 mm cant away from platform and 1110 mm platform height from the nearest rail, so minimum height of live parts from platform standing surface is 3014 mm. Therefore it fulfils the distance required in the EN50122-1 for 1500 V d.c. Cant and platform height values have been obtained from lidar surveys in Annex C of tender documentation.	2	4	6

OBB41 -

Approx. Location	Miles	14
	Yards	438
Soffit height		4703 mm
Width		6,7 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running solution with contenary with zero encumbrance based on tolerances/allowances considered in hierarchy case 14 given in the Functional Requirement Spectification for DART+ Programme but with 4400 mm CW height.

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB41	14	Static EC	4400	4261	25	14	50	0	25	20	30	0	0	0	100	5	0	0	4630	4703
		Dynamic EC	4400	4261	25	14	50	0	25	20	30	25	0	50	80	5	0	0	4685	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4400 mm and spans are lower than 12 m, so minimum CWH will be 4261 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB45 -

Approx.	Miles	15
Location	Yards	856
Soffit height		4715 mm
Width		4,81 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running solution with contenary with zero encumbrance based on tolerances/allowances considered in hierarchy case 13 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB45	13	Static EC	4400	4261	25	14	50	0	25	20	30	0	0	0	100	5	0	0	4630	4715
		Dynamic EC	4400	4261	25	14	50	0	25	20	30	25	0	70	80	5	0	0	4705	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4400 mm and spans are lower than 12 m, so minimum CWH will be 4261 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB46 BALDONGAN

Approx.	Miles	16
Location	Yards	172
Soffit height		~4860 mm
Width		7,1 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 10 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB46	10	Static EC	4500	4336	25	14	75	0	25	20	30	0	0	0	150	5	0	0	4805	~4860
		Dynamic EC	4500	4336	25	14	75	0	25	20	30	25	0	70	100	5	0	0	4850	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4500 mm and spans are lower than 12 m, so minimum CWH will be 4336 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5

OBB47 SKERRIES GOLF CLUB

Approx.	Miles	16
Location	Yards	1038
Soffit height		4900 mm
Width		4,74 m
Station		N
Flat/arched		Arched

PROPOSED ELECTRICAL SOLUTION

Free running solution with 100 mm of minimum dropper based on tolerances/allowances considered in hierarchy case 9 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB47	9	Static EC	4500	4223	27	125	75	0	25	20	30	0	0	0	150	5	0	0	4805	4900
		Dynamic EC	4500	4223	27	125	75	0	25	20	30	25	0	110	100	5	0	0	4890	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4500 mm and spans are lower than 12 m, so minimum CWH will be 4223 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB49 GOLF LINKS RD SKERRIES

Approx.	Miles	17
Location	Yards	524
Soffit height		4690 mm
Width		7,42 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running solution with contenary with zero encumbrance based on tolerances/allowances considered in hierarchy case 14 given in the Functional Requirement Spectification for DART+ Programme but with 4400 mm CW height.

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB49	14	Static EC	4400	4275	16	9	50	0	25	20	30	0	0	0	100	5	0	0	4630	4690
		Dynamic EC	4400	4275	16	9	50	0	25	20	30	25	0	50	80	5	0	0	4685	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4400 mm and spans are lower than 12 m, so minimum CWH will be 4275 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB51A SKERRIES FOOTBRIDGE

Approx.	Miles	17
Location	Yards	1708
Soffit height		4815 mm
Width		2,25 m
Station		Y
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 13 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB51A	13	Static EC	4480	4316	25	14	75	0	25	20	30	0	0	0	100	5	0	0	4735	4815
		Dynamic EC	4480	4316	25	14	75	0	25	20	30	25	0	70	80	5	0	0	4810	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4480 mm and spans are lower than 12 m, so minimum CWH will be 4316 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Contact wire height < 4700 mm	Live parts of the OHLE or pantograph are closer to platform standing surface than minimum required	Electrocution	4	4	8	In the station the proposed adjacent spans are lower than 30 m, so considering pretamping CWH is 4555 mm, the minimum CWH will be 4431 mm. Pantograph depth is 210 mm and therefore minimum height for live parts is 4221 mm from ToR. Worst point is 80 mm cant away from platform and platform height of 1165 mm from nearest rail, so minimum height of live parts from platform standing surface is 3060 mm.Therefore it fulfils the distance required in the EN50122-1 for 1500 V d.c. Cant and platform height values have been obtained from lidar surveys in Annex C of tender documentation. This distance has been compared with those of the latest overbridge survey and used the highest one.	2	4	6

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB57A BALBRIGGAN FOOTBRIDGE

Approx.	Miles	21
Location	Yards	1328
Soffit height		4775 mm
Width		2,38 m
Station		Y
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 13 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB57A	13	Static EC	4440	4276	25	14	75	0	25	20	30	0	0	0	100	5	0	0	4695	4775
		Dynamic EC	4440	4276	25	14	75	0	25	20	30	25	0	70	80	5	0	0	4770	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4440 mm and spans are lower than 12 m, so minimum CWH will be 4276 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Contact wire height < 4700 mm	Live parts of the OHLE or pantograph are closer to platform standing surface than minimum required	Electrocution	4	4	8	In the station the proposed adjacent spans are lower than 30 m, so considering pretamping CWH is 4515 mm, the minimum CWH will be 4391 mm. Pantograph depth is 210 mm and therefore minimum height for live parts is 3512 mm from ToR. Worst point is 80 mm cant away from platform and platform height of 1105 mm, so minimum height of live parts from platform standing surface is 3080 mm.Therefore it fulfils the distance required in the EN50122-1 for 1500 V d.c. Cant and platform height values have been obtained from lidar surveys in Annex C of tender documentation. This distance has been compared with those of the latest overbridge survey and used the highest one.	2	4	6

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB62 -

Approx.	Miles	22
Location	Yards	1573
Soffit height		~4880 mm
Width		7,85 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 10 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB62	10	Static EC	4500	4311	25	14	100	0	25	20	30	0	0	0	150	5	0	0	4830	~4880
		Dynamic EC	4500	4311	25	14	100	0	25	20	30	25	0	70	100	5	0	0	4875	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4500 mm and spans are lower than 12 m, so minimum CWH will be 4311 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5

OBB63 -

Approx.	Miles	23
Location	Yards	866
Soffit height		4735 mm
Width		4,47 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 13 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB63	13	Static EC	4400	4236	25	14	75	0	25	20	30	0	0	0	100	5	0	0	4655	4735
		Dynamic EC	4400	4236	25	14	75	0	25	20	30	25	0	70	80	5	0	0	4730	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4400 mm and spans are lower than 12 m, so minimum CWH will be 4236 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6

OBB66 GORMANSTOWN STATION ROADBRIDGE

Approx.	Miles	24
Location	Yards	19
Soffit height		4880 mm
Width		4,52 m
Station		Y
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 10 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB66	10	Static EC	4525	4361	25	14	75	0	25	20	30	0	0	0	150	5	0	0	4830	4880
		Dynamic EC	4525	4361	25	14	75	0	25	20	30	25	0	70	100	5	0	0	4875	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

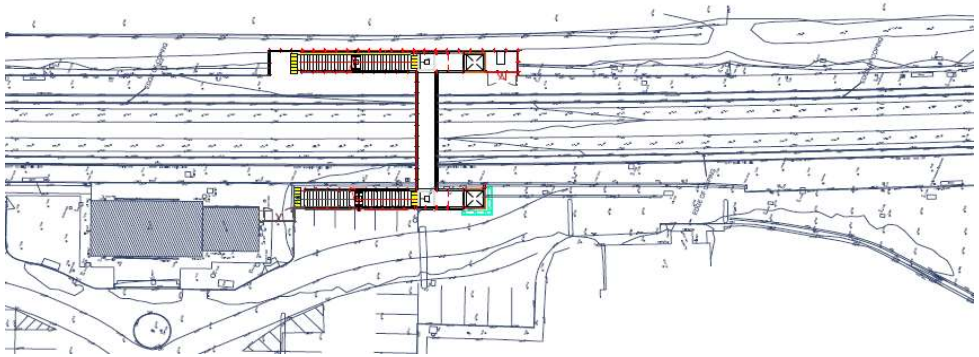
- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4525 mm and spans are lower than 12 m, so minimum CWH will be 4361 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Contact wire height < 4700 mm	Live parts of the OHLE or pantograph are closer to platform standing surface than minimum required	Electrocution	4	4	8	In the station the proposed adjacent spans are lower than 45 m, so considering pretamping CWH is 4600 mm, the minimum CWH will be 4398 mm. Pantograph depth is 210 mm and therefore minimum height for live parts is 4188 mm from ToR. Worst situation is considering 110 mm cant towards the platform and platform height is 1050 mm, so minimum height of live parts from platform standing surface is 3112 mm.Therefore it fulfils the distance required in the EN50122-1 for 1500 V d.c. Cant and platform height values have been obtained from lidar surveys in Annex C of tender documentation. This distance has been compared with those of the latest overbridge survey and used the highest one.	2	4	6

OBB66A(T GORMANSTOWN STATION FOOTBRIDGE (PLANNED)

Approx. Location	Miles	24
	Yards	120
Soffit height		~5274 mm
Width		2,55 m
Station		Y
Flat/arched		Flat



PROPOSED ELECTRICAL SOLUTION

Free running solution with 100 mm minimum encumbrance based on tolerances/allowances considered in hierarchy case 6 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB66A(TBC)	6	Static EC	4645	4275	33	187	100	0	25	20	30	0	150	0	270	5	0	0	5245	5274
		Dynamic EC	4645	4275	33	187	100	0	25	20	30	25	150	110	150	5	0	0	5260	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4645 mm and spans are lower than 55 m, so minimum CWH will be 4275 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Contact wire height < 4700 mm	Live parts of the OHLE or pantograph are closer to platform standing surface than minimum required	Electrocution	4	4	8	In the station the proposed adjacent spans are lower than 60 m, so considering pretamping CWH is 4745 mm, the minimum CWH will be 4436 mm. Pantograph depth is 210 mm and therefore minimum height for live parts is 4226 mm from ToR. Worst situation is considering 110 mm cant towards the platform and platform height is 1050 mm, so minimum height of live parts from platform standing surface is 3150 mm.Therefore it fulfils the distance required in the EN50122-1 for 1500 V d.c. Cant and platform height values have been obtained from lidar surveys in Annex C of tender documentation. This distance has been compared with those of the latest overbridge OBB66 survey and used the highest one.	2	4	6

OBB68 -

Approx.	Miles	24
Location	Yards	1757
Soffit height		4920 mm
Width		6.55 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Free running contenary solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 10 given in the Functional Requirement Spectification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB68	10	Static EC	4540	4351	25	14	100	0	25	20	30	0	0	0	150	5	0	0	4870	4920
		Dynamic EC	4540	4351	25	14	100	0	25	20	30	25	0	70	100	5	0	0	4915	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4540 mm and spans are lower than 12 m, so minimum CWH will be 4351 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5

OBB77 -

Approx. Location	Miles	29
	Yards	1452
Soffit height		~4850 mm
Width		8,2 m
Station		N
Flat/arched		Flat

PROPOSED ELECTRICAL SOLUTION

Fitted solution with zero encumbrance based on tolerances/allowances considered in hierarchy case 13 given in the Functional Requirement Specification for DART+ Programme

			Nominal CW height	Minimum position of the contact wire	Pre/Natural sag (OHLE Messenger + Contact wire)	Sag due to Ice Load (OHLE Messenger + Contact wire)	Track Maintenance Tamping allowance	Track Construction tolerance	Track Maintenance tolerance	OHLE construction tolerance	OHLE maintenance tolerance	CW and panto wear	System height	Uplift	Electrical clearance	Survey tolerance	Support height (fitted solution)	Arched allowance (Arched deck overbridges)	Minimum soffit height (mm)	Actual soffit height (mm)
OBB77	13	Static EC	4400	4261	25	14	50	0	25	20	30	0	0	0	100	5	120	0	4750	~4850
		Dynamic EC	4400	4261	25	14	50	0	25	20	30	25	0	70	80	5	120	0	4825	

RISKS ASSESSMENT

The evaluation of risks considers the evaluation of the frequency (F) of occurrence of the event and the evaluation of the consequence (C) of the event in case it occurs. In both cases, they can be ranked from 1 (low likely of occurrence/low impact) to 5 (high likely/high impact). The risk evaluation (2 to 10) is obtained from the sum of both categories:

- Result 7 or higher: Intolerable risk
- Result 5 or 6: Tolerable risk
- Result 4 or lower: Negligible low risk

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Contact wire located closed to rolling stock than minimum required	Touch potential, Electrocution	4	4	8	In the overbridge, proposed CWH is 4400 mm and spans are lower than 12 m, so minimum CWH will be 4261 mm according to the allowances and sag considered in the FRS and therefore higher than absolute minimum (4190 mm) given in the CME- TMS-327 Vehicle Gauging and in the FRS. In adjacent spans, span lengths will be limited in order to maintain the CWH higher than 4190 mm in any case.	1	4	5

			EVALUATION				EVALUATION		
Hazard Cause	**Hazard -** The unsafe act or condition.	**Hazard Event** Description of the Hazard Event (the RISK) and the consequence.	**F**	**C**	**Result**	**Safety Measures - mitigation description**	**F**	**C**	**Result**
Contact wire height < 4700 mm	Steep transition between nominal CWH and required CWH in the overbridge	Bad dynamic behaviour and quality of current collection. Increase of pantograph and contact wire wear.	5	2	7	Transition between different contact wire height will respect values given in the FRS. These values are according to values indicated in Table 11 of EN50119 for required design speed.	3	2	5
Restricted electrical clearances of new OHLE at legacy structures, due to local route constraints.	Public use of legacy overbridges and structures with reduced electrical clearances.	Touch potential, Electrocution	4	4	8	Proposed OHLE solution considers static electrical clearance of 100 mm and dynamic electrical clearance of 80 mm, which are the minimum values according to I-ETR-4101 / Maintenance Parameters for 1500 Vdc OHLE; chapter 2.2 Electrical Clearances - subchapter 2.2.1 and FRS. Additionally flashover protection could be also considered.	2	4	6
Insufficient load capacity of overbridge structure	Adding additional construction loads to structure	Instability and collapse of existing structure	3	5	8	Capacity of the overbridge will be checked in the following stages of the design	1	5	6

Appendix B

Reports E1 to E6

Reports are as follows:

- E1- OBB39 Options Report
- E2- OBB44 Options Report
- E3- OBB55 Options Report
- E4- OBB78 Options Report
- E5- OBB80/80A/80B Options Report
- E6- OBB81 Options Report