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Iarnród Éireann
Irish Rail

25th October 2024

[redacted]

Email: [redacted]

Re: Response: FOI request IE_FOI_842

Dear [redacted]

I refer to your request dated 21st September 2024 made under the Freedom of Information Act 2014, which was received by my office on 23rd September 2024, for records held by Iarnród Éireann.

Request:

Copy of all DART+ Coastal South Greystones Capacity Improvements Technical Note D+WP56- ARP-P2-SL-RP-OP-000001
DART+ Coastal Performance Modelling Results D+WP56-ARP-ZZ-AL-RP-OP-000001
DART+ Coastal BEMU B2 Substation – SET Preliminary Design Report-D+WP56-ARDP3-BE-RP-HV-000002-P08
DART+ BEMU Planning Report D+WP56-ARP-P4-BE-RP-RO-000003
BEMU Options Study D3422300-JAC-REP-EMF-000001 | P04
NTA Greater Dublin Area Transport Strategy 2022-2042, including Bray to Arklow Area Based Transport Assessment
Department of Transport and Department for Infrastructure Draft All Island Strategic Rail Review
South Eastern Line Capacity Study 2011 ¢ Wicklow County Development Plan 2022-2028
Wicklow Town & Rathnew Local Area Plan Pre-Draft Issue 2023 and 2013-2019.
Greystones / Delgany & Kilcoole Local Area Plan 2013 – 2019.

I, Paul Wilcock, have now made a final decision to part grant your request on 24th October 2024. You have sought access to the records as listed above and I consider this an appropriate form of access in this case. Accordingly, a copy of the records is now attached including a copy of the schedule to these records.

Rights of appeal

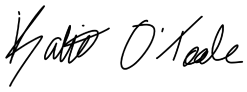
In the event that you are not happy with this decision you can make an appeal in relation to this matter, you can do so by writing to the FOI Unit, Corporate Communications, Iarnród Éireann Irish Rail, Connolly Station, Amiens St, Dublin 1 or by e-mail to foi@irishrail.ie. You should make your appeal within 4 weeks (20 working days) from the date of this notification, where a day is defined as a working day excluding, the weekend and public holidays, however, the making of a late appeal may be permitted in appropriate circumstances.
The appeal will involve a complete reconsideration of the matter by a more senior member of the staff of this body.
Should you have any questions or concerns regarding the above, please contact the FOI Office on [redacted]

Should you wish to discuss the above, please contact me by email at FOI@irishrail.ie or by phone at [redacted]

Yours sincerely,

Cathaoirleach Chairman - P Gaffney(UK), **Stiúrthóirí** Directors: F Allen, C Griffiths (UK), T McGee(UK), M McGreevy (UK), J Moloney; F O'Mahony, T Wynne; **Príomh Fheidhmeannach** Chief Executive: D Franks
Iarnród Éireann – Irish Rail, cuideachta ghníomhaíochta ainmnithe, faoi theorainn scaireanna, cláraithe in Éirinn ag Stáisiún Uí Chonghaile, Baile Átha Cliath 1, Ur. 119571 Ur. CBL: IE 4812851 O
Iarnród Éireann – Irish Rail, a designated activity company, limited by shares, registered in Ireland at Connolly Station, Dublin 1, No. 119571 VAT No. IE 4812851 O

PP



Mr Paul Wilcock, Decision Maker, Iarnród Éireann

Freedom of Information Request:
Schedule of Records for IE_FOI_842 : Summary for Decision Making

Record No.	Date of Record	Brief Description	No. of Pages	Decision: Grant/Part Grant/Refuse	Section of Act if applicable	Record Edited/Identify Deletions
1		D+WP56-ARP-P2-SL-RP-OP-000001		Part Grant	S33	Personal Information of others
2		D+WP56-ARP-ZZ-AL-RP-OP-000001		Part Grant	S34	Personal Information of others
3		D+WP56-ARDP3-BE-RP-HV-000002 08		Part Grant	S35	Personal Information of others
4		D+WP56-ARP-P4-BE-RP-RO-000003		Part Grant	S36	Personal Information of others
5		D+WP56-ARP-P4-BE-RP-RO-000003 P19		Part Grant	S37	Financial information
6		D3422300-JAC-REP-EMF-000001 P04		Part Grant	S37	Personal Information of others



Signed: Katie O'Toole
Data Protection & Freedom of Information Office

Iarnród Éireann

DART+ Coastal South

Greystones Capacity Improvements Technical Note

D+WP56-ARP-P2-SL-RP-OP-000001

P01 | 23 November 2021

[redacted]

Draft

This report considers the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Iarnród Éireann Irish Rail
ARUP

Document verification

ARUP

Job title		DART+ Coastal South		**Job number** 279933-00
Document title		Greystones Capacity Improvements Technical Note		**File reference**
Document ref		D+WP56-ARP-P2-SL-RP-OP-000001		
Revision	**Date**	**Filename**	Bray to Greystones Operations Review Note.docx	
P01	23 Nov 2021	Description	First issue for IÉ review and comment	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	[redacted]
		Signature		[redacted]	
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
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		Description			
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			Prepared by	Checked by	Approved by
		Name			
		Signature			
				Issue Document verification with document	✓

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Appendix A

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Sketches



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1 Executive Summary

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature.

As part of quantitative and qualitative modelling and rail operations investigations into improving service levels between Bray and Greystones DART stations, Arup finds that a 3 TPH service pattern (1 additional train per hour) is the optimal improvement, and can be best achieved through the following package of works:

- The provision of a passing loop from near Bray Head Tunnel Number 4 for 800m towards Greystones;
- The addition of a crossover at Bray Stati[redacted]rm approach road to Platform 1 (Up), removing the constraint at Bray 115B Points;
- Removing the ATP banding speed restriction from the legacy signalling train protection system.

This package of infrastructure and service enhancements will achieve a 50% increase in services, while minimising the possibility of Bray to Greystones services becoming a problematic timetabling constraint to the rest of the DART network. This report proves that there is sufficient platform capacity at Greystones to accommodate a 1 TPH service from Rosslare, in addition to the 3 TPH DART services.

While this report finds it technically possible to achieve a future service level of 4TPH, this is not recommended. A 4 TPH solution would require substantial capital investment compared to a 3 TPH solution, while posing a greater reliability risk, both to Bray to Greystones services, and the wider DART network.

Lastly, this note's recommendation of 3 TPH will impact the parallel Bray Station Turnback optioneering process, as all Bray Station solutions must at minimum be able to handle turning back 9 TPH services.

This note has been produced to allow for a decision on the service specification and principle form of infrastructure interventions to Greystones to be confirmed which will allow optioneering of the Bray to Greystones area to progress.

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2 Introduction

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature. An obvious solution to this problem would be to double track the line; however, this section of railway crosses difficult terrain adjacent to the Irish Sea. Any expansion would require significant civil engineering works, at a capital cost likely not commensurate with the benefits coming from increased capacity and reliability. As such, Arup's task is to examine more cost-effective methods to increase capacity to either 3 or 4 TPH, and evaluate both options in light of the infrastructure they would require, and the impact each frequency would have on the wider DART+ network.

It is worth noting that minimising the run time between Bray and Greystones is not considered an important factor and, as will be seen in the analysis outputs presented below, providing a longer run time has benefits in improving capacity and reliability.

A report by Jacobs in 2020 examined the practical infrastructure enhancement choices and settled on a combination of extending double tracking south from Bray and north from Greystones to minimize the length of single tracking. Arup's investigation uses this study as a starting point, developing further options off the initial proposal.

The purpose of this note is as follows:

1. To present Arup's infrastructure options for providing both a 3 TPH or 4 TPH service to Greystones.
2. To explain the infrastructure requirements, Bray to Greystones performance, and wider DART network impacts of choosing to run either 3 TPH or 4 TPH.
3. To identify infrastructure recommendations.
4. To provide some high-level costings of the infrastructure for a 3 TPH and a 4 TPH service.
5. To advise IÉ to either pursue a 3 TPH or 4 TPH service between Bray to Greystones, and present a preferred set of infrastructure solutions to achieve the recommended service level.

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3 Existing Capacity Constraints

In addition to the length of single line section , there are a number of other existing constraints worth noting.

3.1 ATP Speed banding

The current signalling arrangements include automatic train protection (ATP) speed banding which limits the speed a train can travel to a margin lower than the line speed.

Arup understands that IÉ is planning a separate signalling project that will upgrade the current train protection system to a more modern system, removing these limits and allowing trains to run at the line speed.

This note assumes that this signalling work on th[redacted]ction is completed, thereby removing the current speed limits caused by (ATP) banding.

Arup analysed a further set of options on the effects of not removing ATP banding, but these have not been included in this note. This analysis concludes that it is essential for the signalling works to be carried out for any 4 TPH scenario. For 3 TPH the results indicate it is marginally possible to provide increased services without the signalling works, but would require significant other infrastructure upgrades such as double tracking through Greystones.

3.2 Bray 115B Points

The points shown in Figure 1 below are just south of Bray Station and provide a significant operational constraint on the network.

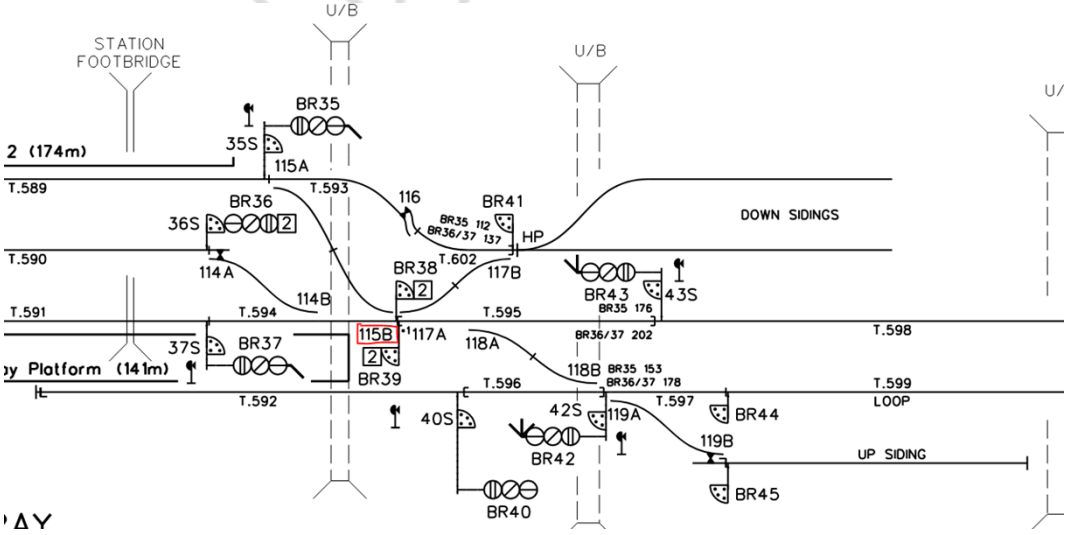


Figure 1: Excerpt from IÉ signalling diagram, showing Bray Station

They provide a single point at which all of the following moves must pass through and will therefore conflict:

- All trains leaving Bray and heading towards Greystones;
- All trains arriving at Bray from Greystones;
- All trains departing the Down sidings and heading to the Bray Platform 1;
- All trains heading to and/or from the Up sidings at Bray.

The signalling design for this area also compounds the operational restriction. The main route for all southbound services passes through the Down platform, whose protecting signal, BR35, has an overlap that stretches beyond points 115B to fully encompass the junction. This means that a train sat or passing through the main Down platform will block any train coming in the opposite direction, preventing any parallel moves through Bray Station. [redacted]

3.3 Greystones platform Occupancy

The TSS assumes that to provide the additional DART capacity on the Bray to Greystones section the existing Rosslare services will terminate at Greystones. Checks have been undertaken against the options to determine if any additional infrastructure is required at Greystones to provide the required platform capacity for the Rosslare services.

3.4 Line speeds

There are small discrepancies between the start and stop locations of line speed changes provided in the RailSys model to those in the working timetable (WTT). Arup has reviewed these and confirms there is no meaningful difference between the two on the findings of this study.

4 Operational Modelling

Arup undertook RailSys modelling and high level quantitative analysis to examine what infrastructure enhancements would be required to meet the increased frequencies of 3 and 4 TPH. Through an optioneering process, Arup tested a series of design solutions, building the infrastructure in RailSys to test the performance of different track layouts.

Using technical outputs — such as signal occupation/clearance times — Arup undertook a finer grained quantitative analysis in excel, examining performance in light of:

- Capacity Utilisation;
- Runtime;
- Runtime allowance;

- Minimum Time Between Opposing Services.

The below options are based on different permutations of infrastructure options that are deemed viable within the project scope for improving capacity (in essence ruling out double tracking, tunnelling, or extensive work around Bray Head).

The analysis considered five constituent infrastructure components:

a. Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m (suffix a).

b. Passing Loop from Bray Head Tunnel Number 4 for 800m towards Greystones (suffix b).

c. Double Tracking from Bray Station for 700m to Putland Road (suffix c).

f. A southern headshunt at Greysto[redacted]

h. Removal of the constraint at 115B points through the provision of an additional connection from the Bay platform approach to the Up Bray platform (suffix h). This allows for a shorter but less expensive extension of double tracking using an existing up loop road.

The suffixes provide a shorthand for explaining which combination of constituent infrastructure components each individual option is made up of. For example, Option 2acf is made up of:

a. *Suffix a (Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m)*

+

c. *Suffix c (Double Tracking from Bray Station for 700m to Putland Road)*

+

f. *Suffix f (A southern headshunt at Greystones Station)*

All options are prefixed with a 2, as part of a comprehensive numbering system for all options involving Bray Station, Bray to Greystones, and Greystones Station. Prefix "2" indicates that the option assumes the removal of ATP speed banding.

		Greystones		Greystones	Bray	Signalling
Option Name	Description	Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
2a	Double Tracking Greystones	✓	X	X	X	✓
2b	Greystones Loop	X	✓	X	X	✓

2c	Bray Double Track	X	X	X	✓	✓
2ac	Greystones + Bray Double Tracking	✓	X	X	✓	✓
2acf	Greystones + Bray Double Tracking + South Turnback	✓	X	✓	✓	✓
2acf+	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	✓	X	✓	✓	✓
2bc	Greystones Loop + Bray Double Track	X	✓	X	✓	✓
2bh	Greystones Loop + Bray Additional Crossover	X	✓	X	✓*	✓

Table 1: Infrastructure options and constituent components

In line with other DART+ Coastal project analyses, Arup used a capacity utilisation value of around 75% to be the cut-off towards failing an option. This is in line with UIC Code 406, which recommends a capacity utilisation rate of at maximum 75% for mixed traffic lines during the peak hour.

For each option, Arup developed a theoretical timetable, with trains leaving at regular intervals. In reality, trains on this section may not be evenly spaced, with arrival and departure times instead dictated by other constraints on different parts of the DART network.

As such, due to the single-track nature of the Bray to Greystones route and the fact that services on this section will be interlined with other DART services in the city centre, Arup considers it necessary to provide the maximum possible spare capacity, thus increasing service reliability and timetabling flexibility. For higher train frequencies of 4 TPH, Arup assumes that a 75% capacity utilisation rate is the hard maximum, with any preferred option ideally having a substantially lower capacity utilisation to allow for some redundancy in timetable planning and in times of delay. For 3 TPH scenarios, Arup assumes that capacity utilisation rates may still be judged as passing even if they are 1-2 % over 75%, due to the smaller quantum of trains lessening the need to provide substantial timetabling redundancy.

4.1 Results

4.1.1 3 TPH

As can be seen below, all options can provide adequate capacity to enable 3 TPH. Additionally, there is an approximately 1 minute's difference in runtime between the fastest and slowest option, with Option 2acf providing almost obstruction free runtime, and Option 2a requiring substantial pathing allowance in order to facilitate passing services in the up and down directions.

Note that for all options involving a loop at Greystones, at least one direction must stop and dwell for 30 seconds in order to enable the passing move. This has a negative effect on runtime, but greatly decreases capacity utilisation. Option 2a instead requires trains in the Up direction to operate far below the rolling stock's peak performance, allowing for the passing move without necessitating a stop at the end of the double track section.

It should also be noted that the Minimum Opposing Gap is a value showing the closest time in between two services coming into conflict, with a higher value representing a more robust option.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option 2a	Double Tracking Greystones	PASS	00:09:19	00:00:05	00:07:42	76%		1	50%
Option 2b	Greystones Loop	PASS	00:08:48	00:00:11	00:07:43	70%		1	47%
Option 2c	Bray Double Track	PASS	00:08:03	00:02:48	00:08:01	72%		2	65%
Option 2ac	Greystones + Bray Double Tracking	PASS	00:08:14	00:01:48	00:08:16	64%		2	62%
Option 2acf	Greystones + Bray Double Tracking + South Turnback	PASS	00:07:58	00:04:47	00:07:58	59%		2	44%

Option 2acf+	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:04:17	00:07:58	55%		2	44%
Option 2bc	Greystones Loop + Bray Double Track	PASS	00:08:58	00:00:18	00:07:59	57%		1	47%
Option 2bh	Greystones Loop + Bray Additional Crossover	PASS	00:09:19	[redacted]	00:07:42	76%		1	

Table 3: Performance of options for 3 TPH

4.1.2 4 TPH

Adding an additional train per hour requires significantly higher levels of infrastructure enhancement, as well as creative use of such infrastructure. All successful options include the double tracking from Bray station, and either a loop or double tracking from Greystones. The highest performing options combines a double tracking at Bray and at Greystones with a southern head shunt, as well as a 1 second dwell at the end of the Greystones double tracking.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option 2a	Double Tracking Greystones	FAIL	00:09:19	-00:02:03	00:07:42	101%		1	17%
Option 2b	Greystones Loop	FAIL	00:08:48	-00:00:18	00:07:58	94%		1	17%
Option 2c	Bray Double Track	FAIL	00:08:03	00:00:21	00:08:01	97%		2	64%
Option 2ac	Greystones + Bray Double Tracking	FAIL	00:09:30	00:00:02	00:07:58	85%		1	17%

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Option 2acf	Greystones + Bray Double Tracking + South Turnback	FAIL	00:07:58	00:00:07	00:07:58	78%		2	77%
Option 2acf+	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:01:22	00:07:58	73%		2	73%
Option 2bc	Greystones Loop + Bray Double Track	FAIL	00:08:58	[redacted]	07:59	77%		1	17%
Option 2bh	Greystones Loop + Bray Additional Crossover	FAIL				77%		1	

Table 4: Performance of options for 4TPH

Greystones and Rosslare Services

For all 3 TPH options, there is sufficient capacity in the existing two platform layout at Greystones to accommodate a 1 TPH terminating service from Rosslare. For Option 2acf at 4 TPH, Greystones requires an additional south facing platform to be able to robustly handle both DART and DMU services. All other options at 4 TPH have sufficient capacity in the existing layout to handle the additional 1 TPH Rosslare service without an additional platform.

Note that the capacity utilisation value is calculated as the largest available gap between services, divided by an assumed time of 10 minutes that it would take a Rosslare DMU service to occupy a platform, de-train its passengers, and vacate the platform, including junction margins (6 minute platform re-occupation + 3 minute junction margin + 1 minute journey time).

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5 Impact on Bray and TSS 1C

The planned service level to Greystones has a potential impact on the infrastructure required at Bray to deliver TSS 1C. Under TSS 1C it is required to turnback at minimum 10 DARTs at Bray. If additional services are proposed to Greystones the number of turnback services to turnback at Bray will proportionally decrease.

It is considered likely that it will still be operationally beneficial to allow the full 10 DARTs to turnback at Bray, therefore checks have been undertaken on the options to determine if this service pattern can be provided.

Full optioneering of the Bray turnback works have yet to be completed, however to allow for a fair comparison of the Bray to Greystones options the following are applied to the recommended infrastructure and costing assessment that follows.

- The double tracking at Bray for 700m (suffix c) will provide the infrastructure required for turning back 10 TPH at Bray;
- Where the Bray double tracking is not provided in an option infrastructure suffix h is applied at Bray (i.e., the additional crossover).

The Bray area is also required to accommodate stabling of trains (7 No.). Currently the changes noted above at Bray have the following impacts on stabling:

- Infrastructure suffix h provides a stabling Capacity of 5 FLUs. The drawings provided demonstrate how this could be increased to 7FLUs;
- The double tracking at Bray for 700m (suffix c) provides a stabling capacity of 4 FLUs. It is considered this can be increased to 7 FLUs through the inclusions of the works illustrated on Infrastructure suffix h plus the lengthening of one down siding with bridge widening.

It is important to note these are not necessarily the recommended stabling works, however are provided to allow for a fair comparison of costs.

5.1.1 Operational Reliability

Due to the performance risks inherent in operating a single-track railway, it is imperative that any infrastructure solution offers the greatest possible performance, in order to enhance reliability and flexibility.

Furthermore, the DART+ network is highly interlined, and timetables are already constrained in the following areas:

- Glasnevin Junction;
- Ossory Road Junction;
- Connolly Station Platforms 5-7;

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- Turnback services at Bray, Grand Canal Dock, Connolly, Clongriffin, Malahide, and Drogheda;
- Possible passing locations for Enterprise services.

Since Bray-Greystones services will be interlined with wider DART+ services, they could become an additional constraint onto the DART+ timetable. This compounds the reliability risks coming from operating this section of single-track railway.

6 Infrastructure Interventions

In line with the above modelling analysis, this note presents a recommended infrastructure solution to provide the 3 TPH and 4 TPH as follows:

6.1.1 3 TPH Preferred Option [redacted]

To accommodate a service level of 3 TPH, Arup recommends Option 2bh:

b. The provision of a passing loop from Bray Head Tunnel Number 4 for 800m towards Greystones;
h. The addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points

This combines the relatively high performance of the Bray additional crossover, which unlocks a shorter section of double tracking in the station area, with the high performance and lower relative cost of the Greystones loop.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

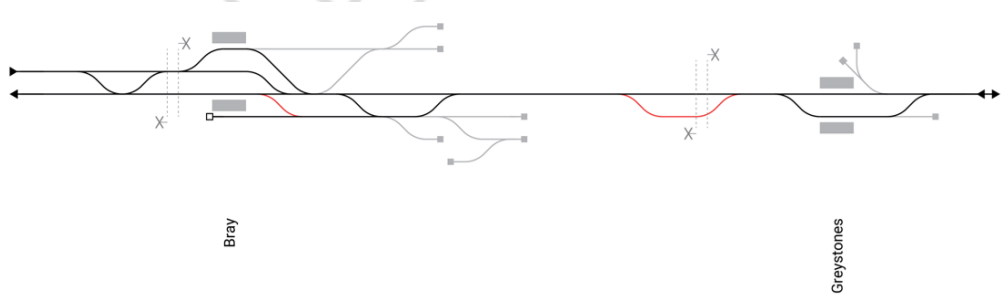


Figure 2: Preferred 3 TPH Option 2bh

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
X	✓	X	✓	✓

Table 6: Option 2bh components

4 TPH Preferred Option

To accommodate a service level of 4 TPH, Arup recommends Option 2acf+:

a. The provision of double tracking from Bray station for 700m to Putland Road;
c. The provision of double tracking from Greystones station to Bray Head Tunnel Number 4 for 2400m;
f. A southern headshunt at Greystones Station;

This option also requires an operation enhancement, with Up direction trains departing Greystones to dwell for 1 second at the end of the Greystones double track section.

This option also requires additional stabling cha[redacted]e TSS— these remain to be developed.

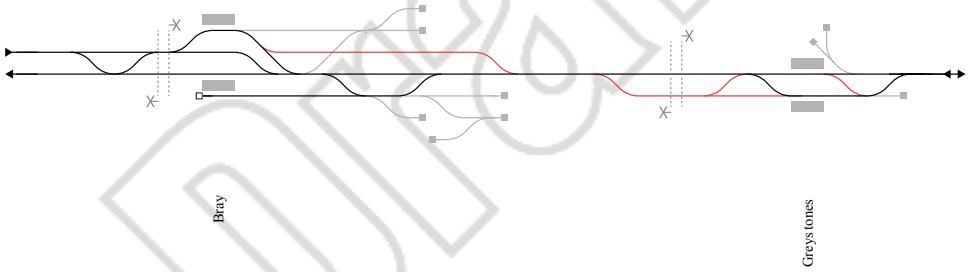


Figure 3: Preferred 4TPH Option 2acf+

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
✓	X	✓	✓	✓

Table 8:Option 2acf+ components

Since Greystones services will be interlined directly with DART services through the City Centre Loop Line, it is essential that any option provide a substantial level of flexibility and robustness. Service timetabling is already dictated by

pathing constraints in other parts of the network as described in 5.1.1; therefore, it is highly preferable that there are no additional timetabling constraints from the Bray to Greystones section. Aiming to operate a 4 TPH service between Bray and Greystones will be challenging; therefore, to minimise performance risk to the rest of the network any feasible option must provide the near maximum level of infrastructure and operational enhancements — short of investing in fully double tracking.

As such, for 4 TPH Arup recommends Option 2acf+. This option adds all possible infrastructure enhancements, with significant sections of double track, dedicated arrival and departure platforms at Greystones, and with DART services turning back at a separate point on a siding clear of the mainline.



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7 Costings

To Follow

7.1 General

7.2 3 trains per hour

7.3 4 trains per hour



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8 Conclusion

Due to the need to provide a more than normal level of robustness and capacity and the fact that a service level of 4 TPH only works with the most intensive of infrastructure interventions (and even then only with a small margin of robustness) Arup proposes that IÉ aim to provide a service level of 3 TPH between Bray and Greystones.

There are two fundamental reasons Arup recommends operating 3 TPH rather than 4 TPH:

1. Introducing a 4 TPH service on to this section of line will introduce another critical constraint on the DART network. The network already has a number of other critical junctions and constraints which pose challenges for timetable planning and for providing a reliable service. The introduction of a 4 TPH service where th[redacted]bility will result in challenges keeping a reliable service.
2. The Cost of the Infrastructure required for 4 TPH is significantly greater than that of the 3 TPH (TBC).

To achieve a 3 TPH service, Arup recommends adopting Option 2bh: Greystones Loop with Bray Additional Crossover. This option provides a good level of operational robustness, while minimising capital construction costs and disruption.

8.1 Next Steps

Following a decision on whether to proceed with 3 TPH or 4 TPH for the chosen Greystones service, the design and optioneering can be developed in conjunction with the TSS and stabling requirements at Bray.

Detailed signalling and permanent way design will be required to refine Option 2bh into a viable constructable project. Future sensitivity analysis can also be undertaken to understand the balance between shortening the Bray double track section while still meeting the capacity requirements of 3 TPH.

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Appendix A

Sketches

[redacted]

Draft

A1 Costing sketches

The following sketches/drawings have been used to provide the cost estimate

4TPH

Jacbos Layouts

32110401-JAC-GCN-XX-DR-CE-0001

32110401-JAC-GCN-XX-DR-CE-0003

32110401-JAC-GCN-XX-DR-CE-0004

Southerfn Greystones Turnback

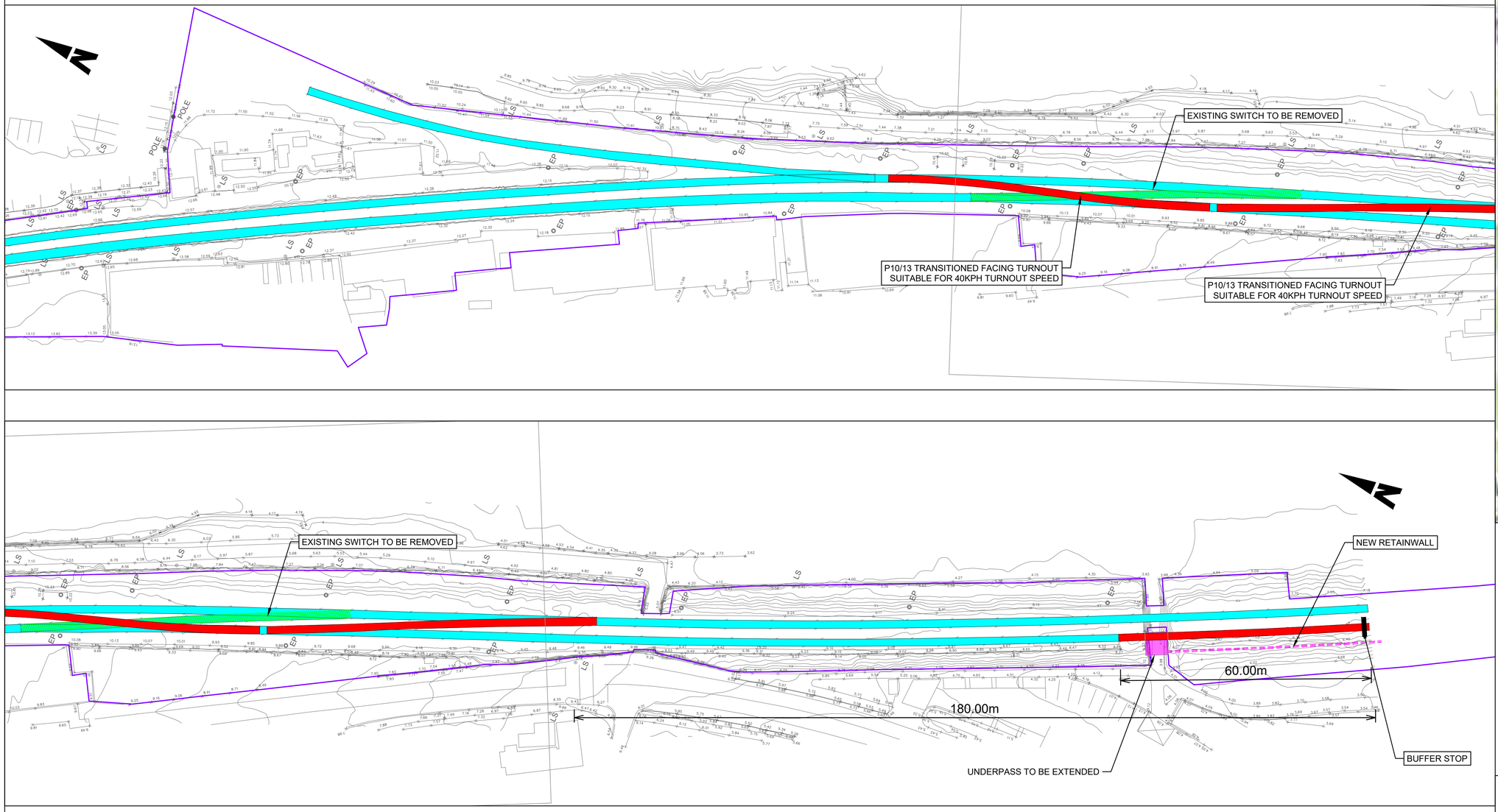
Greystones down stabling [redacted]

3TPH

Bray points 115 works

Greystones Loop

Draft





LEGEND:

- IRISH RAIL PROPERTY BOUNDARY
- EXISTING RAIL TRACK RETAINED
- EXISTING RAIL TRACK REMOVED
- NEW RAIL TRACK
- DRIVERS WALKWAY
- NEW RETAINING WALL
- EXISTING RAILWAY PLATFORM

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DART+ Coastal North

NTA Údarás Náisiúnta Iompair National Transport Authority

Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
P01	10/09/2021				--

Client: Iarnród Éireann Irish Rail	Engineering Designer: ARUP			
Date: 10/09/2021	Scale: 1:500 @ A1, 1:1000 @ A3	Drawn	Checked	Approved
Project Code: D+WP56	Originator Code: ARP	QMS Code: 280275-00		

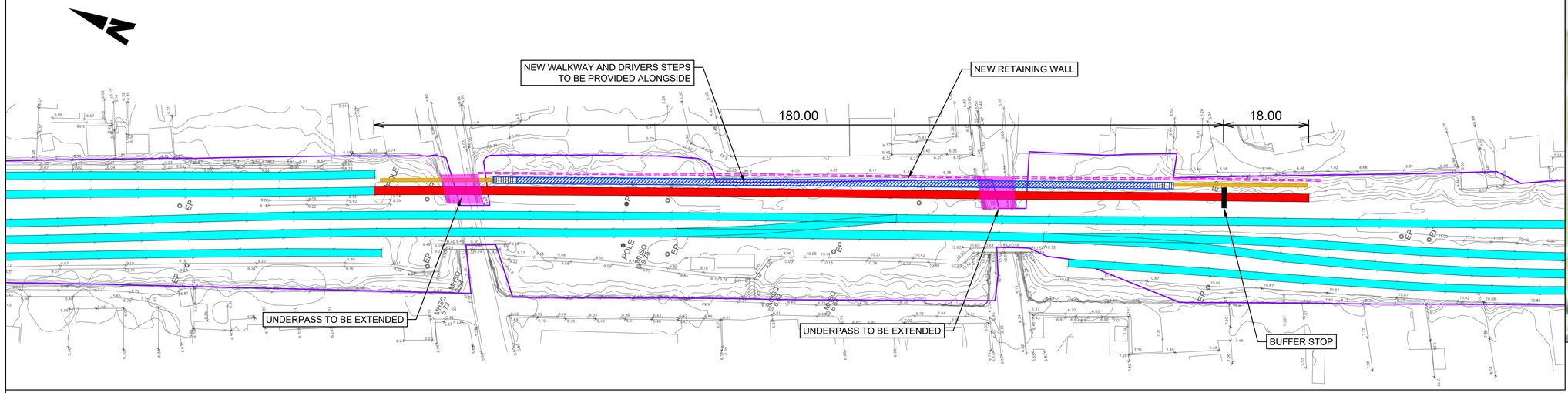
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Drawing Title: GREYSTONES SOUTHERN TURNBACK

Drawing File Name	Sheet Number	Status	Rev
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LEGEND:

- IRISH RAIL PROPERTY BOUNDARY
- EXISTING RAIL TRACK RETAINED
- EXISTING RAIL TRACK REMOVED
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Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Project Title: **DART+ COASTAL NORTH**

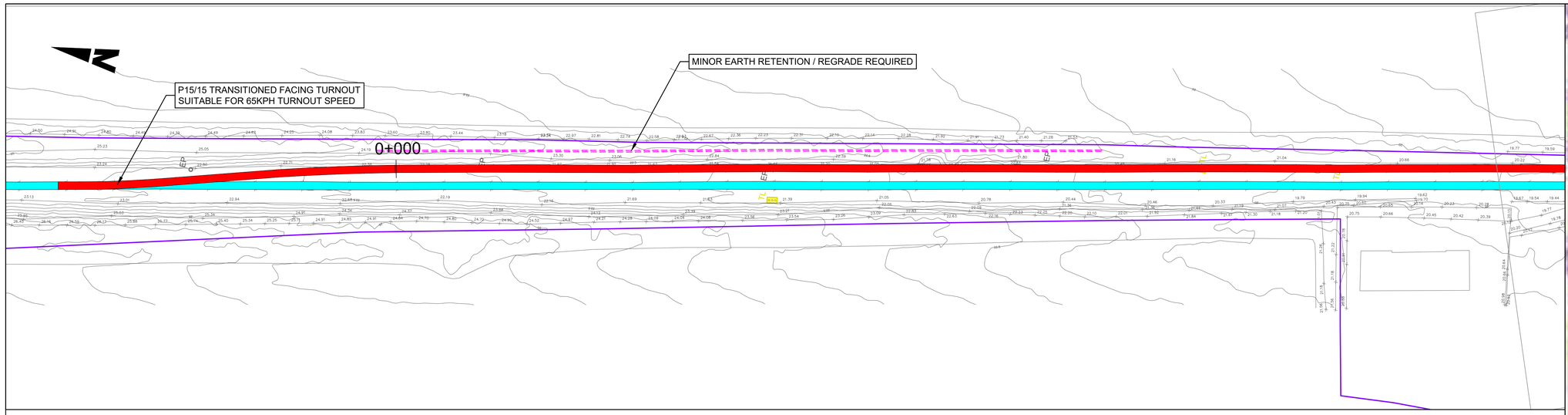
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ADDITIONAL STABING OPTION
SINGLE DOWN SIDING EXTENSION

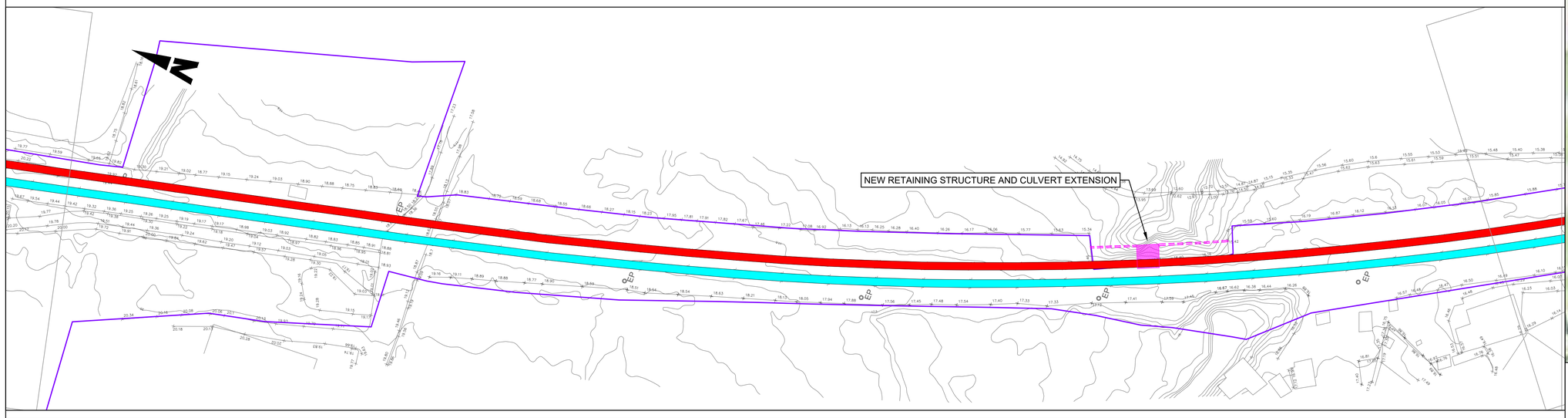
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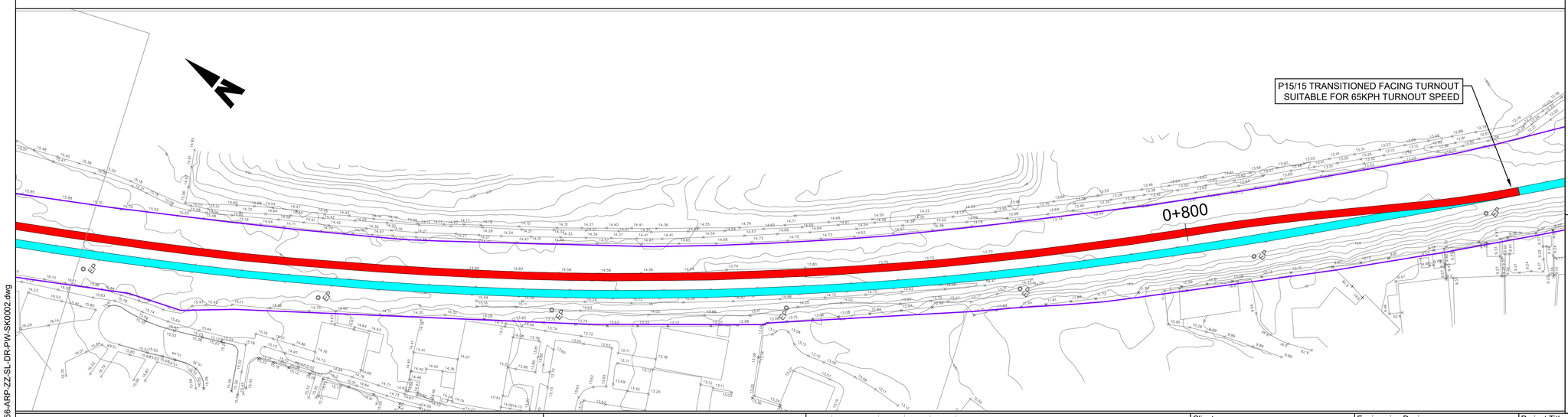
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LEGEND:

- IRISH RAIL PROPERTY BOUNDARY
- EXISTING RAIL TRACK RETAINED
- EXISTING RAIL TRACK REMOVED
- NEW RAIL TRACK
- DRIVERS WALKWAY
- NEW RETAINING WALL
- EXISTING RAILWAY PLATFORM

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Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
P01	10/09/2021				--

Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Date	Scale	Drawn	Checked	Approved
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Project Code	Originator Code	QMS Code
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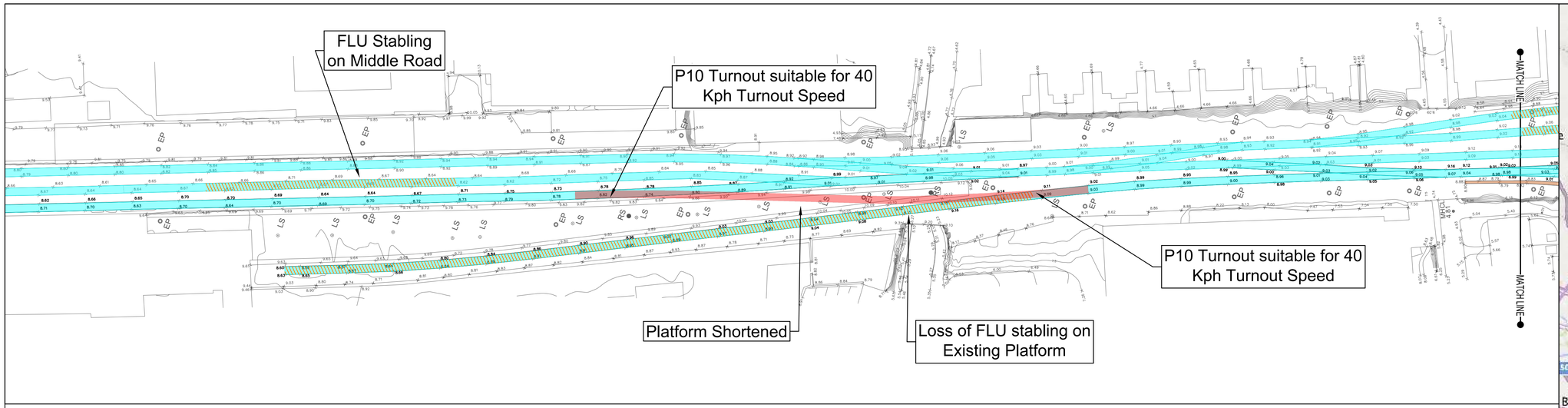
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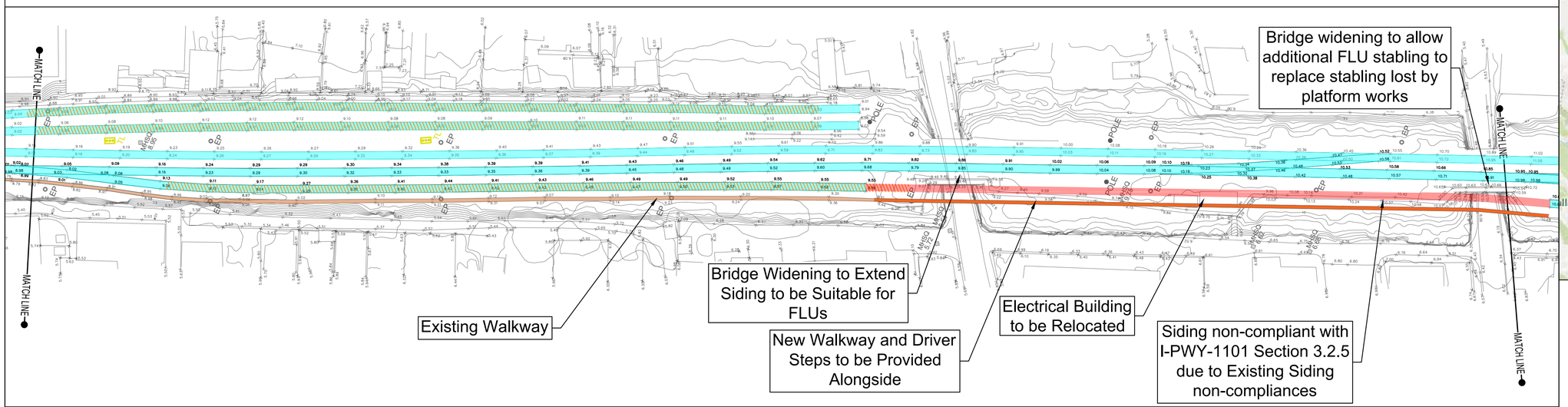
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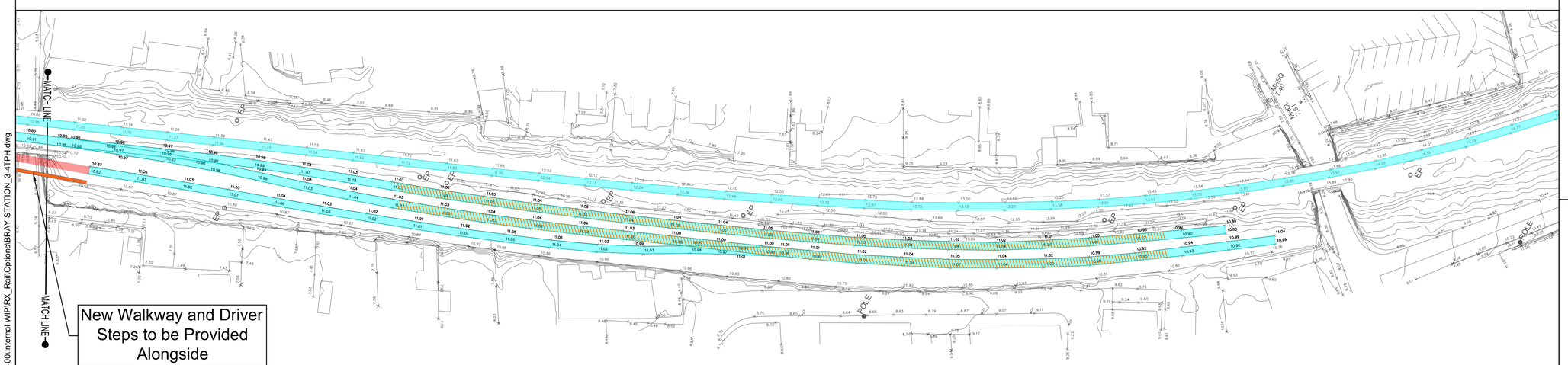
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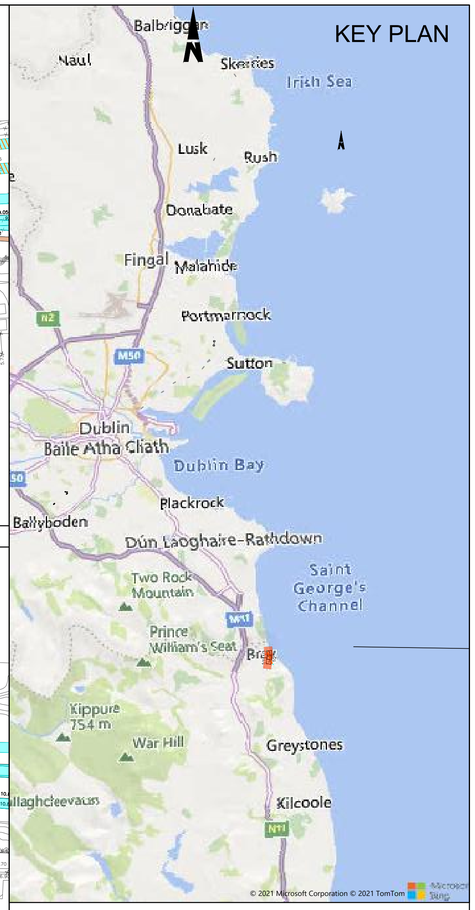
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LEGEND:

- EXISTING RAIL TRACK RETAINED
- NEW RAIL TRACK
- EXISTING STABLING LOCATION
- EXISTING WALKWAY
- NEW WALKWAY TO BE PROVIDED
- EXISTING STATION

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DART+ Coastal North

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Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
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Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Date	Scale	Drawn	Checked	Approved
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Project Code: | Originator Code: ARP | QMS Code:

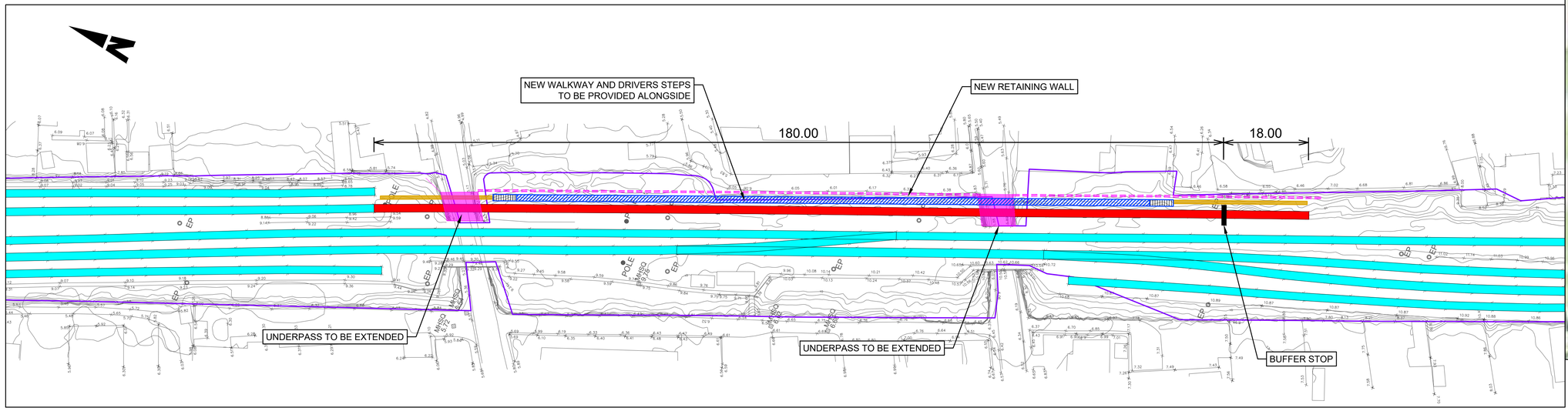
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Drawing Title: BRAY STATION
GENERAL ARRANGEMENT
OPTION 3 - 4 TPH

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LEGEND:

- IRISH RAIL PROPERTY BOUNDARY
- EXISTING RAIL TRACK RETAINED
- EXISTING RAIL TRACK REMOVED
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Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
P01	10/09/2021				--

Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Project Title: **DART+ COASTAL NORTH**

Drawing Title: BRAY STATION
ADDITIONAL STABING OPTION
SINGLE DOWN SIDING EXTENSION

Date	Scale	Drawn	Checked	Approved
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Project Code	Originator Code	QMS Code	Drawing File Name	Sheet Number	Status	Rev
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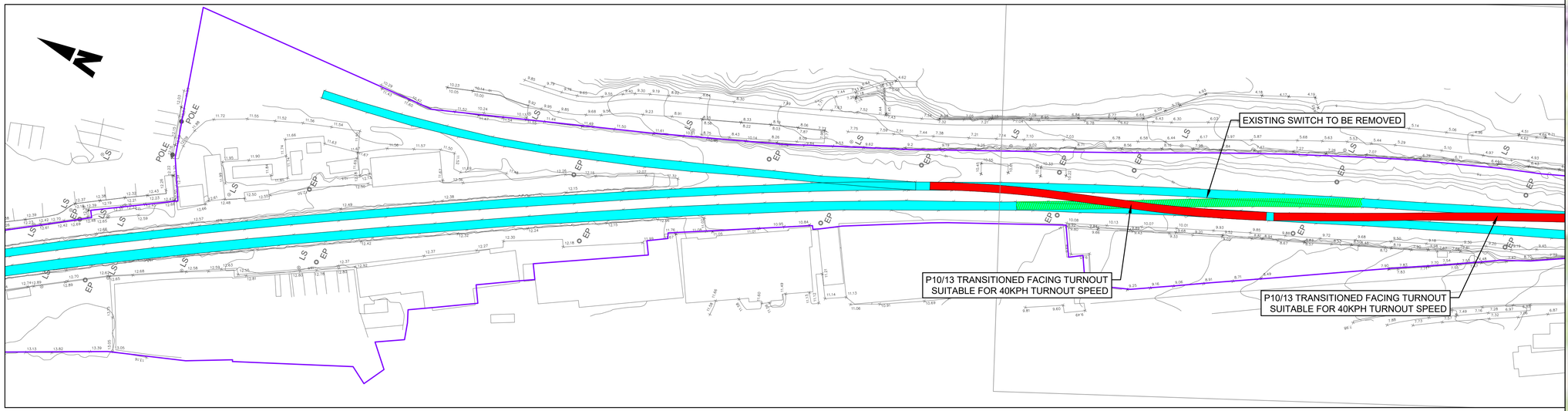
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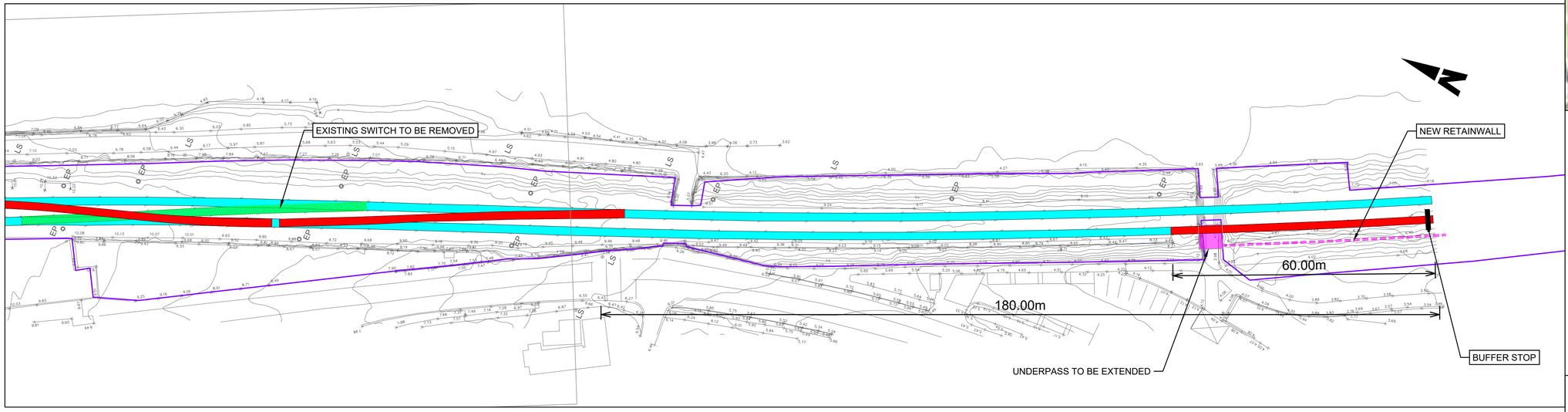
Sketches

A1 Costing sketches

The following sketches/drawings have been used to provide the cost estimate

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D+WP56-ARP-ZZ-SL-DR-PW-SK0002	Greystones Loop	2
D+WP56-ARP-ZZ-SL-DR-PW-SK0003	Bray re-configuration (upper part of the drawing)	3
	Bray Up Sidings Extension (middle and lower part of the drawing)	4
D+WP56-ARP-ZZ-SL-DR-PW-SK0004	Bray Dn Sidings Extension	5
32110404-JAC-GCN-XX-DR-CE-0001	Jacobs design, Bray Double tracking	6
32110404-JAC-GCN-XX-DR-CE-0003 32110404-JAC-GCN-XX-DR-CE-0004	Jacobs design, Greystones Double tracking	7







LEGEND:

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DART+ Coastal North

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Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
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Engineering Designer: ARUP

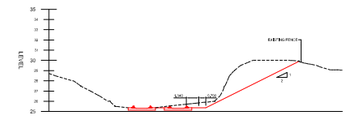
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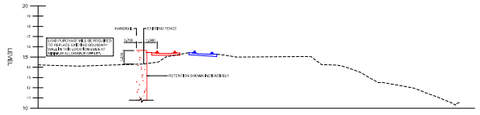
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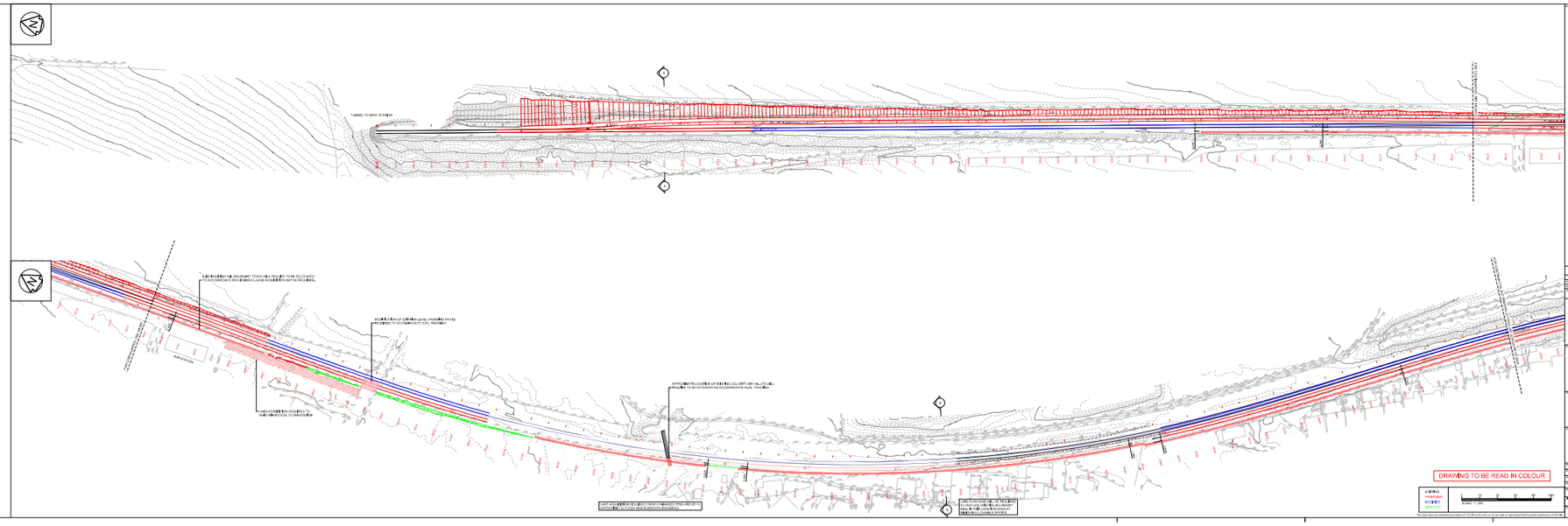
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SECTION A-A @ CH27250
SCALE 1:100



SECTION B-B @ CH28240
SCALE 1:100



KEY:
- PROPOSED TRACK ALIGNMENT
- EXISTING TRACK
- EXISTING GROUND PROFILE
- RETAINING WALL
- PROPOSED HANDRAIL
- EARTHWORKS CUT SLOPE @ 1(2)
- EARTHWORKS FILL SLOPE @ 1(2)

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Údarás Náisiúnta Iompair
National Transport Authority

JACOBS

DART EXPANSION
TECHNICAL OPTION STUDY

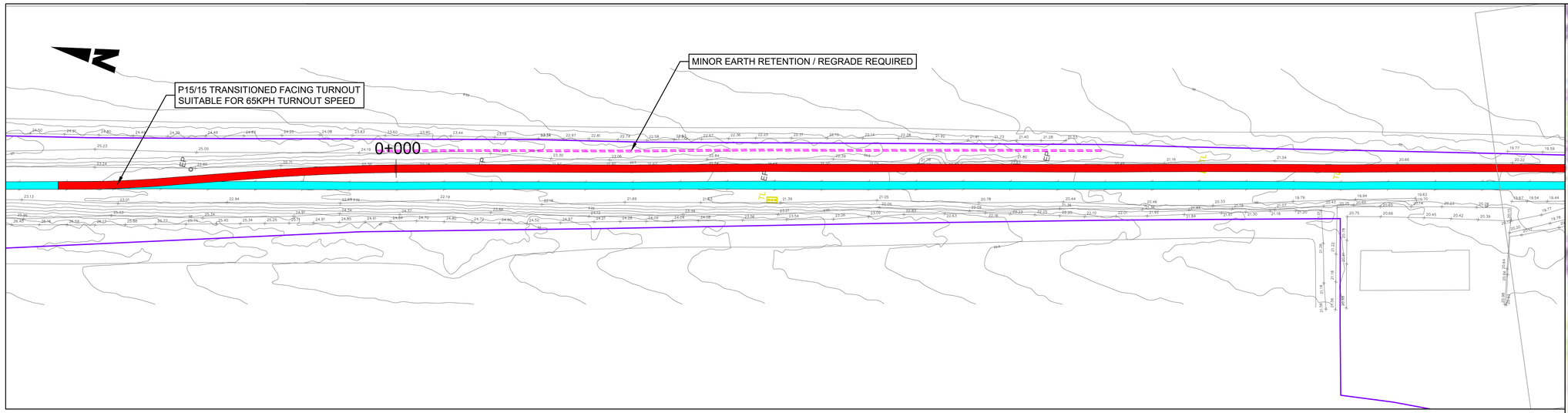
GREYSTONES SERVICE IMPROVEMENT STUDY
GENERAL ARRANGEMENT
SHEET 3

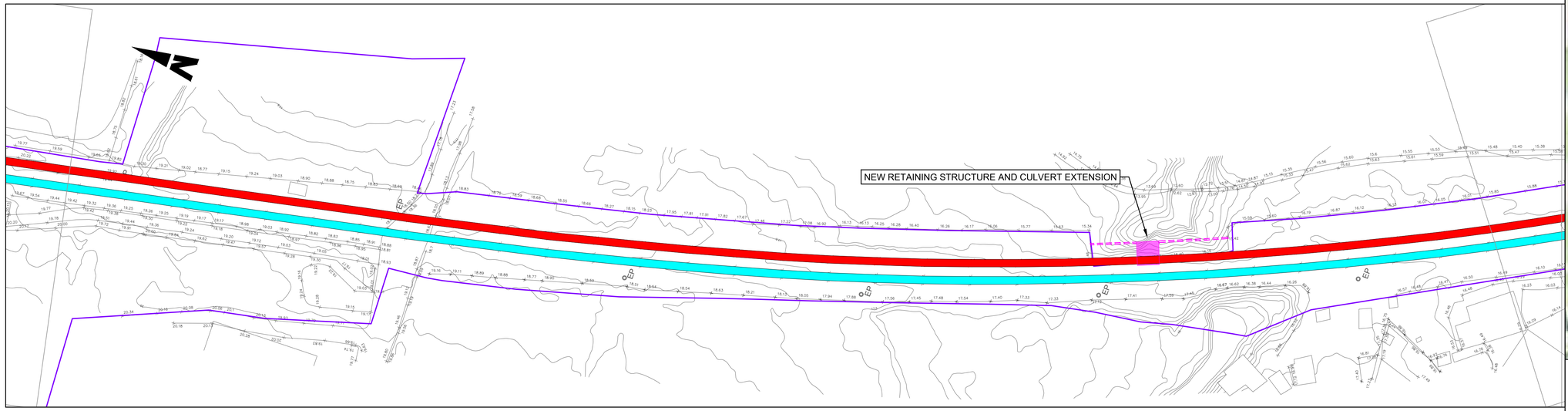
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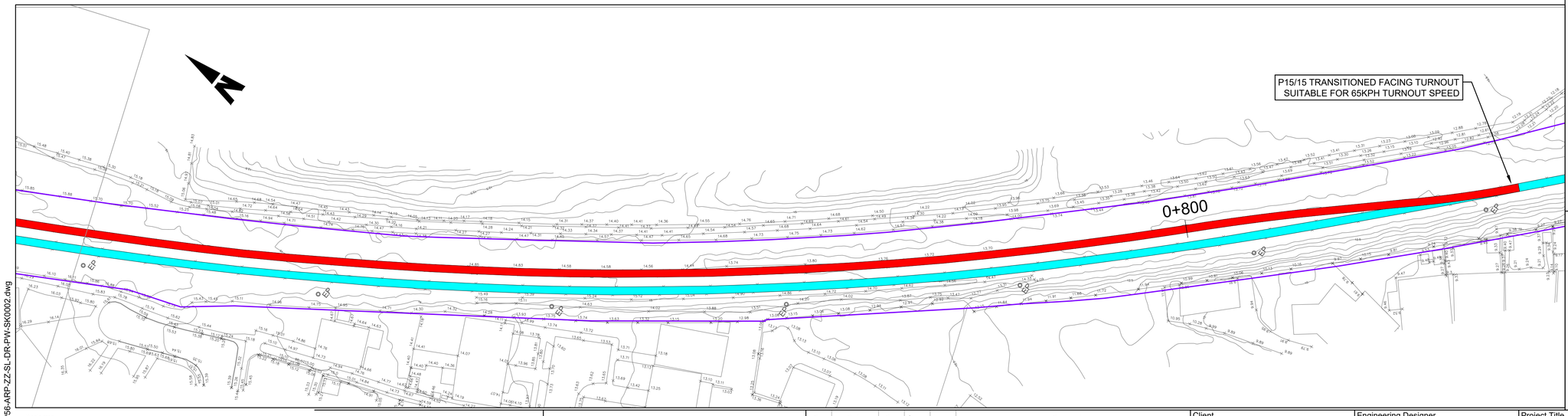
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Status: IP01









LEGEND:

- IRISH RAIL PROPERTY BOUNDARY
- EXISTING RAIL TRACK RETAINED
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Rev	Date	Drn	Chk'd	App'd	Description
P01	10/09/2021				--

Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Project Title: **DART+ COASTAL NORTH**

Drawing Title: GREYSTONES LOOP

Date	Scale	Drawing File Name	Sheet Number	Status	Rev
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Project Code	Originator Code	QMS Code
D+WP56	ARP	280275-00

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Iarnród Éireann

DART+ Coastal South

Greystones Capacity Improvements Technical Note

D+WP56-ARP-P2-SL-RP-OP-000001

P02 | 15 December 2021

This report considers the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Dublin D04 T6X0
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www.arup.com

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Irish Rail
ARUP

Document verification

ARUP

Job title		DART+ Coastal South		**Job number** 279933-00
Document title		Greystones Capacity Improvements Technical Note		**File reference**
Document ref		D+WP56-ARP-P2-SL-RP-OP-000001		
Revision	**Date**	**Filename**	Bray to Greystones Operations Review Note.docx	
P01	23 Nov 2021	Description	First issue for IÉ review and comment	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	[redacted]
		Signature		[redacted]	
P02	15 Dec 2021	Filename			
		Description	Updated to suit comments. Costing Infrmation added		
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	[redacted]
		Signature		[redacted]	
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
			Issue Document verification with document		✓

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Appendices

Appendix A

Sketches

1 Executive Summary

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature.

Following quantitative and qualitative modelling and rail operations investigations into improving service levels between Bray and Greystones DART stations, Arup finds that a 3 TPH service pattern (1 additional train per hour) is the optimal improvement, and can be best achieved through the following package of works:

- the provision of a passing loop from near Bray Head Tunnel Number 4 for 800m towards Greystones; and,
- the addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points.

A loop of 800m is sufficient to enable a passing move with one direction having priority over the other, balancing increased runtime with increased timetable performance and robustness.

Note that the above recommendations are predicated on the delivery of a separate project to replace the legacy ATP protection system between Bray and Greystones with ETCS Level 1, removing the ATP banding speed restriction.

This package of infrastructure and service enhancements will achieve a 50% increase in services, while minimising the possibility of Bray to Greystones services becoming a problematic timetabling constraint to the rest of the DART network. This report proves that there is sufficient platform capacity at Greystones to accommodate a 1 TPH service from Rosslare, in addition to the 3 TPH DART services.

While this report finds it technically possible to achieve a future service level of 4TPH, it does not recommend this choice. A 4 TPH solution would require substantial capital investment compared to a 3 TPH solution, while posing a greater reliability risk, both to Bray to Greystones services, and the wider DART network.

Lastly, this note's recommendation of 3 TPH will impact the parallel Bray Station Turnback optioneering process, as all Bray Station solutions must, at a minimum, be able to handle turning back 9 TPH services.

This note has been produced to allow for a decision on the service specification and principal form of infrastructure interventions to Greystones to be confirmed, which will allow optioneering of the Bray to Greystones area to progress.

2 Introduction

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature. An obvious solution to this problem would be to double track the line; however, this section of railway crosses difficult terrain adjacent to the Irish Sea. Any expansion would require significant civil engineering works, at a capital cost likely not commensurate with the benefits coming from increased capacity and reliability. As such, Arup's task is to examine more cost-effective methods to increase capacity to either 3 or 4 TPH, and evaluate both options in light of the infrastructure they would require, and the impact each frequency would have on the wider DART+ network.

It is worth noting that minimising the run time between Bray and Greystones is not considered an important factor and, as will be seen in the analysis outputs presented below, providing a longer run time has benefits in improving capacity and reliability.

A report by Jacobs in 2020 examined the practical infrastructure enhancement choices and settled on a combination of extending double tracking south from Bray and north from Greystones to minimize the length of single tracking. Arup's investigation uses this study as a starting point, developing further options off the initial proposal.

The purpose of this note is as follows:

1. To present Arup's infrastructure options for providing both a 3 TPH or 4 TPH service to Greystones.
2. To explain the infrastructure requirements, Bray to Greystones performance, and wider DART network impacts of choosing to run either 3 TPH or 4 TPH.
3. To identify infrastructure recommendations.
4. To provide some high-level costings of the infrastructure for a 3 TPH and a 4 TPH service.
5. To advise IÉ to either pursue a 3 TPH or 4 TPH service between Bray to Greystones, and present a preferred set of infrastructure solutions to achieve the recommended service level.

3 Existing Capacity Constraints

In addition to the length of single line section , there are a number of other existing constraints worth noting.

3.1 ATP Speed banding

The current signalling arrangements include automatic train protection (ATP) speed banding which limits the speed a train can travel to a margin lower than the line speed.

Arup understands that IÉ is executing a separate signalling project that will upgrade the current train protection system to ETCS Level 1, removing these limits and allowing trains to run at the line speed.

This note assumes that this signalling work on the Bray-Greystones section is completed, thereby removing the current speed limits caused by (ATP) banding.

Arup analysed a further set of options on the effects of not removing ATP banding, however these have not been included in this note. This analysis concludes that it is essential for the signalling works to be carried out for any 4 TPH scenario. For 3 TPH the results indicate it is marginally possible to provide increased services without the signalling works, but it would require significant other infrastructure upgrades such as double tracking through Greystones.

3.2 Bray 115B Points

The points shown in Figure 1 below are just south of Bray Station and provide a significant operational constraint on the network.

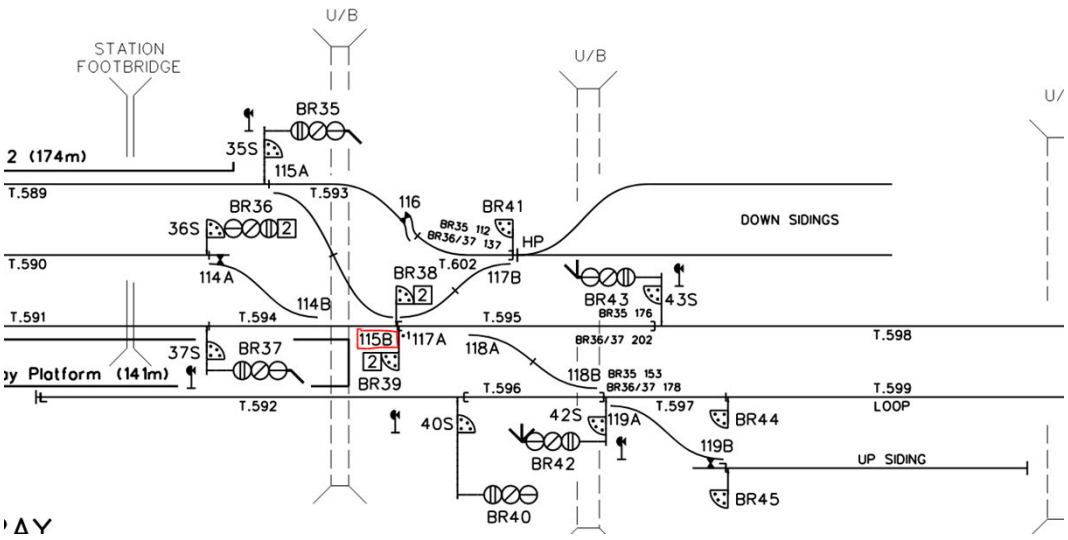


Figure 1: Excerpt from IÉ signalling diagram, showing Bray Station

They provide a single point at which all of the following moves must pass through and will therefore conflict:

- All trains leaving Bray and heading towards Greystones;
- All trains arriving at Bray from Greystones;
- All trains departing the Down sidings and heading to the Bray Platform 1;
- All trains heading to and/or from the Up sidings at Bray.

The signalling design for this area also compounds the operational restriction. The main route for all southbound services passes through the Down platform, whose protecting signal, BR35, has an overlap that stretches beyond points 115B to fully encompass the junction. This means that a train sat or passing through the main Down platform will block any train coming in the opposite direction, preventing any parallel moves through Bray Station.

3.3 Greystones platform Occupancy

The TSS assumes that to provide the additional DART capacity on the Bray to Greystones section the existing Rosslare services will terminate at Greystones. Checks have been undertaken against the options to determine if any additional infrastructure is required at Greystones to provide the required platform capacity for the Rosslare services.

3.4 Line speeds

There are small discrepancies between the start and stop locations of line speed changes provided in the RailSys model to those in the working timetable (WTT). Arup has reviewed these and confirms there is no meaningful difference between the two on the findings of this study.

4 Operational Modelling

Arup undertook RailSys modelling and high level quantitative analysis to examine what infrastructure enhancements would be required to meet the increased frequencies of 3 and 4 TPH. Through an optioneering process, Arup tested a series of design solutions, building the infrastructure in RailSys to test the performance of different track layouts.

Using technical outputs — such as signal occupation/clearance times — Arup undertook a finer grained quantitative analysis in excel, examining performance in light of:

- Capacity Utilisation;
- Runtime;
- Runtime allowance;

- Minimum Time Between Opposing Services.

The below options are based on different permutations of infrastructure options that are deemed viable within the project scope for improving capacity (in essence ruling out double tracking, tunnelling, or extensive work around Bray Head).

The analysis considered five constituent infrastructure components:

a. Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m (suffix a).

b. Passing Loop from Bray Head Tunnel Number 4 for 800m towards Greystones (suffix b).

c. Double Tracking from Bray Station for 700m to Putland Road (suffix c).

f. A southern headshunt at Greystones Station (suffix f).

h. Removal of the constraint at 115B points through the provision of an additional connection from the Bay platform approach to the Up Bray platform (suffix h). This allows for a shorter but less expensive extension of double tracking using an existing up loop road.

The suffixes provide a shorthand for explaining which combination of constituent infrastructure components each individual option is made up of. For example, Option 2acf is made up of:

a. *Suffix a (Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m)*

+

c. *Suffix c (Double Tracking from Bray Station for 700m to Putland Road)*

+

f. *Suffix f (A southern headshunt at Greystones Station)*

All options are prefixed with a 2, as part of a comprehensive numbering system for all options involving Bray Station, Bray to Greystones, and Greystones Station. Prefix "2" indicates that the option assumes the removal of ATP speed banding.

		Greystones		Greystones	Bray	Signalling
Option Name	Description	Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
2a	Double Tracking Greystones	✓	X	X	X	✓
2b	Greystones Loop	X	✓	X	X	✓

2c	Bray Double Track	X	X	X	✓	✓
2ac	Greystones + Bray Double Tracking	✓	X	X	✓	✓
2acf	Greystones + Bray Double Tracking + South Turnback	✓	X	✓	✓	✓
2acf+	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	✓	X	✓	✓	✓
2bc	Greystones Loop + Bray Double Track	X	✓	X	✓	✓
2bh	Greystones Loop + Bray Additional Crossover	X	✓	X	✓*	✓

Table 1: Infrastructure options and constituent components

In line with other DART+ Coastal project analyses, Arup used a capacity utilisation value of around 75% to be the cut-off towards failing an option. This is in line with UIC Code 406, which recommends a capacity utilisation rate of at maximum 75% for mixed traffic lines during the peak hour.

For each option, Arup developed a theoretical timetable, with trains leaving at regular intervals. In reality, trains on this section may not be evenly spaced, with arrival and departure times instead dictated by other constraints on different parts of the DART network.

As such, due to the single-track nature of the Bray to Greystones route and the fact that services on this section will be interlined with other DART services in the city centre, Arup considers it necessary to provide the maximum possible spare capacity, thus increasing service reliability and timetabling flexibility. For higher train frequencies of 4 TPH, Arup assumes that a 75% capacity utilisation rate is the hard maximum, with any preferred option ideally having a substantially lower capacity utilisation to allow for some redundancy in timetable planning and in times of delay. For 3 TPH scenarios, Arup assumes that capacity utilisation rates may still be judged as passing even if they are 1-2 % over 75%, due to the smaller quantum of trains lessening the need to provide substantial timetabling redundancy.

4.1 Results

4.1.1 3 TPH

As can be seen below, all options can provide adequate capacity to enable 3 TPH. Additionally, there is an approximately 1 minute's difference in runtime between the fastest and slowest option, with Option 2acf providing almost obstruction free runtime, and Option 2a requiring substantial pathing allowance in order to facilitate passing services in the up and down directions.

Note that for all options involving a loop at Greystones, at least one direction must stop and dwell for 30 seconds in order to enable the passing move. This has a negative effect on runtime, but greatly decreases capacity utilisation. Option 2a instead requires trains in the Up direction to operate far below the rolling stock's peak performance, allowing for the passing move without necessitating a stop at the end of the double track section.

It should also be noted that the Minimum Opposing Gap is a value showing the closest time in between two services coming into conflict, with a higher value representing a more robust option.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option 2a	Double Tracking Greystones	PASS	00:09:19	00:00:05	00:07:42	76%		1	17%
Option 2b	Greystones Loop	PASS	00:08:48	00:00:11	00:07:43	70%		1	17%
Option 2c	Bray Double Track	PASS	00:08:03	00:02:48	00:08:01	72%		2	45%
Option 2ac	Greystones + Bray Double Tracking	PASS	00:08:14	00:01:48	00:08:16	64%		1	17%
Option 2acf	Greystones + Bray Double Tracking + South Turnback	PASS	00:07:58	00:04:47	00:07:58	59%		2	56%

Option 2acf+	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:04:17	00:07:58	55%		2	56%
Option 2bc	Greystones Loop + Bray Double Track	PASS	00:08:58	00:00:18	00:07:59	57%		1	17%
Option 2bh	Greystones Loop + Bray Additional Crossover	PASS	00:08:48	00:00:20	00:07:43	58%		1	17%

Table 3: Performance of options for 3 TPH

4.1.2 4 TPH

Adding an additional train per hour requires significantly higher levels of infrastructure enhancement, as well as creative use of such infrastructure. All successful options include the double tracking from Bray station, and either a loop or double tracking from Greystones. The highest performing options combines a double tracking at Bray and at Greystones with a southern head shunt, as well as a 1 second dwell at the end of the Greystones double tracking.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option 2a	Double Tracking Greystones	FAIL	00:09:19	-00:02:03	00:07:42	101%		1	17%
Option 2b	Greystones Loop	FAIL	00:08:48	-00:00:18	00:07:58	94%		1	17%
Option 2c	Bray Double Track	FAIL	00:08:03	00:00:21	00:08:01	97%		2	64%
Option 2ac	Greystones + Bray Double Tracking	FAIL	00:09:30	00:00:02	00:07:58	85%		1	17%

Option 2acf	Greystones + Bray Double Tracking + South Turnback	FAIL	00:07:58	00:00:07	00:07:58	78%		2	77%
Option 2acf+	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:01:22	00:07:58	73%		2	73%
Option 2bc	Greystones Loop + Bray Double Track	FAIL	00:08:58	00:00:19	00:07:59	77%		1	17%
Option 2bh	Greystones Loop + Bray Additional Crossover	FAIL	00:08:48	00:00:20	00:07:43	77%		1	17%

Table 4: Performance of options for 4TPH

Greystones and Rosslare Services

For all 3 TPH options, there is sufficient capacity in the existing two platform layout at Greystones to accommodate a 1 TPH terminating service from Rosslare. For Option 2acf at 4 TPH, Greystones requires an additional south facing platform to be able to robustly handle both DART and DMU services. All other options at 4 TPH have sufficient capacity in the existing layout to handle the additional 1 TPH Rosslare service without an additional platform.

Note that the capacity utilisation value is calculated as the largest available gap between services, divided by an assumed time of 10 minutes that it would take a Rosslare DMU service to occupy a platform, de-train its passengers, and vacate the platform, including junction margins (6 minute platform re-occupation + 3 minute junction margin + 1 minute runtime).

5 Impact on Bray and TSS 1C

The planned service level to Greystones has a potential impact on the infrastructure required at Bray to deliver TSS 1C. Under TSS 1C it is required to turnback at minimum 10 DARTs at Bray. If additional services are proposed to Greystones the number of turnback services to turnback at Bray will proportionally decrease.

It is considered likely that it will still be operationally beneficial to allow the full 10 DARTs to turnback at Bray, therefore checks have been undertaken on the options to determine if this service pattern can be provided.

Full optioneering of the Bray turnback works have yet to be completed, however to allow for a fair comparison of the Bray to Greystones options the following are applied to the recommended infrastructure and costing assessment that follows.

- The double tracking at Bray for 700m (suffix c) will provide the infrastructure required for turning back 10 TPH at Bray;
- Where the Bray double tracking is not provided in an option infrastructure suffix h is applied at Bray (i.e., the additional crossover).

The Bray area is also required to accommodate stabling of trains (7 No.). Currently the changes noted above at Bray have the following impacts on stabling:

- Infrastructure suffix h provides a stabling Capacity of 5 FLUs. The drawings provided demonstrate how this could be increased to 7FLUs;
- The double tracking at Bray for 700m (suffix c) provides a stabling capacity of 4 FLUs. It is considered this can be increased to 7 FLUs through the inclusions of the works illustrated on Infrastructure suffix h plus the lengthening of one down siding with bridge widening.

It is important to note these are not necessarily the recommended stabling works, however are provided to allow for a fair comparison of costs.

5.1.1 Operational Reliability

Due to the performance risks inherent in operating a single-track railway, it is imperative that any infrastructure solution offers the greatest possible performance, in order to enhance reliability and flexibility.

Furthermore, the DART+ network is highly interlined, and timetables are already constrained in the following areas:

- Glasnevin Junction;
- Ossory Road Junction;
- Connolly Station Platforms 5-7;

- Turnback services at Bray, Grand Canal Dock, Connolly, Clongriffin, Malahide, and Drogheda;
- Possible passing locations for Enterprise services.

Since Bray-Greystones services will be interlined with wider DART+ services, they could become an additional constraint onto the DART+ timetable. This compounds the reliability risks coming from operating this section of single-track railway.

6 Infrastructure Interventions

In line with the above modelling analysis, this note presents a recommended infrastructure solution to provide the 3 TPH and 4 TPH as follows:

6.1.1 3 TPH Preferred Option

To accommodate a service level of 3 TPH, Arup recommends Option 2bh:

b. The provision of a passing loop from Bray Head Tunnel Number 4 for 800m towards Greystones;
h. The addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points

This combines the relatively high performance of the Bray additional crossover, which unlocks a shorter section of double tracking in the station area, with the high performance and lower relative cost of the Greystones loop.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

Note that this option requires changes in operational assumptions, with trains in the Up direction (towards Dublin) requiring a stop at Bray Head loop for at least 30 seconds. Dwell time at this point can be increased or decreased to regulate train throughput, and regularise service, along with managing the departure time from Greystones. This analysis assumes long dwell times at Greystones, (nearly 16 minutes), allowing for substantial robustness and ability to recover from late arrivals). Increasing the minimum dwell time at Bray Head loop (up to 8 minutes) will increase the minimum opposing gap between services, and subsequently improve performance, while having a negative impact on runtimes.

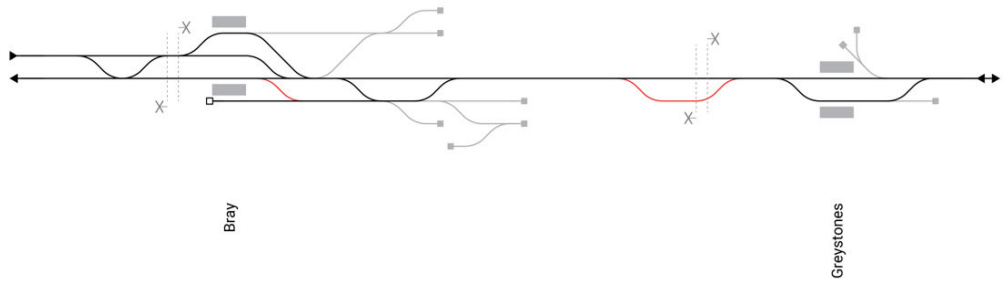


Figure 2: Preferred 3 TPH Option 2bh

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking/Bray Crossover	ATP Banding Removed
X	✓	X	✓	✓

Table 6: Option 2bh components

4 TPH Preferred Option

To accommodate a service level of 4 TPH, Arup recommends Option 2acf+:

a. The provision of double tracking from Bray station for 700m to Putland Road;
c. The provision of double tracking from Greystones station to Bray Head Tunnel Number 4 for 2400m;
f. A southern headshunt at Greystones Station;

This option also requires an operation enhancement, with Up direction trains departing Greystones to dwell for 1 second at the end of the Greystones double track section.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

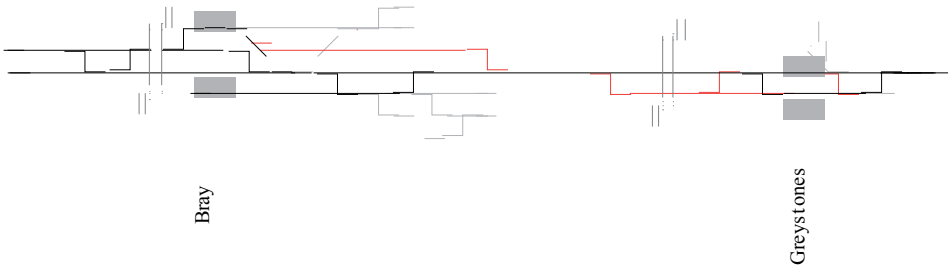


Figure 3: Preferred 4TPH Option 2acf+

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
✓	X	✓	✓	✓

Table 8:Option 2acf+ components

Since Greystones services will be interlined directly with DART services through the City Centre Loop Line, it is essential that any option provide a substantial level of flexibility and robustness. Service timetabling is already dictated by pathing constraints in other parts of the network as described in 5.1.1; therefore, it is highly preferable that there are no additional timetabling constraints from the Bray to Greystones section. Aiming to operate a 4 TPH service between Bray and Greystones will be challenging; therefore, to minimise performance risk to the rest of the network any feasible option must provide the near maximum level of infrastructure and operational enhancements — short of investing in fully double tracking.

As such, for 4 TPH Arup recommends Option 2acf+. This option adds all possible infrastructure enhancements, with significant sections of double track, dedicated arrival and departure platforms at Greystones, and with DART services turning back at a separate point on a siding clear of the mainline.

7 Cost Analysis

Cost estimates have been produced for the various components discussed above and are summarised in Table 6. These estimates are for comparative purposes only and represent the high-level nature of this study.

Full cost breakdown information has been provided separately.

Skteches and drawings used for costing are included in Appendix A.

7.1 General

Table 10: Estimate Summaries

Component	Description	Estimate
Component 1	Greystones Southern Turnback	[redacted]
Component 2	Greystones Loop	[redacted]
Component 3	Bray Reconfiguration	[redacted]
Component 4	Bray Up Sidings Extension	[redacted]
Component 5	Bray Down Sidings Extension	[redacted]
Component 6	Bray Double Tracking (Jacobs design)	[redacted]
Component 7	Greystones Double Tracking (Jacobs design)	[redacted]

Note that the costs associated with the signalling changes to remove the ATP banding are not included as they are assumed to be undertaken by a separate project. These works are, however, required for the service improvements to occur.

7.2 3 trains per hour

For 3 TPH the following components are recommended to be included in the estimate

- Component 2
- Component 3

- Component 4

This yields an estimate of [redacted]

7.3 4 trains per hour

For 4 TPH the following components are recommended to be included in the estimate:

- Component 1
- Component 4
- Component 5
- Component 6
- Component 7

This yields an estimate of [redacted]

8 Conclusion

Due to the need to provide a more than normal level of robustness and capacity and the fact that a service level of 4 TPH only works with the most intensive of infrastructure interventions (and even then only with a small margin of robustness) Arup proposes that IÉ aim to provide a service level of 3 TPH between Bray and Greystones.

There are two fundamental reasons Arup recommends operating 3 TPH rather than 4 TPH:

1. Introducing a 4 TPH service on to this section of line will introduce another critical constraint on the DART network. The network already has a number of other critical junctions and constraints which pose challenges for timetable planning and for providing a reliable service. The introduction of a 4 TPH service where there is little room flexibility will result in challenges keeping a reliable service.
2. The Cost of the Infrastructure required for 4 TPH is significantly greater than that of the 3 TPH.

To achieve a 3 TPH service, Arup recommends adopting Option 2bh: Greystones Loop with Bray Additional Crossover. This option provides a good level of operational robustness, while minimising capital construction costs and disruption.

8.1 Next Steps

Following a decision on whether to proceed with 3 TPH or 4 TPH for the chosen Greystones service, the design and optioneering can be developed in conjunction with the TSS and stabling requirements at Bray.

Detailed signalling and permanent way design will be required to refine Option 2bh into a viable constructable project. Future sensitivity analysis can also be undertaken to understand the balance on the works required at Bray while still meeting the capacity requirements of 3 TPH.

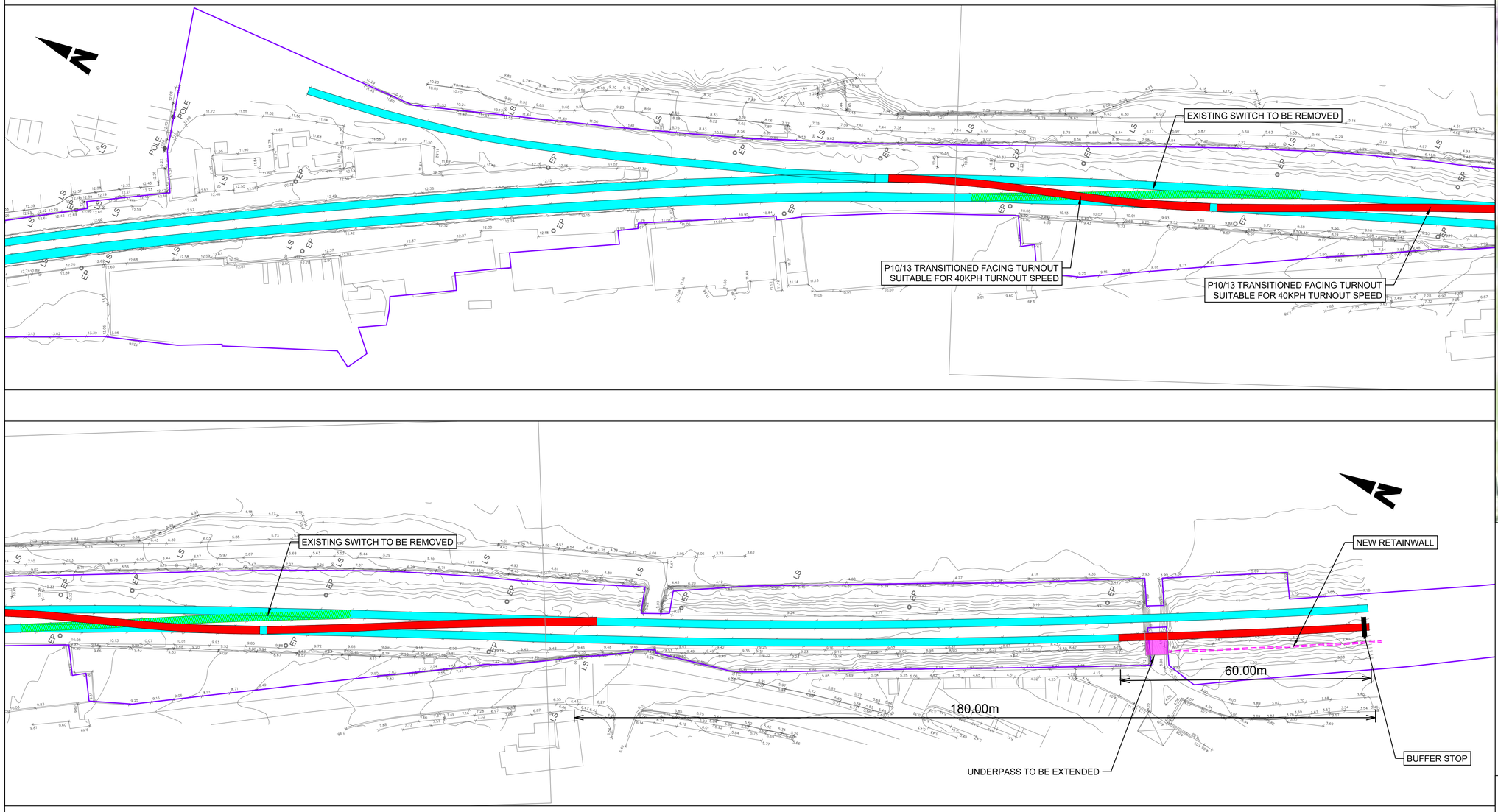
Appendix A

Sketches

A1 Costing sketches

The following sketches/drawings have been used to provide the cost estimate

Drawing Reference	Description	Component
D+WP56-ARP-ZZ-SL-DR-PW-SK0001	Greystones Southern Turnback	1
D+WP56-ARP-ZZ-SL-DR-PW-SK0002	Greystones Loop	2
D+WP56-ARP-ZZ-SL-DR-PW-SK0003	Bray re-configuration (upper part of the drawing)	3
	Bray Up Sidings Extension (middle and lower part of the drawing)	4
D+WP56-ARP-ZZ-SL-DR-PW-SK0004	Bray Dn Sidings Extension	5
32110404-JAC-GCN-XX-DR-CE-0001	Jacobs design, Bray Double tracking	6
32110404-JAC-GCN-XX-DR-CE-0003 32110404-JAC-GCN-XX-DR-CE-0004	Jacobs design, Greystones Double tracking	7





LEGEND:

- IRISH RAIL PROPERTY BOUNDARY
- EXISTING RAIL TRACK RETAINED
- EXISTING RAIL TRACK REMOVED
- NEW RAIL TRACK
- DRIVERS WALKWAY
- NEW RETAINING WALL
- EXISTING RAILWAY PLATFORM

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DART+ Coastal North

NTA Údarás Náisiúnta Iompair National Transport Authority

Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
P01	10/09/2021				--

Client: Iarnród Éireann Irish Rail	Engineering Designer: ARUP			
Date: 10/09/2021	Scale: 1:500 @ A1, 1:1000 @ A3	Drawn	Checked	Approved
Project Code: D+WP56	Originator Code: ARP	QMS Code: 280275-00		

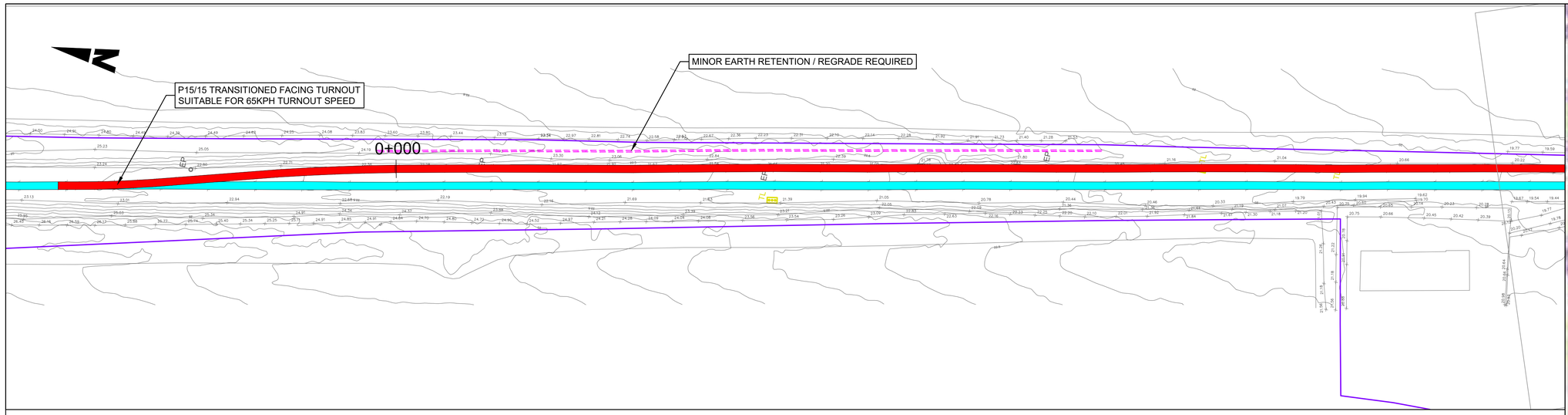
Project Title: **DART+ COASTAL NORTH**

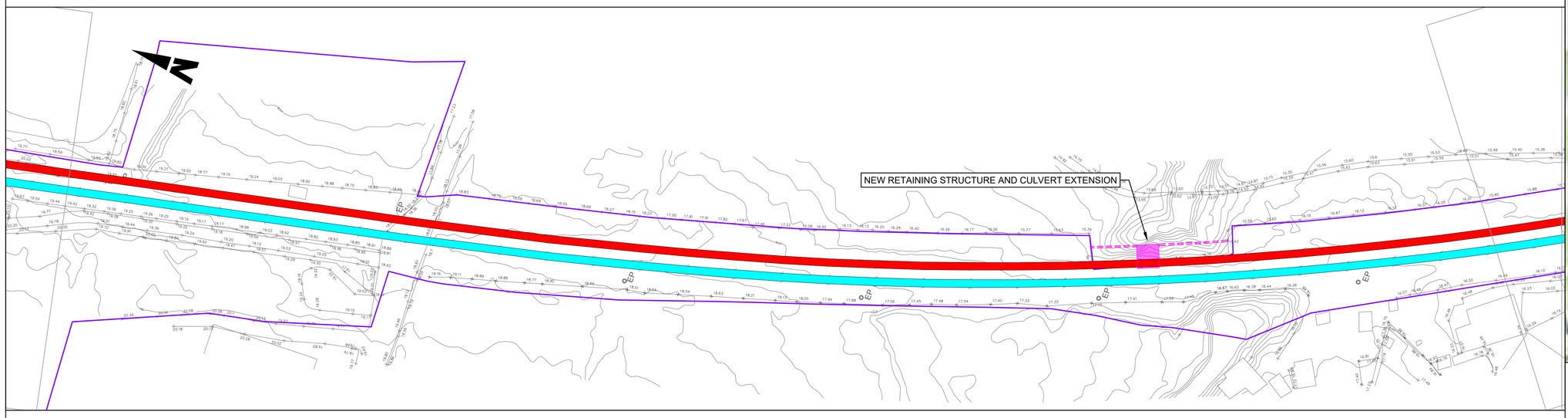
Drawing Title: GREYSTONES SOUTHERN TURNBACK

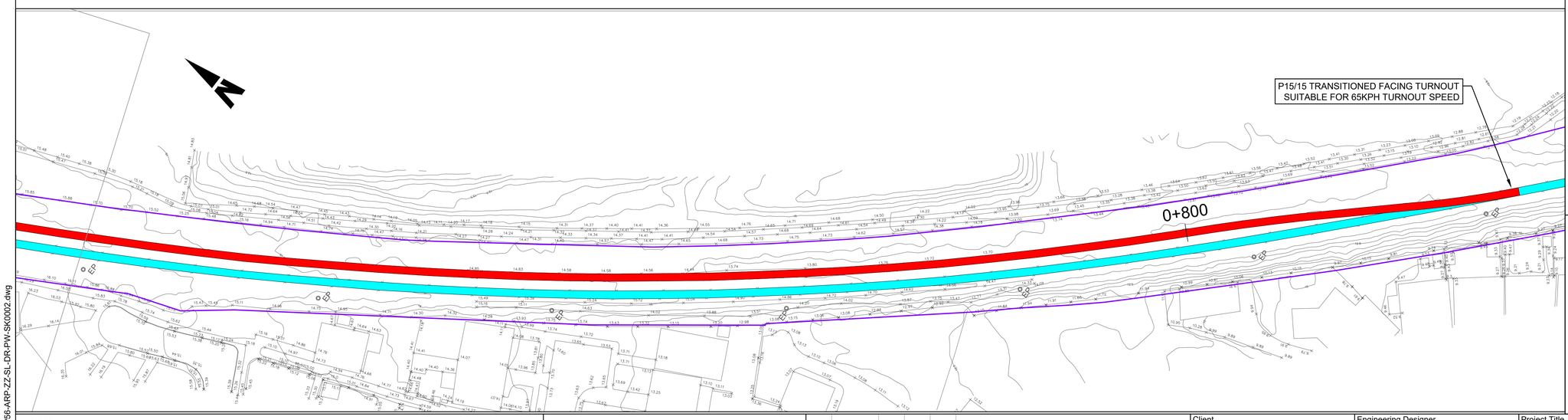
Drawing File Name	Sheet Number	Status	Rev
D+WP56-ARP-ZZ-SL-DR-PW-SK0001	1 of 1	S3	P01

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LEGEND:

- IRISH RAIL PROPERTY BOUNDARY
- EXISTING RAIL TRACK RETAINED
- EXISTING RAIL TRACK REMOVED
- NEW RAIL TRACK
- DRIVERS WALKWAY
- NEW RETAINING WALL
- EXISTING RAILWAY PLATFORM

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DART+ Coastal North

NTA Údarás Náisiúnta Iompair National Transport Authority

Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
P01	10/09/2021	[redacted]			--

Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Date: 10/09/2021 | Scale: 1:500 @ A1, 1:1000 @ A3 | Drawn | Checked | Approved

Project Code: D+WP56 | Originator Code: ARP | QMS Code: 280275-00

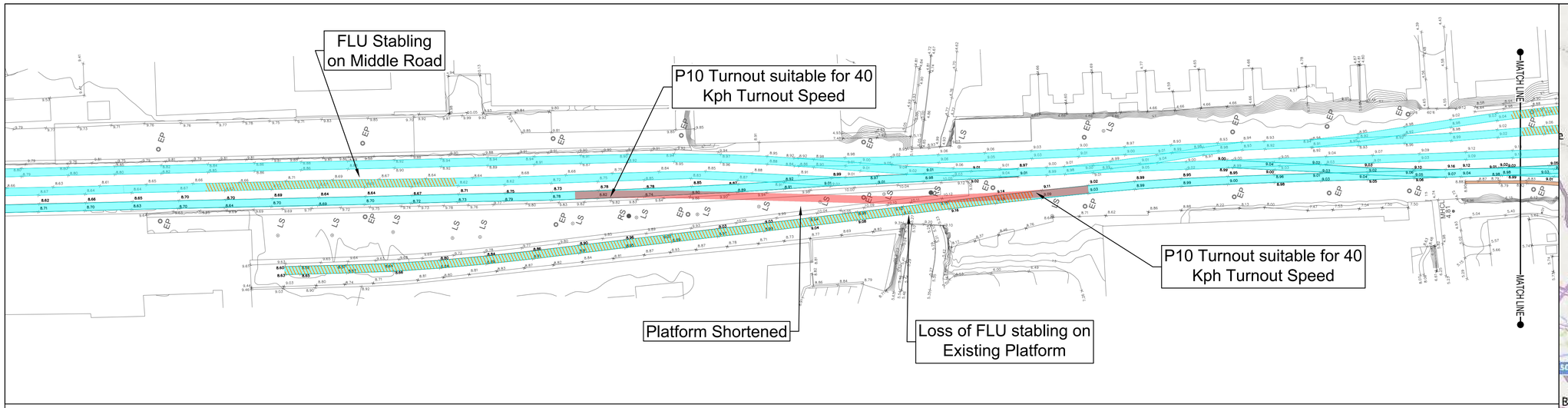
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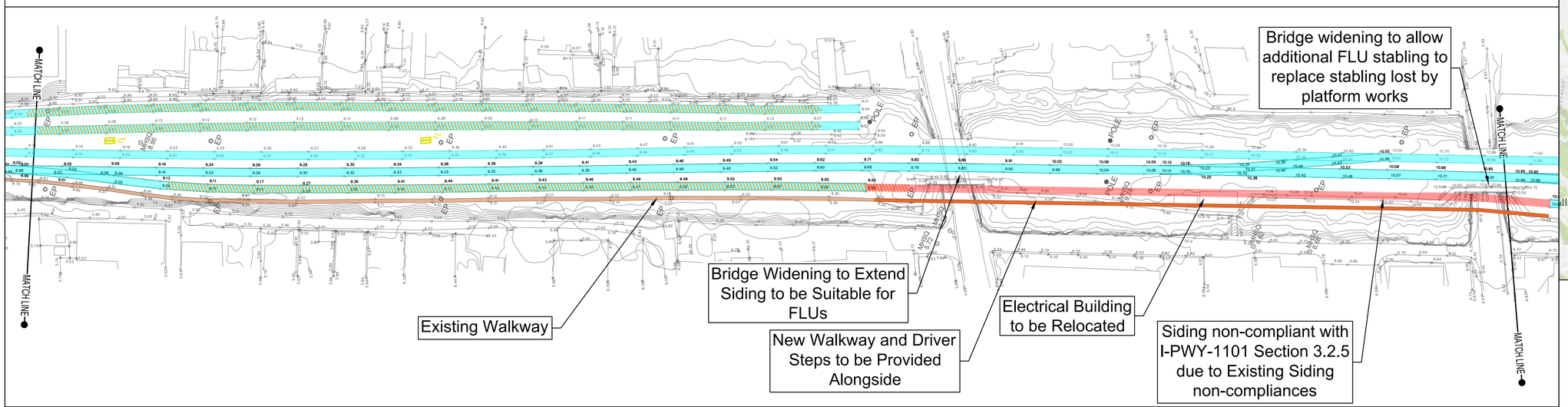
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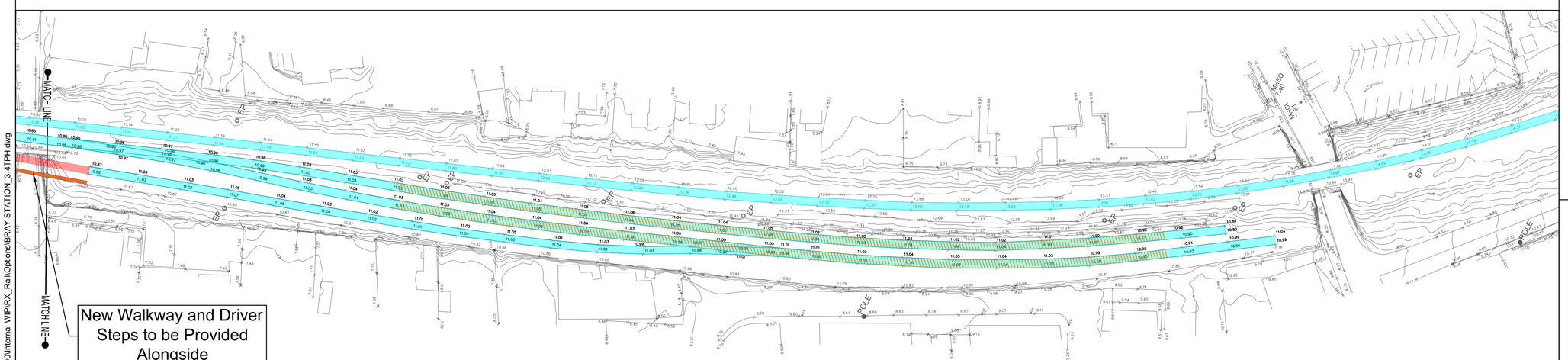
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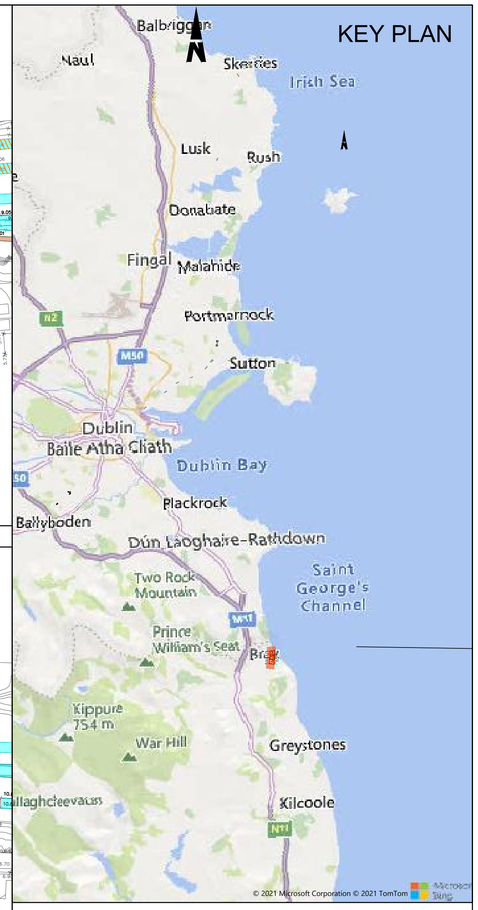
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LEGEND:

- EXISTING RAIL TRACK RETAINED
- NEW RAIL TRACK
- EXISTING STABLING LOCATION
- EXISTING WALKWAY
- NEW WALKWAY TO BE PROVIDED
- EXISTING STATION

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DART+ Coastal North

NTA Údarás Náisiúnta Iompair National Transport Authority

Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
					--

Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Date	Scale	Drawn	Checked	Approved
	1:500 @ A1 1:1000 @ A3			

Project Code: | Originator Code: ARP | QMS Code:

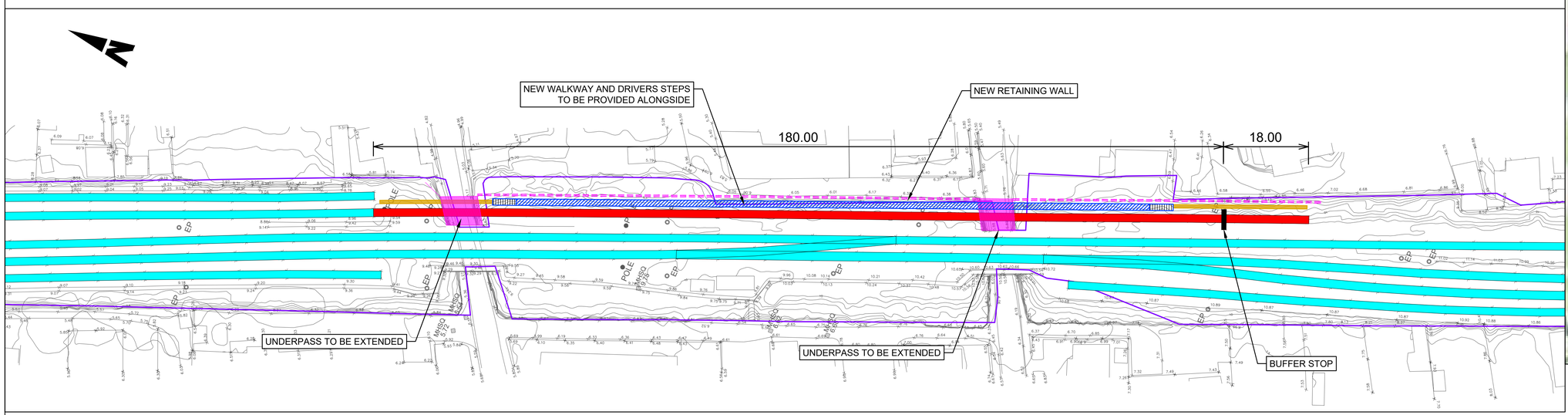
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Drawing Title: BRAY STATION
GENERAL ARRANGEMENT
OPTION 3 - 4 TPH

Drawing File Name	Sheet Number	Status	Rev
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LEGEND:

- IRISH RAIL PROPERTY BOUNDARY
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- EXISTING RAIL TRACK REMOVED
- NEW RAIL TRACK
- DRIVERS WALKWAY
- NEW RETAINING WALL
- EXISTING RAILWAY PLATFORM

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DART+ Coastal North

NTA National Transport Authority

Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
P01	10/09/2021	[redacted]			--

Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Date	Scale	Drawn	Checked	Approved
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Project Code	Originator Code	QMS Code
D+WP56	ARP	280275-00

Project Title: **DART+ COASTAL NORTH**

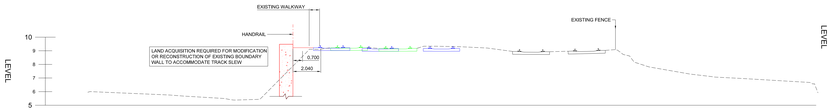
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ADDITIONAL STABING OPTION
SINGLE DOWN SIDING EXTENSION

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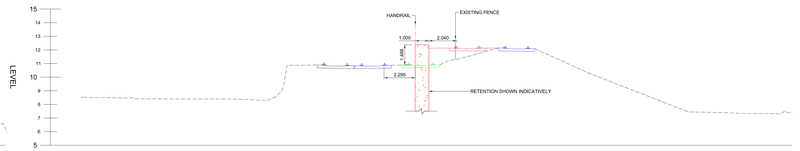
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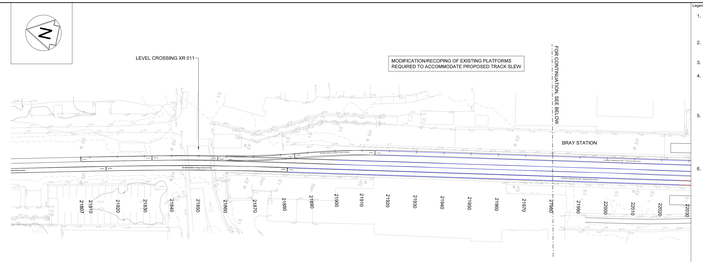
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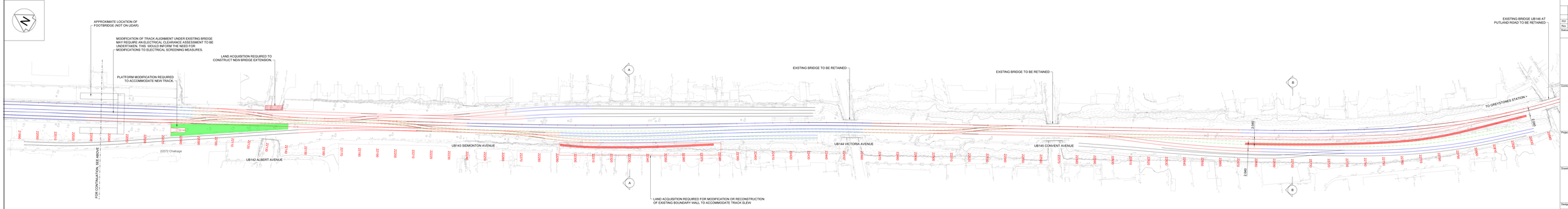


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SECTION B-B @ CH22700
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SCALE 1: 500

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2. FOR HORIZONTAL P-WAY ALIGNMENT, REFER TO MODEL 32110401-JAC-GCN-XX-M2-TR-0002
3. ALL DIMENSION IN METRES UNLESS OTHERWISE STATED.
4. PROVISIONAL SPATIAL REQUIREMENTS FOR ACCOMMODATING DUAL TRACK ALIGNMENT HAVE BEEN BASED ON THE PROVISION OF A 700MM WIDE WALKING ROUTE, OFFSET 1340MM FROM RUNNING EDGE OF RAIL AS PER IeRWY-1101.
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6. WHERE RETENTION IS INDICATED SUITABLE SITE INVESTIGATION AND GEOTECHNICAL INVESTIGATION SHOULD BE GATHERED AT FUTURE DESIGN STAGES TO ALLOW APPLICATION OF THE FOLLOWING HIERARCHY:
   1) JUSTIFICATION OF STEEPER SLOPES;
   2) USE OF STABILISATION TECHNIQUES ON STEEPER SLOPES;
   3) USE OF RETENTION MEASURES.

KEY:

- PROPOSED TRACK ALIGNMENT
- EXISTING TRACK
- EXISTING GROUND PROFILE
- RETAINING WALL
- PROPOSED HANDRAIL
- EARTHWORKS CUT (SLOPE @ 1:2)
- EARTHWORKS FILL (SLOPE @ 1:2)

Rev	Date	Description of Revisions	Drawn	Chkd	Appr
P01	08/04/20	FOR INFORMATION	JT	CF	SD

Status: FOR INFORMATION ONLY

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Project:

DART EXPANSION TECHNICAL OPTION STUDY

Drawing Title:

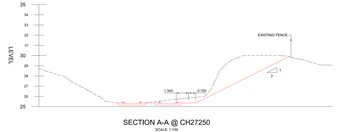
GREYSTONES SERVICE IMPROVEMENT STUDY GENERAL ARRANGEMENT SHEET 1

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Drawn:	[redacted]	Signed:	Date: 08/04/20
Checked:	[redacted]	Signed:	Date: 08/04/20
Approved:	[redacted]	Signed:	Date: 08/04/20
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Alternative Reference:		Sheet:	1 of 4

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Revision: P01

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Drawing Number
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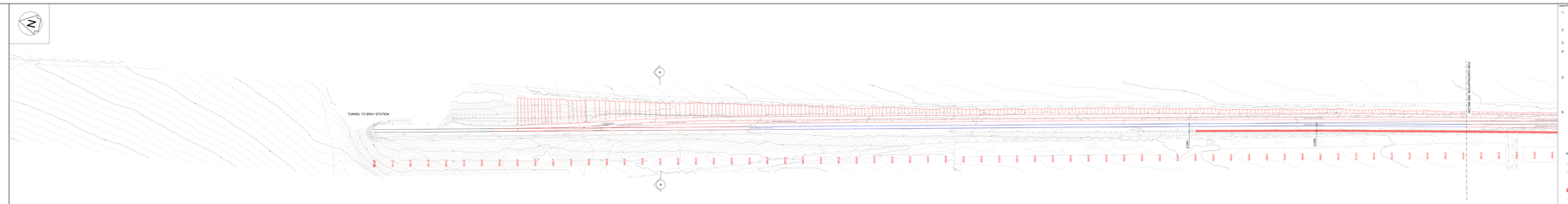
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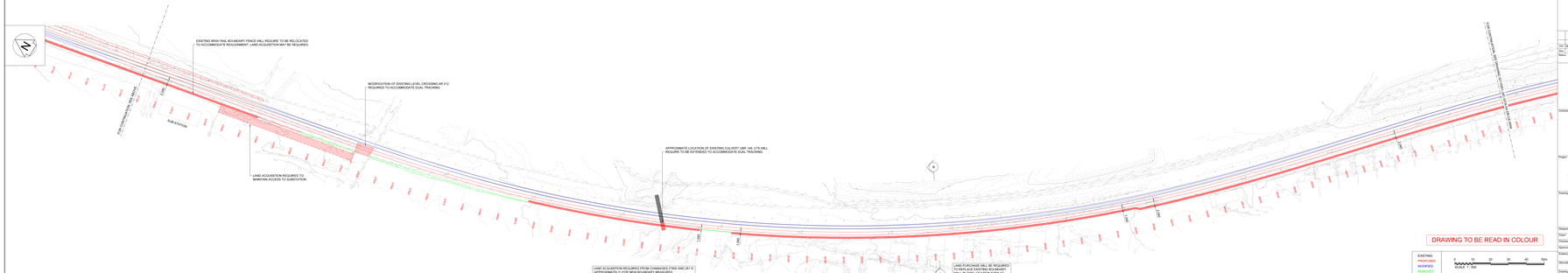
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SCALE: 1:100





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SCALE 1 : 500

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5. AN INITIAL RECRAILING FEASIBILITY EXERCISE HAS BEEN CARRIED OUT FOR A MAXIMUM ALLOWABLE SLOPE OF 1 IN 2 (1:2) FOR EARTHWORKS CUTTINGS AND FILLS. DUE TO CONSTRAINTS IT HAS BEEN ASSUMED RETENTION WILL BE REQUIRED. WHERE SLOPES HAVE BEEN USED THIS WILL BE CONFIRMED AT DETAILED DESIGN STAGE FOLLOWING INVESTIGATION AT A FUTURE DESIGN STAGE.

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KEY:

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- RETAINING WALL
- PROPOSED HANDRAIL
- EARTHWORKS CUT (SLOPE @ 1:2)
- EARTHWORKS FILL (SLOPE @ 1:2)

Rev	Date/Ltr	Description of Revisions	Drawn	Appd
Rev 1	30/04/21	FOR INFORMATION ONLY	JF	GF

Status

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Project

DART EXPANSION
TECHNICAL OPTION STUDY

Drawing Title

GREYSTONES SERVICE IMPROVEMENT STUDY
GENERAL ARRANGEMENT
SHEET 3

	Signed	Date
Designed		
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Checked		09/04/21
Approved		09/04/21

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Alternative Reference

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Sheet No. 3 of 4

Revision P01

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Iarnród Éireann

DART+ Coastal South

Greystones Capacity Improvements Technical Note

D+WP56-ARP-P2-SL-RP-OP-000001

P03 | 19 January 2022

This report considers the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Document verification

ARUP

Job title		DART+ Coastal South		**Job number** 279933-00
Document title		Greystones Capacity Improvements Technical Note		**File reference**
Document ref		D+WP56-ARP-P2-SL-RP-OP-000001		
Revision	**Date**	**Filename**	Bray to Greystones Operations Review Note.docx	
P01	23 Nov 2021	Description	First issue for IÉ review and comment	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
P02	15 Dec 2021	Filename			
		Description	Updated to suit comments. Costing Infrmation added		
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
P03	19 Jan 2022	Filename			
		Description	Naming convention Updated		
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
			Issue Document verification with document		✓

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Appendices

Appendix A

Sketches

Appendix B

Cost Estimates

1 Executive Summary

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature.

Following quantitative and qualitative modelling and rail operations investigations into improving service levels between Bray and Greystones DART stations, Arup finds that a 3 TPH service pattern (1 additional train per hour) is the optimal improvement, and can be best achieved through the following package of works:

- the provision of a passing loop from near Bray Head Tunnel Number 4 for 800m towards Greystones; and,
- the addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points.

A loop of 800m is sufficient to enable a passing move with one direction having priority over the other, balancing increased runtime with increased timetable performance and robustness.

Note that the above recommendations are predicated on the delivery of a separate project to replace the legacy ATP protection system between Bray and Greystones with ETCS Level 1, removing the ATP banding speed restriction.

This package of infrastructure and service enhancements will achieve a 50% increase in services, while minimising the possibility of Bray to Greystones services becoming a problematic timetabling constraint to the rest of the DART network. This report proves that there is sufficient platform capacity at Greystones to accommodate a 1 TPH service from Rosslare, in addition to the 3 TPH DART services.

While this report finds it technically possible to achieve a future service level of 4TPH, it does not recommend this choice. A 4 TPH solution would require substantial capital investment compared to a 3 TPH solution, while posing a greater reliability risk, both to Bray to Greystones services, and the wider DART network.

Lastly, this note's recommendation of 3 TPH will impact the parallel Bray Station Turnback optioneering process, as all Bray Station solutions must, at a minimum, be able to handle turning back 9 TPH services.

This note has been produced to allow for a decision on the service specification and principal form of infrastructure interventions to Greystones to be confirmed, which will allow optioneering of the Bray to Greystones area to progress.

2 Introduction

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature. An obvious solution to this problem would be to double track the line; however, this section of railway crosses difficult terrain adjacent to the Irish Sea. Any expansion would require significant civil engineering works, at a capital cost likely not commensurate with the benefits coming from increased capacity and reliability. As such, Arup's task is to examine more cost-effective methods to increase capacity to either 3 or 4 TPH, and evaluate both options in light of the infrastructure they would require, and the impact each frequency would have on the wider DART+ network.

It is worth noting that minimising the run time between Bray and Greystones is not considered an important factor and, as will be seen in the analysis outputs presented below, providing a longer run time has benefits in improving capacity and reliability.

A report by Jacobs in 2020 examined the practical infrastructure enhancement choices and settled on a combination of extending double tracking south from Bray and north from Greystones to minimize the length of single tracking. Arup's investigation uses this study as a starting point, developing further options off the initial proposal.

The purpose of this note is as follows:

1. To present Arup's infrastructure options for providing both a 3 TPH or 4 TPH service to Greystones.
2. To explain the infrastructure requirements, Bray to Greystones performance, and wider DART network impacts of choosing to run either 3 TPH or 4 TPH.
3. To identify infrastructure recommendations.
4. To provide some high-level costings of the infrastructure for a 3 TPH and a 4 TPH service.
5. To advise IÉ to either pursue a 3 TPH or 4 TPH service between Bray to Greystones, and present a preferred set of infrastructure solutions to achieve the recommended service level.

3 Existing Capacity Constraints

In addition to the length of single line section , there are a number of other existing constraints worth noting.

3.1 ATP Speed banding

The current signalling arrangements include automatic train protection (ATP) speed banding which limits the speed a train can travel to a margin lower than the line speed.

Arup understands that IÉ is executing a separate signalling project that will upgrade the current train protection system to ETCS Level 1, removing these limits and allowing trains to run at the line speed.

This note assumes that this signalling work on the Bray-Greystones section is completed, thereby removing the current speed limits caused by (ATP) banding.

Arup analysed a further set of options on the effects of not removing ATP banding, however these have not been included in this note. This analysis concludes that it is essential for the signalling works to be carried out for any 4 TPH scenario. For 3 TPH the results indicate it is marginally possible to provide increased services without the signalling works, but it would require significant other infrastructure upgrades such as double tracking through Greystones.

3.2 Bray 115B Points

The points shown in Figure 1 below are just south of Bray Station and provide a significant operational constraint on the network.

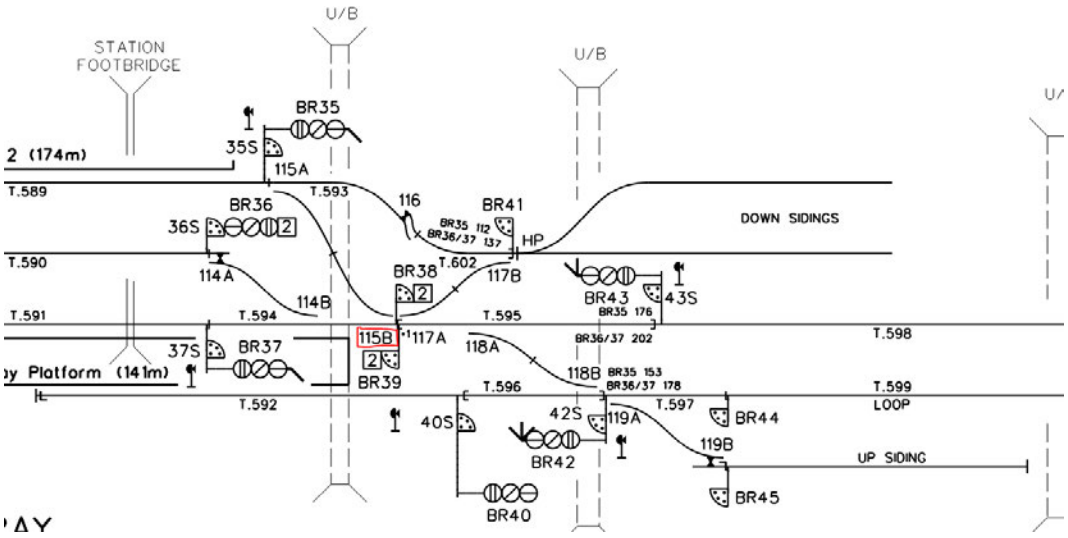


Figure 1: Excerpt from IÉ signalling diagram, showing Bray Station

They provide a single point at which all of the following moves must pass through and will therefore conflict:

- All trains leaving Bray and heading towards Greystones;
- All trains arriving at Bray from Greystones;
- All trains departing the Down sidings and heading to the Bray Platform 1;
- All trains heading to and/or from the Up sidings at Bray.

The signalling design for this area also compounds the operational restriction. The main route for all southbound services passes through the Down platform, whose protecting signal, BR35, has an overlap that stretches beyond points 115B to fully encompass the junction. This means that a train sat or passing through the main Down platform will block any train coming in the opposite direction, preventing any parallel moves through Bray Station.

3.3 Greystones platform Occupancy

The TSS assumes that to provide the additional DART capacity on the Bray to Greystones section the existing Rosslare services will terminate at Greystones. Checks have been undertaken against the options to determine if any additional infrastructure is required at Greystones to provide the required platform capacity for the Rosslare services.

3.4 Line speeds

There are small discrepancies between the start and stop locations of line speed changes provided in the RailSys model to those in the working timetable (WTT). Arup has reviewed these and confirms there is no meaningful difference between the two on the findings of this study.

4 Operational Modelling

Arup undertook RailSys modelling and high level quantitative analysis to examine what infrastructure enhancements would be required to meet the increased frequencies of 3 and 4 TPH. Through an optioneering process, Arup tested a series of design solutions, building the infrastructure in RailSys to test the performance of different track layouts.

Using technical outputs — such as signal occupation/clearance times — Arup undertook a finer grained quantitative analysis in excel, examining performance in light of:

- Capacity Utilisation;
- Runtime;
- Runtime allowance;

- Minimum Time Between Opposing Services.

The below options are based on different permutations of infrastructure options that are deemed viable within the project scope for improving capacity (in essence ruling out double tracking, tunnelling, or extensive work around Bray Head).

The analysis considered five constituent infrastructure components:

- **Component 1 -** A southern headshunt at Greystones Station
- **Component 2 -** Passing Loop from Bray Head Tunnel Number 4 for 800m towards Greystones
- **Component 3-** Removal of the constraint at 115B points through the provision of an additional connection from the Bay platform approach to the Up Bray platform. This allows for a shorter but less expensive extension of double tracking using an existing up loop road.
- **Component 6 -** Double Tracking from Bray Station for 700m to Putland Road.
- **Component 7 -** Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m.

Components 4 and 5, relate to resulting stabling infrastructure changes which are required as a result of other works and are discussed in Section 5

The suffixes provide a shorthand for explaining which combination of constituent infrastructure components each individual option is made up of. For example, Option B(1+6+7) is made up of:

Component 1 (A southern headshunt at Greystones Station)

+

Component 6 (Double Tracking from Bray Station for 700m to Putland Road)

+

Component 7 (Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m)

All options are prefixed with a B, as part of a comprehensive numbering system for all options involving Bray Station, Bray to Greystones, and Greystones Station. Prefix “B” indicates that the option assumes the removal of ATP speed banding.

		Greystones	Greystones	Bray	Signalling

Option Name	Description	Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
B (7)	Double Tracking Greystones	✓	X	X	X	✓
B (2)	Greystones Loop	X	✓	X	X	✓
B (6)	Bray Double Track	X	X	X	✓	✓
B(6+7)	Greystones + Bray Double Tracking	✓	X	X	✓	✓
B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	✓	X	✓	✓	✓
B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	✓	X	✓	✓	✓
B (2+6)	Greystones Loop + Bray Double Track	X	✓	X	✓	✓
B (2+3)	Greystones Loop + Bray Additional Crossover	X	✓	X	✓*	✓

Table 1: Infrastructure options and constituent components

In line with other DART+ Coastal project analyses, Arup used a capacity utilisation value of around 75% to be the cut-off towards failing an option. This is in line with UIC Code 406, which recommends a capacity utilisation rate of at maximum 75% for mixed traffic lines during the peak hour.

For each option, Arup developed a theoretical timetable, with trains leaving at regular intervals. In reality, trains on this section may not be evenly spaced, with arrival and departure times instead dictated by other constraints on different parts of the DART network.

As such, due to the single-track nature of the Bray to Greystones route and the fact that services on this section will be interlined with other DART services in the city centre, Arup considers it necessary to provide the maximum possible spare capacity, thus increasing service reliability and timetabling flexibility. For higher train frequencies of 4 TPH, Arup assumes that a 75% capacity utilisation rate is the hard maximum, with any preferred option ideally having a substantially lower capacity utilisation to allow for some redundancy in timetable planning and in times of delay. For 3 TPH scenarios, Arup assumes that capacity utilisation rates may still be judged as passing even if they are 1-2 % over 75%, due to the

smaller quantum of trains lessening the need to provide substantial timetabling redundancy.

4.1 Results

4.1.1 3 TPH

As can be seen below, all options can provide adequate capacity to enable 3 TPH. Additionally, there is an approximately 1 minute's difference in runtime between the fastest and slowest option, with Option B(1+6+7) providing almost obstruction free runtime, and Option B(7) requiring substantial pathing allowance in order to facilitate passing services in the up and down directions.

Note that for all options involving a loop at Greystones, at least one direction must stop and dwell for 30 seconds in order to enable the passing move. This has a negative effect on runtime, but greatly decreases capacity utilisation. Option B(7) instead requires trains in the Up direction to operate far below the rolling stock's peak performance, allowing for the passing move without necessitating a stop at the end of the double track section.

It should also be noted that the Minimum Opposing Gap is a value showing the closest time in between two services coming into conflict, with a higher value representing a more robust option.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option B (7)	Double Tracking Greystones	PASS	00:09:19	00:00:05	00:07:42	76%		1	17%
Option B (2)	Greystones Loop	PASS	00:08:48	00:00:11	00:07:43	70%		1	17%
Option B (6)	Bray Double Track	PASS	00:08:03	00:02:48	00:08:01	72%		2	45%
Option B (6+7)	Greystones + Bray Double Tracking	PASS	00:08:14	00:01:48	00:08:16	64%		1	17%

Option B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	PASS	00:07:58	00:04:47	00:07:58	59%		2	56%
Option B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:04:17	00:07:58	55%		2	56%
Option B (2+6)	Greystones Loop + Bray Double Track	PASS	00:08:58	00:00:18	00:07:59	57%		1	17%
Option B (2+3)	Greystones Loop + Bray Additional Crossover	PASS	00:08:48	00:00:20	00:07:43	58%		1	17%

Table 2: Performance of options for 3 TPH

4.1.2 4 TPH

Adding an additional train per hour requires significantly higher levels of infrastructure enhancement, as well as creative use of such infrastructure. All successful options include the double tracking from Bray station, and either a loop or double tracking from Greystones. The highest performing options combines a double tracking at Bray and at Greystones with a southern head shunt, as well as a 1 second dwell at the end of the Greystones double tracking.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option B (7)	Double Tracking Greystones	FAIL	00:09:19	-00:02:03	00:07:42	101%		1	17%
Option B (2)	Greystones Loop	FAIL	00:08:48	-00:00:18	00:07:58	94%		1	17%
Option B (6)	Bray Double Track	FAIL	00:08:03	00:00:21	00:08:01	97%		2	64%

Option B (6+7)	Greystones + Bray Double Tracking	FAIL	00:09:30	00:00:02	00:07:58	85%		1	17%
Option B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	FAIL	00:07:58	00:00:07	00:07:58	78%		2	77%
Option B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:01:22	00:07:58	73%		2	73%
Option B (2+6)	Greystones Loop + Bray Double Track	FAIL	00:08:58	00:00:19	00:07:59	77%		1	17%
Option B (2+3)	Greystones Loop + Bray Additional Crossover	FAIL	00:08:48	00:00:20	00:07:43	77%		1	17%

Table 3: Performance of options for 4TPH

4.1.3 Greystones and Rosslare Services

For all 3 TPH options, there is sufficient capacity in the existing two platform layout at Greystones to accommodate a 1 TPH terminating service from Rosslare. For Option B(1+6+7) at 4 TPH, Greystones requires an additional south facing platform to be able to robustly handle both DART and DMU services. All other options at 4 TPH have sufficient capacity in the existing layout to handle the additional 1 TPH Rosslare service without an additional platform.

Note that the capacity utilisation value is calculated as the largest available gap between services, divided by an assumed time of 10 minutes that it would take a Rosslare DMU service to occupy a platform, de-train its passengers, and vacate the platform, including junction margins (6 minute platform re-occupation + 3 minute junction margin + 1 minute runtime).

5 Impact on Bray and TSS 1C

The planned service level to Greystones has a potential impact on the infrastructure required at Bray to deliver TSS 1C. Under TSS 1C it is required to turnback at minimum 10 DARTs at Bray. If additional services are proposed to Greystones the number of turnback services to turnback at Bray will proportionally decrease.

It is considered likely that it will still be operationally beneficial to allow the full 10 DARTs to turnback at Bray, therefore checks have been undertaken on the options to determine if this service pattern can be provided.

Full optioneering of the Bray turnback works have yet to be completed, however to allow for a fair comparison of the Bray to Greystones options the following are applied to the recommended infrastructure and costing assessment that follows.

- The double tracking at Bray for 700m (Component 6) will provide the infrastructure required for turning back 10 TPH at Bray;
- Where the Bray double tracking is not provided in an option infrastructure Component 3 is applied at Bray (i.e., the additional crossover).

The Bray area is also required to accommodate stabling of trains (7 No.). Currently the changes noted above at Bray have the following impacts on stabling:

- Infrastructure component 3 provides a stabling Capacity of 5 FLUs. This can be increased to the required 7 FLUs by the introduction of Infrastructure Component 4.
- **Component 4** is the extension of the Bray Up Sidings (middle and lower part of the drawing D+WP56-ARP-ZZ-SL-DR-PW-SK0003).
- The double tracking at Bray for 700m (Component 6) provides a stabling capacity of 4 FLUs. It is considered this can be increased to 7 FLUs through the inclusions of Infrastructure Component 4 plus the introduction of Infrastructure Component 5.
- **Component 5** is the extension of the Bray Down Sidings (as shown on D+WP56-ARP-ZZ-SL-DR-PW-SK0004).

It is important to note these are not necessarily the recommended stabling works, however are provided to allow for a reasonable comparison of costs.

5.1.1 Operational Reliability

Due to the performance risks inherent in operating a single-track railway, it is imperative that any infrastructure solution offers the greatest possible performance, in order to enhance reliability and flexibility.

Furthermore, the DART+ network is highly interlined, and timetables are already constrained in the following areas:

- Glasnevin Junction;
- Ossory Road Junction;
- Connolly Station Platforms 5-7;
- Turnback services at Bray, Grand Canal Dock, Connolly, Clongriffin, Malahide, and Drogheda;
- Possible passing locations for Enterprise services.

Since Bray-Greystones services will be interlined with wider DART+ services, they could become an additional constraint onto the DART+ timetable. This compounds the reliability risks coming from operating this section of single-track railway.

6 Infrastructure Interventions

In line with the above modelling analysis, this note presents a recommended infrastructure solution to provide the 3 TPH and 4 TPH as follows:

6.1.1 3 TPH Preferred Option

To accommodate a service level of 3 TPH, Arup recommends Option B (2+3):

> **Component 2 -** The provision of a passing loop from Bray Head Tunnel Number 4 for 800m towards Greystones;
> **Component 3 -** The addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points

This combines the relatively high performance of the Bray additional crossover, which unlocks a shorter section of double tracking in the station area, with the high performance and lower relative cost of the Greystones loop.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

Note that this option requires changes in operational assumptions, with trains in the Up direction (towards Dublin) requiring a stop at Bray Head loop for at least 30 seconds. Dwell time at this point can be increased or decreased to regulate train throughput, and regularise service, along with managing the departure time from Greystones. This analysis assumes long dwell times at Greystones, (nearly 16 minutes), allowing for substantial robustness and ability to recover from late arrivals). Increasing the minimum dwell time at Bray Head loop (up to 8 minutes) will increase the minimum opposing gap between services, and subsequently improve performance, while having a negative impact on runtimes.

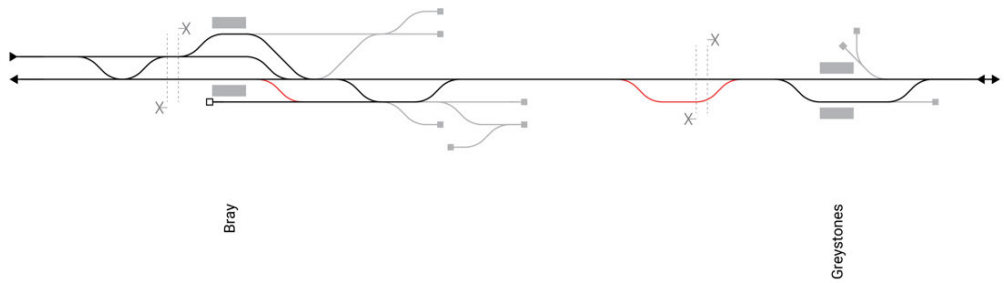


Figure 2: Preferred 3 TPH Option B (2+3)

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking/Bray Crossover	ATP Banding Removed
X	✓	X	✓	✓

Table 4: Option B (2+3) components

6.1.2 4 TPH Preferred Option

To accommodate a service level of 4 TPH, Arup recommends Option B (1+6+7)*:

> **Component 1** - A southern headshunt at Greystones Station;
> **Component 6 -** The provision of double tracking from Bray station for 700m to Putland Road;
> **Component 7** - The provision of double tracking from Greystones station to Bray Head Tunnel Number 4 for 2400m;

This option also requires an operation enhancement, with Up direction trains departing Greystones to dwell for 1 second at the end of the Greystones double track section.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

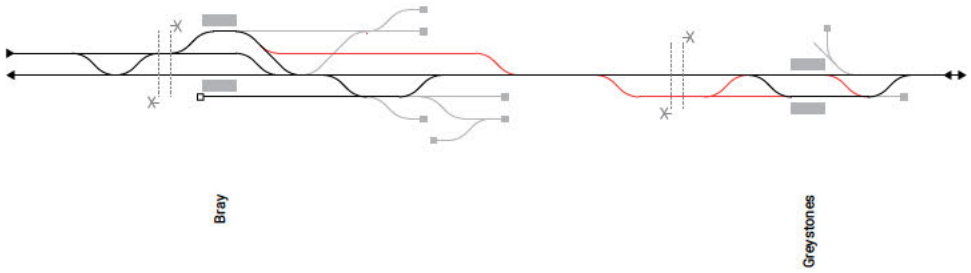


Figure 3: Preferred 4TPH Option B(1+6+7)*

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
✓	X	✓	✓	✓

Table 5:Option B(1+6+7)* components

Since Greystones services will be interlined directly with DART services through the City Centre Loop Line, it is essential that any option provide a substantial level of flexibility and robustness. Service timetabling is already dictated by pathing constraints in other parts of the network as described in 5.1.1; therefore, it is highly preferable that there are no additional timetabling constraints from the Bray to Greystones section. Aiming to operate a 4 TPH service between Bray and Greystones will be challenging; therefore, to minimise performance risk to the rest of the network any feasible option must provide the near maximum level of infrastructure and operational enhancements.

As such, for 4 TPH Arup recommends Option B(1+6+7)*. This option adds all possible infrastructure enhancements, with significant sections of double track, dedicated arrival and departure platforms at Greystones, and with DART services turning back at a separate point on a siding clear of the mainline.

6.1.3 4 TPH Alternatives

Given even running a 4TPH service with the infrastructure highlighted above will be challenging with regards to reliability and performance, two options would be recommended to be investigated further:

1. Introduce of a shuttle service to run to Greystones (either from Bray or from a new south facing termination point south of Conolly) for the additional services to minimise timetable interactions and hence performance risk.
2. Budget and business case for a full double tracking between Bray and Greystones, noting the considerable cost and need to do so with cognisance of coastal erosion.

7 Cost Analysis

Cost estimates have been produced for the various components discussed above and are summarised in Table 6. These estimates are for comparative purposes only and represent the high-level nature of this study.

Full cost breakdown information has been provided separately.

Sketches and drawings used for costing are included in Appendix A.

7.1 General

Table 6: Estimate Summaries

Component	Description	[redacted]
Component 1	Greystones Southern Turnback	
Component 2	Greystones Loop	
Component 3	Bray Reconfiguration	
Component 4	Bray Up Sidings Extension	
Component 5	Bray Down Sidings Extension	
Component 6	Bray Double Tracking (Jacobs design)	
Component 7	Greystones Double Tracking (Jacobs design)	

Note that the costs associated with the signalling changes to remove the ATP banding are not included as they are assumed to be undertaken by a separate project. These works are, however, required for the service improvements to occur.

7.2 3 trains per hour

For 3 TPH the following components are recommended to be included in the estimate

- Component 2
- Component 3

- Component 4

This yields an estimate of [redacted]

7.3 4 trains per hour

For 4 TPH the following components are recommended to be included in the estimate:

- Component 1
- Component 4
- Component 5
- Component 6
- Component 7

This yields an estimate of [redacted]

8 Conclusion

Due to the need to provide a more than normal level of robustness and capacity and the fact that a service level of 4 TPH only works with the most intensive of infrastructure interventions (and even then only with a small margin of robustness) Arup proposes that IÉ aim to provide a service level of 3 TPH between Bray and Greystones.

There are two fundamental reasons Arup recommends operating 3 TPH rather than 4 TPH:

1. Introducing a 4 TPH service on to this section of line will introduce another critical constraint on the DART network. The network already has a number of other critical junctions and constraints which pose challenges for timetable planning and for providing a reliable service. The introduction of a 4 TPH service where there is little room flexibility will result in challenges keeping a reliable service.
2. The Cost of the Infrastructure required for 4 TPH is significantly greater than that of the 3 TPH.

To achieve a 3 TPH service, Arup recommends adopting Option B(2+3): Greystones Loop with Bray Additional Crossover. This option provides a good level of operational robustness, while minimising capital construction costs and disruption.

8.1 Next Steps

Following a decision on whether to proceed with 3 TPH or 4 TPH for the chosen Greystones service, the design and optioneering can be developed in conjunction with the TSS and stabling requirements at Bray.

Detailed signalling and permanent way design will be required to refine Option B(2+3) into a viable constructable project. Future sensitivity analysis can also be undertaken to understand the balance on the works required at Bray while still meeting the capacity requirements of 3 TPH.

Appendix A

Sketches

A1 Costing sketches

The following sketches/drawings have been used to provide the cost estimate

Drawing Reference	Description	Component
D+WP56-ARP-ZZ-SL-DR-PW-SK0001	Greystones Southern Turnback	1
D+WP56-ARP-ZZ-SL-DR-PW-SK0002	Greystones Loop	2
D+WP56-ARP-ZZ-SL-DR-PW-SK0003	Bray re-configuration (upper part of the drawing)	3
	Bray Up Sidings Extension (middle and lower part of the drawing)	4
D+WP56-ARP-ZZ-SL-DR-PW-SK0004	Bray Dn Sidings Extension	5
32110404-JAC-GCN-XX-DR-CE-0001	Jacobs design, Bray Double tracking	6
32110404-JAC-GCN-XX-DR-CE-0003 32110404-JAC-GCN-XX-DR-CE-0004	Jacobs design, Greystones Double tracking	7

Appendix B

Cost Estimates

B1

DRAWING TO BE READ IN COLOUR

SCALE 1:1000

FOR INFORMATION ONLY

Dublin Transport Authority

JACOBS

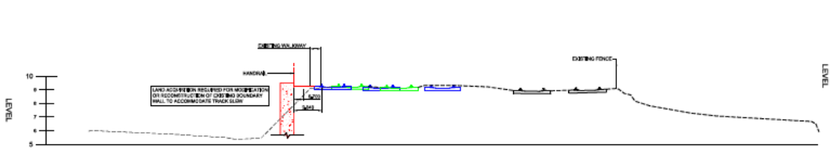
DART EXPANSION

TECHNICAL OPTION STUDY

GREYSTONES SERVICE IMPROVEMENT STUDY GENERAL ARRANGEMENT SHEET 4

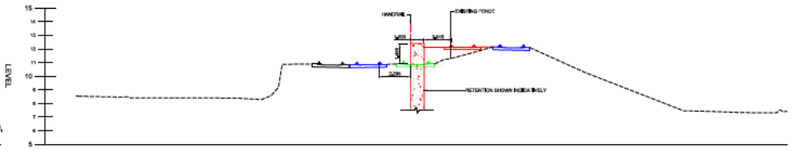
SECTION PA5 @ CH29070

SECTION AA @ CH29070



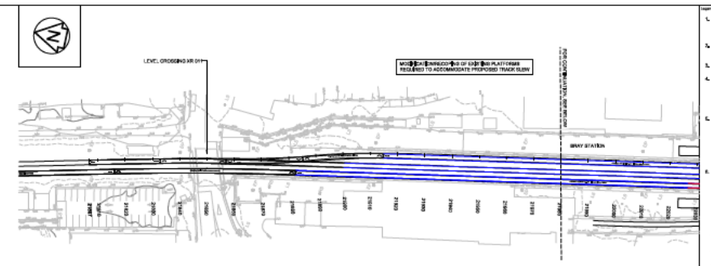
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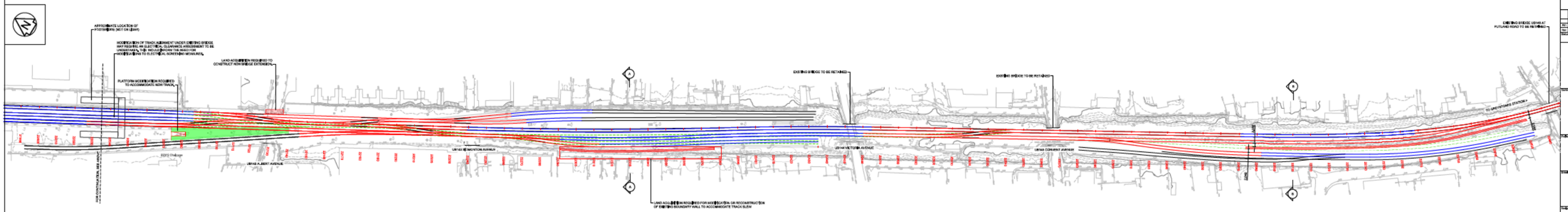
SCALE 1:250



SECTION B-B @ CH22700

SCALE 1:250





DRAWING TO BE READ IN COLOUR

EXISTING
PROPOSED
MODIFIED
REMOVED

SCALE 1:500

Legend Notes

1. FOR LIDAR SURVEY, REFER TO MODEL:
321104D1-IAC-GCN-XX-DR-CE-0001 CREATED FROM LIDAR SURVEY PROVIDED BY [redacted] 29/05/18.
2. FOR HORIZONTAL TRACK ALIGNMENT, REFER TO MODEL:
321104D1-IAC-GCN-XX-DR-CE-0002
3. ALL DIMENSIONS IN METRES UNLESS OTHERWISE STATED.
4. PRELIMINARY SPATIAL REQUIREMENTS FOR ACCOMMODATING DUAL TRACK ALIGNMENT HAVE BEEN BASED ON THE PROVISION OF A 700MM WIDE VARIABLE WIDTH OFFSET ENSURE FROM RUNNING EDGE OF RAIL AS PER IM-PAC-ITC-4.
5. ANNUAL RETAINING FEASIBILITY EXERCISE HAS BEEN CARRIED OUT FOR A MAXIMUM ALLOWABLE SLOPE OF 1 IN 2, WHERE THERE MAY ADVANTAGE DUE TO SPACE CONSTRAINTS OR NON-RAILWAY RETENTION WALL IS REQUIRED, WHERE SLOPES HAVE BEEN USED THEY WILL REQUIRE TO BE CONFIRMED BY GEOTECHNICAL INVESTIGATION AT A FUTURE DESIGN STAGE.
6. WHERE RETENTION INDICATED SUITABLE SITE INVESTIGATION AND GEOTECHNICAL INVESTIGATION SHOULD BE CARRIED AT FUTURE DESIGN STAGES TO ALLOW APPLICATION OF THE FOLLOWING HIERARCHY:
1) JUSTIFICATION OF STEEPER SLOPES?
2) USE OF STABILISATION TECHNIQUES ON STEEPER SLOPES?
3) USE OF RETENTION MEASURES.

KEY:

- PROPOSED TRACK ALIGNMENT
- EXISTING TRACK
- EXISTING GROUND PROFILE
- RETAINING WALL
- PROPOSED HANDRAIL
- EARTHWORKS CUT (SLOPE @ 1:2)
- EARTHWORKS FILL (SLOPE @ 1:2)

Rev	Date	Description	Drawn	Chkd	Appr
P01	[redacted]	FOR INFORMATION	JF	CF	SS

Status: FOR INFORMATION ONLY

Client: Údarás Náisiúnta Iompair / National Transport Authority

Consultant: JACOBS — Merlin House, Merlin Road, Dublin 4, Ireland. Tel: [redacted] Fax: [redacted]. www.jacobs.com

Project: DART EXPANSION TECHNICAL OPTION STUDY

Drawing Title: GREYSTONES SERVICE IMPROVEMENT STUDY GENERAL ARRANGEMENT SHEET 1

	Signed	Date
Designed	[redacted]	[redacted]
Drawn	[redacted]	[redacted]
Checked	[redacted]	[redacted]
Approved	[redacted]	[redacted]

Scale: 1:500 — 1:1000 @ A3 — X

Coordinate System: [redacted]

Sheet: 1 of 4

Drawing Number: 321104D1-IAC-GCN-XX-DR-CE-0001

Status: P01

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Sheet Size A1 594 x 1189

ORDER OF COST ESTIMATES

FOR

DART + COASTAL SOUTHERN LINE

GREYSTONES TO BRAY INFRASTRUCTURE

Issue and Revision Record:

Rev.	Date	Prepared by	Checked	Description
0	14-Dec-21	[redacted]	[redacted]	Estimate issue

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Documentation

DART+ Coastal: Greystones to Bray drawings thus:
32110401-JAC-GCN-XX-DR-CE-0001 (Component 6)
32110401-JAC-GCN-XX-DR-CE-0003 (Component 7)
32110401-JAC-GCN-XX-DR-CE-0004 (Component 7)
D+WP56-ARP-ZZ-SL-DR-PW-SK0001 (Component 1)
D+WP56-ARP-ZZ-SL-DR-PW-SK0002 (Component 2)
D+WP56-ARP-ZZ-SL-DR-PW-SK0003 (Components 3 & 4)
D+WP56-ARP-ZZ-SL-DR-PW-SK0004 (Component 5)

Notes and assumptions

Generally

See work items for specific assumptions
See attached take off for each option
Anticipated final cost before inflation based on 4Q19
Pricing is in Euros. A factor of 1.16 has been used to convert from pounds sterling to Euro.
An allowance has been made for local costing.
Signalling costs are based pro rata on those supplied by Arup for the Northern Line. Design will need to be developed in the next phase and the costs reviewed
Driver's walkway assumed to be granular material surface or similar
Assume no alterations to track drains are required

Risk

Priced at 34% of the point estimate in line with the Preliminary Business Case.

Inflation

Priced at 25% of the anticipated final cost in line with the Preliminary Business Case.

Summary of Group Element Costs									
RMM Vol 1 Ref	Group Element	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6	Component 7	Comments / Assumptions
1	**Direct Construction Works**								
1.01	Permanent Way Works	[redacted]							
1.02	Civil Engineering Works								
1.03	Signalling, Electrification and Telecomms								
1.04	Railway Electrification and Power Supply								
	DIRECT CONSTRUCTION WORKS COSTS (A)	[redacted]							
2	**Preliminaries, overheads and profit**								
2.01	Preliminaries								
2.02	Contractor Overheads and profit								
	INDIRECT CONSTRUCTION WORKS COSTS (B)								
	CONSTRUCTION COST (C)								
3	**Project / Design Team Fees and Other Project Development Costs**								
3.01	Design Team Fees								*Employer (Consultant) design costs*
3.02	Project Management Team Fees								
3.03	Other Project Development Costs								
	EMPLOYER INDIRECT COSTS (D)								
	POINT ESTIMATE Construction + Development Cost (E)								
4	**Risk**								
4.01	Risk								
5									
5.01	Discount back to Q4 2019								
	ANTICIPATED FINAL COST Cost limit excluding inflation								
6	**Inflation**								
6.01	Inflation - 25%	[redacted]							
7	**VAT**								
7.01	VAT - 13.5%								
	Anticipated Final Cost - AFC TOTAL COST LIMIT	14,448,383	14,724,033	5,386,746	7,215,253	7,895,386	44,242,039	90,851,440	

PROJECT NAME	DART+ Coastal Greystones to Bray					
	Component 1 - Greystones Southern Turnback			TOTAL	[redacted]	
RMM Vol 1 Ref	Description	Quantity	Unit	Rate	Cost	Comments
1	Direct Construction Works					
1.01	Permanent Way Works					
	Remove plain line	229	m			All works mid-week/weekend nights
	Remove crossover	0	nr			
	New plain line	422	m			
	Track foundations	422	m			
	Turnouts	4	nr			
	Buffer stop - *assume sliding friction type and including stop light*	1	nr			
1.02	Civil Engineering Works					
	Earthworks - embankment	51	m			Normal working hours
	Remove stone retaining wall - assume some temporary works for stability	51	m			Ditto
	Retaining wall	51	m			Ditto
	Extend pedestrian underpass	1	sum			Mid-week/weekend nights
1.03	Signalling, Electrification and Telecomms					
	Allowance for modifications to power cabling and SCADA	1	sum			Normal working hours
	Signalling (no detail - Provisional sum)	1	sum			Mid-week/weekend nights.
	Signalling - allow additional provisional allowance for alterations to panels at signalling centres	1	sum			Included above
	Points heating	4	nr			New turnouts only. Mid-week/weekend nights
	Allowance for diversion of existing utilities and railway services	1	nr			Assume none required
1.04	Railway Electrification and Power Supply					
	Remove existing OLE	154	m			All works mid-week/weekend nights
	OLE	496	m			
	Allowance for overlaps (tie-ins to existing OLE)	4	nr			
2	Preliminaries, Overheads & Profit					
2.01	Preliminaries					
	Contractor's Cost Items					
	Preliminaries generally	1	sum			26% of direct works
2.02	Overheads & Profit					
	Overheads & Profit					
	Overheads & Profit	1	sum			11.5% of direct works & preliminaries
3	Project / Design Team Fees and Other Project Development Costs					
3.01	Design Team Fees					
	Project design fees	1	sum			14% of direct works, and preliminaries, overheads and profit.
3.02	Project Management Team Fees					
	Project Management Team Fees	1	sum			10% of direct works, preliminaries & design
3.03	Other Project Costs					
	Land purchase					
	Urban including parkland, golf courses etc		ha			
	Agricultural		ha			
	Other project costs	1	sum			1% of direct works, and preliminaries, overheads and profit.

PROJECT NAME	DART+ Coastal Greystones to Bray					
	Component 2 - Greystones Loop			TOTAL	[redacted]	
RMM Vol 1 Ref	Description	Quantity	Unit	Rate	Cost	Comments
1	Direct Construction Works				[redacted]	
1.01	Permanent Way Works					
	Remove plain line	80	m			All works mid-week/weekend nights
	New plain line	800	m			
	Track foundations	800	m			
	Turnouts	2	nr			
1.02	Civil Engineering Works					
	Earthworks - embankment	197	m			Normal working hours
	Remove stone retaining wall - assume some temporary works for stability	197	m			Ditto
	Retaining wall	197	m			Ditto
	Extend pedestrian underpass	1	sum			Mid-week/weekend nights
1.03	Signalling, Electrification and Telecomms					
	Allowance for modifications to power cabling and SCADA	1	sum			Normal working hours
	Signalling (no detail - Provisional sum)	1	sum			Mid-week/weekend nights
	Signalling - allow additional provisional allowance for alterations to panels at signalling centres	1	sum			Included above
	Points heating	2	nr			New turnouts only. Mid-week/weekend nights
	Allowance for diversion of existing utilities and railway services	1	nr			Currently unknown. Assumed not extensive
1.04	Railway Electrification and Power Supply					
	Remove existing OLE	80	m			All works mid-week/weekend nights
	OLE	840	m			
	Allowance for overlaps (tie-ins to existing OLE)	4	nr			
2	Preliminaries, Overheads & Profit					
2.01	Preliminaries					
	Contractor's Cost Items					
	Preliminaries generally	1	sum			26% of direct works
2.02	Overheads & Profit					
	Overheads & Profit					
	Overheads & Profit	1	sum			11.5% of direct works & preliminaries
3	Project / Design Team Fees and Other Project Development Costs					
3.01	Design Team Fees					
	Project design fees	1	sum			14% of direct works, and preliminaries, overheads and profit.
3.02	Project Management Team Fees					
	Project Management Team Fees	1	sum			10% of direct works, preliminaries & design
3.03	Other Project Costs					
	Land purchase					
	Urban including parkland, golf courses etc		ha			
	Agricultural		ha			
	Other project costs	1	sum			1% of direct works, and preliminaries, overheads and profit.

PROJECT NAME	DART+ Coastal Greystones to Bray					
	Component 3 - Bray Reconfiguration			**TOTAL**	[redacted]	
RMM Vol 1 Ref	**Description**	**Quantity**	**Unit**	**Rate**	**Cost**	**Comments**
1	**Direct Construction Works**					
1.01	**Permanent Way Works**					
	Remove plain line	150	m			All works mid-week/weekend nights
	Turnouts	2	nr			
	Buffer stop - *assume sliding friction type and including stop light*	1	nr			
1.02	**Civil Engineering Works**					
	Shorten existing platform	165	m2			Mid-week/weekend nights
1.03	**Signalling, Electrification and Telecomms**					
	Allowance for modifications to power cabling and SCADA	1	sum			Normal working hours
	Signalling (no detail - Provisional sum)	1	sum			Mid-week/weekend nights
	Signalling - allow additional provisional allowance for alterations to panels at signalling centres	1	sum			Included above
	Points heating	2	nr			New turnouts only. Mid-week/weekend nights
	Allowance for diversion of existing utilities and railway services	1	nr			Assume none required
1.04	**Railway Electrification and Power Supply**					
	OLE	120	m			All works mid-week/weekend nights
	Allowance for overlaps (tie-ins to existing OLE)	2	nr			
2	**Preliminaries, Overheads & Profit**					
2.01	**Preliminaries**					
	Contractor's Cost Items					
	Preliminaries generally	1	sum			26% of direct works
2.02	**Overheads & Profit**					
	Overheads & Profit					
	Overheads & Profit	1	sum			11.5% of direct works & preliminaries
3	**Project / Design Team Fees and Other Project Development Costs**					
3.01	**Design Team Fees**					
	Project design fees	1	sum			14% of direct works, and preliminaries, overheads and profit.
3.02	**Project Management Team Fees**					
	Project Management Team Fees	1	sum			10% of direct works, preliminaries & design
3.03	**Other Project Costs**					
	Land purchase					
	Urban including parkland, golf courses etc		ha			
	Agricultural		ha			
	Other project costs	1	sum			1% of direct works, and preliminaries, overheads and profit.

PROJECT NAME	DART+ Coastal Greystones to Bray					
	Component 4 - Bray Up Sidings Extension			**TOTAL**	[redacted]	
RMM Vol 1 Ref	**Description**	**Quantity**	**Unit**	**Rate**	**Cost**	**Comments**
1	**Direct Construction Works**					
1.01	**Permanent Way Works**					
	Remove plain line	155	m			All works mid-week/weekend nights
	New plain line	155	m			
	Track foundations	155	m			
1.02	**Civil Engineering Works**					
	Stepped access to track	1	nr			Normal working hours
	Relocate electrical building (no detail - Provisional sum)	1	sum			Ditto. New building and electrical equipment
	Widen existing bridges; 2nr road bridges (no detail - Provisional sum)	1	sum			Mid-week/weekend nights
1.03	**Signalling, Electrification and Telecomms**					
	Allowance for modifications to power cabling and SCADA	1	sum			Normal working hours
	Driver's walkway	155	m			Ditto
	Low level lighting to driver's' walkway - say at 4m centres. Includes for power supplies, trenches etc	39	m			Ditto
	Signalling (no detail - Provisional sum)	1	sum			Mid-week/weekend nights
	Signalling - allow additional provisional allowance for alterations to panels at signalling centres	1	sum			Included above
	Allowance for diversion of existing utilities and railway services	1	nr			Assume none required
1.04	**Railway Electrification and Power Supply**					
	OLE	155	m			All works mid-week/weekend nights
	Allowance for overlaps (tie-ins to existing OLE)	2	nr			
2	**Preliminaries, Overheads & Profit**					
2.01	**Preliminaries**					
	Contractor's Cost Items					
	Preliminaries generally	1	sum			26% of direct works
2.02	**Overheads & Profit**					
	Overheads & Profit					
	Overheads & Profit	1	sum			11.5% of direct works & preliminaries
3	**Project / Design Team Fees and Other Project Development Costs**					
3.01	**Design Team Fees**					
	Project design fees	1	sum			14% of direct works, and preliminaries, overheads and profit.
3.02	**Project Management Team Fees**					
	Project Management Team Fees	1	sum			10% of direct works, preliminaries & design
3.03	**Other Project Costs**					
	Land purchase					
	Urban including parkland, golf courses etc		ha			
	Agricultural		ha			
	Other project costs	1	sum			1% of direct works, and preliminaries, overheads and profit.

PROJECT NAME	DART+ Coastal Greystones to Bray					
	Component 5 - Bray Down Sidings Extension			TOTAL	[redacted]	
RMM Vol 1 Ref	Description	Quantity	Unit	Rate	Cost	Comments
1	**Direct Construction Works**					
1.01	**Permanent Way Works**					
	New plain line	198	m			All works mid-week/weekend nights
	Track foundations	198	m			
	Buffer stop - *assume sliding friction type and including stop light*	1	nr			
1.02	**Civil Engineering Works**					
	Earthworks - embankment	178	m			Normal working hours
	Remove stone retaining wall - assume some temporary works for stability	178	m			Ditto
	Retaining wall	178	m			Ditto
	Stepped access to track	1	nr			Ditto
	Widen existing bridges; 2nr road bridges (no detail - Provisional sum)	1	sum			Mid-week/weekend nights
1.03	**Signalling, Electrification and Telecomms**					
	Allowance for modifications to power cabling and SCADA	1	sum			Normal working hours
	Driver's walkway	130	m			Ditto
	Low level lighting to driver's' walkway - say at 4m centres. Includes for power supplies, trenches etc	33	m			Ditto
	Signalling (no detail - Provisional sum)	1	sum			Mid-week/weekend nights
	Signalling - allow additional provisional allowance for alterations to panels at signalling centres	1	sum			Included above
	Allowance for diversion of existing utilities and railway services	1	nr			Currently unknown. Assumed not extensive
1.04	**Railway Electrification and Power Supply**					
	OLE	198	m			All works mid-week/weekend nights
	Allowance for overlaps (tie-ins to existing OLE)	2	nr			
2	**Preliminaries, Overheads & Profit**					
2.01	**Preliminaries**					
	Contractor's Cost Items					
	Preliminaries generally	1	sum			26% of direct works
2.02	**Overheads & Profit**					
	Overheads & Profit					
	Overheads & Profit	1	sum			11.5% of direct works & preliminaries
3	**Project / Design Team Fees and Other Project Development Costs**					
3.01	**Design Team Fees**					
	Project design fees	1	sum			14% of direct works, and preliminaries, overheads and profit.
3.02	**Project Management Team Fees**					
	Project Management Team Fees	1	sum			10% of direct works, preliminaries & design
3.03	**Other Project Costs**					
	Land purchase					
	Urban including parkland, golf courses etc		ha			
	Agricultural		ha			
	Other project costs	1	sum			1% of direct works, and preliminaries, overheads and profit.

PROJECT NAME	DART+ Coastal Greystones to Bray					
	Component 6 - Bray Double Tracking (Jacobs design)			TOTAL	[redacted]	
RMM Vol 1 Ref	Description	Quantity	Unit	Rate	Cost	Comments
1	Direct Construction Works					
1.01	Permanent Way Works					
	Track slew using tamper (2nr passes)	1,150	m			All works mid-week/weekend nights
	Remove plain line	705	m			
	Remove turnouts	1	nr			
	Remove crossover	5	nr			
	New plain line	1,040	m			
	Track foundations	1,040	m			
	Turnouts	2	nr			
	Crossover	7	nr			
	Buffer stop - *assume sliding friction type and including stop light*	1	nr			
1.02	Civil Engineering Works					
	Earthworks - embankment	240	m			Normal working hours
	Remove stone retaining wall - assume some temporary works for stability	240	m			Ditto
	Retaining wall - 5m high	240	m			Ditto
	Handrail to top of retaining wall	240	m			Ditto
	Demolish platform incl foundations; backfill voids and make good	350	m2			Mid-week/weekend nights
	Widen existing bridge; 1nr road bridge (no detail - Provisional sum)	1	sum			Mid-week/weekend nights
1.03	Signalling, Electrification and Telecomms					
	Allowance for modifications to power cabling and SCADA	1	sum			Normal working hours
	Signalling (no detail - Provisional sum)	1	sum			Mid-week/weekend nights
	Signalling - allow additional provisional allowance for alterations to panels at signalling centres	1	sum			Included above
	Points heating	16	nr			New turnouts only. Mid-week/weekend nights
	Allowance for diversion of existing utilities and railway services	1	nr			Currently unknown. Subject to survey
1.04	Railway Electrification and Power Supply					
	OLE	1,649	m			All works mid-week/weekend nights
	Allowance for overlaps (tie-ins to existing OLE)	9	nr			
2	Preliminaries, Overheads & Profit					
2.01	Preliminaries					
	Contractor's Cost Items					
	Preliminaries generally	1	sum			26% of direct works
2.02	Overheads & Profit					
	Overheads & Profit					
	Overheads & Profit	1	sum			11.5% of direct works & preliminaries
3	Project / Design Team Fees and Other Project Development Costs					
3.01	Design Team Fees					
	Project design fees	1	sum			14% of direct works, and preliminaries, overheads and profit.
3.02	Project Management Team Fees					
	Project Management Team Fees	1	sum			10% of direct works, preliminaries & design
3.03	Other Project Costs					
	Land purchase					
	Urban including parkland, golf courses etc	0.07	ha			

	Agricultural		ha	[redacted]	[redacted]	
	Other project costs	1	sum			1% of direct works, and preliminaries, overheads and profit.

PROJECT NAME	DART+ Coastal Greystones to Bray					
	Component 7 - Greystones Double Tracking (Jacobs design)			TOTAL	[redacted]	
RMM Vol 1 Ref	Description	Quantity	Unit	Rate	Cost	Comments
1	Direct Construction Works					
1.01	Permanent Way Works					
	Track slew using tamper (2nr passes)	2,158	m			All works mid-week/weekend nights
	New plain line	2,625	m			
	Track foundations	2,625	m			
	Turnouts	1	nr			
	Crossover	2	nr			
1.02	Civil Engineering Works					
	Earthworks - cutting	7,760	m3			Mid-week/weekend nights.
	Earthworks - embankment	1,360	m			Normal working hours
	Remove stone retaining wall - assume some temporary works for stability	2,080	m			Ditto
	Retaining wall - 5m high	2,000	m			Ditto
	Handrail to top of retaining wall	1,540	m			Ditto
	UTX Culvert	5	Lm			Mid-week/weekend nights.
	Modify existing level crossing	1	PS			Ditto
	Rebuild overbridge	1	sum			Ditto. OB152
	Rebuild underbridge	1	sum			Ditto. UB150 - assume new structure required
	New footbridge	1	sum			Ditto. OB151
1.03	Signalling, Electrification and Telecomms					
	Allowance for modifications to power cabling and SCADA	1	sum			Normal working hours
	Driver's walkway	2,270	m			Ditto
	Low level lighting to driver's' walkway - say at 4m centres. Includes for power supplies, trenches etc	568	m			Ditto. Assume not reauired to walking route along top of retaining wall
	Signalling (no detail - Provisional sum)	1	sum			Mid-week/weekend nights.
	Signalling - allow additional provisional allowance for alterations to panels at signalling centres	1	sum			Included above
	Points heating	5	nr			New turnouts only. Mid-week/weekend nights
	Allowance for diversion of existing utilities and railway services	1	nr			Currently unknown. Subject to survey
1.04	Railway Electrification and Power Supply					
	OLE	3,269	m			All works mid-week/weekend nights
	Allowance for overlaps (tie-ins to existing OLE)	4	nr			
2	Preliminaries, Overheads & Profit					
2.01	Preliminaries					
	Contractor's Cost Items					
	Preliminaries generally	1	sum			26% of direct works
2.02	Overheads & Profit					
	Overheads & Profit					
	Overheads & Profit	1	sum			11.5% of direct works & preliminaries
3	Project / Design Team Fees and Other Project Development Costs					
3.01	Design Team Fees					
	Project design fees	1	sum			14% of direct works, and preliminaries, overheads and profit.
3.02	Project Management Team Fees					
	Project Management Team Fees	1	sum			10% of direct works, preliminaries & design
3.03	Other Project Costs					

	Land purchase					
	Urban including parkland, golf courses etc	0.1	ha			
	Agricultural		ha			
	Other project costs	1	sum			1% of direct works, and preliminaries, overheads and profit.

item code	Principal Cost Heading	Description	Unit	Rate €	Rate %	
1	**Preliminaries**	Contractor's Preliminaries	%		26	
2	**Overhead and Profit**	Contractor's Overhead and Profit	%		11.5	
3	**Design**	Project Design Team Fees	%		14	
4	**PM**	Project Management Team Fees	%		10	
5	**Other**	Other Project Development *(excluding Land Cost and compensation costs)*	%	[redacted]	1	
6	**Pway Works**	Remove plain line and recover	m			
7	**Pway Works**	Remove turnouts	nr			
8	**Pway Works**	Remove crossover	nr			
9	**Pway Works**	Track foundations	m			
10	**Pway Works**	New plain line	m			
11	**Pway Works**	Turnouts	nr			
12	**Pway Works**	Crossover	nr			
13	**Civil Eng Works**	Earthworks - cutting	m3			
14	**Civil Eng Works**	Earthworks - embankment	m			
15	**Civil Eng Works**	Retaining wall	m			
16	**Civil Eng Works**	Retaining wall - 5m high	m			
17	**RE & PWS**	OLE	m			
18	**RE & PWS**	Allowance for overlaps (tie-ins to existing OLE)	nr			
19	**SET**	Allowance for modifications to power cabling and SCADA	sum			
20	**Civil Eng Works**	Boundary fencing (assume metal palisade)	m			
21	**Building Works**	Remove existing platform fencing	m			
22	**Civil Eng Works**	Remove existing boundary fencing	m			
23	**Building Works**	Alterations to platform edge - adjust copers as necessary	m			
24		Remove plain line	m			
25		Demolish platform incl foundations; backfill voids and make good	m2			Assumes brick/block and fill, excludes canopies
26		Platform fencing	m			
27		Driver's walkway	m			
28		Buffer stop - *assume sliding friction type and including stop light*				
29		Remove stone retaining wall - assume some temporary works for stability				
30	**Civil Eng Works**	Handrail to top of retaining wall	m			
31	**Pway Works**	Track slew using tamper (2nr passes)	m			Two passes x 95.25/pass
32		UTX Culvert	m			Includes excavation/disposal, ducting, 1nr additional Cubis-type chamber c/w steps and cover
33		Modify existing level crossing	PS			
34		Rebuild overbridge	PS			
35		Rebuild underbridge	PS			
36		New footbridge	sum			Based on Lisburn Park & Ride budget estimate for Corderoy[redacted]) 2020
37		Points heating	nr			

Conversion: **£1 =** **€1.16**

Greystones/Bray

Component 1 - Greystones Southern Turnback
Drg: D+WP56-ARP-ZZ-SL-DR-PW-SK0001

Drivers' walkway 700mm wide with lighting

Earthworks

Retaining wall

Stepped access

Permanent way

Plain line where crossover removed (southbound)

Track foundations

Turnout

Crossover

Buffer stop

Remove plain line - say

Remove crossover

Remove stone retaining wall (assume as new retaining wall)

Extended underpass (5m wide x 3m long)

OLE

Crossover

Remove OLE

Crossover

Signalling

nr

Component 2 - Greystones Loop
Drg: D+WP56-ARP-ZZ-SL-DR-PW-SK0002

Drivers' walkway 700mm wide with lighting

Earthworks

Retaining wall

Stepped access

Permanent way

Plain line where crossover removed (southbound)

Track foundations

Turnout

Crossover

Buffer stop

Remove plain line - say

Remove crossover

Remove stone retaining wall (assume as new retaining wall)

Extended culvert (5m wide x 3m long)

OLE

Crossover

Remove OLE

Crossover

Signalling

Component 3 - Bray Reconfiguration
Drg: D+WP56-ARP-ZZ-SL-DR-PW-SK0003

Drivers' walkway 700mm wide with lighting

Earthworks

Retaining wall	[redacted]	
Stepped access		
Permanent way		
Track foundations		
Turnout		
Buffer stop		
Remove plain line - say		
Remove stone wall (assume as new retaining wall)		
Shorten existing platform		
OLE		
Signalling		
Component 4 - Bray Up Sidings Extension **Drg: D+WP56-ARP-ZZ-SL-DR-PW-SK0003**		
Drivers' walkway 700mm wide with lighting	[redacted]	
Earthworks		
Retaining wall		
Stepped access		
Permanent way		
Track foundations		
Turnout		
Crossover		
Buffer stop		
Remove plain line - say		
Remove stone wall (assume as new retaining wall)		
Eletrical building relocation (no detail, so PS only)		
Bridge widening (no detail, PS only)		
OLE		Crossover
Signalling		
Component 5 - Bray Down Sidings Extension **Drg: D+WP56-ARP-ZZ-SL-DR-PW-SK0004**		
Drivers' walkway 700mm wide with lighting	[redacted]	
Earthworks		
Retaining wall		
Stepped access		
Permanent way		Plain line between crossover & turnout (northbound)
Track foundations		
Turnout		
Crossover		
Buffer stop		
Remove plain line - say		
Remove stone wall (assume as new retaining wall)		
Extended underpass (5m wide x 3m long)		
OLE		Crossover
Signalling		Crossover

Component 6

Land acquisition

Component 7

Cutting

Cross-section at A-A
Chain 27240 - say
Chain 27430 - say
Chain 27640 - say
Chain 27740 - say

Volume of excavation

Embankment

Cross-section at A-A drawing 3
Cross-section at A-A drawing 4

Volume of filling

Cutting

Cross-section at B-B drawing 4

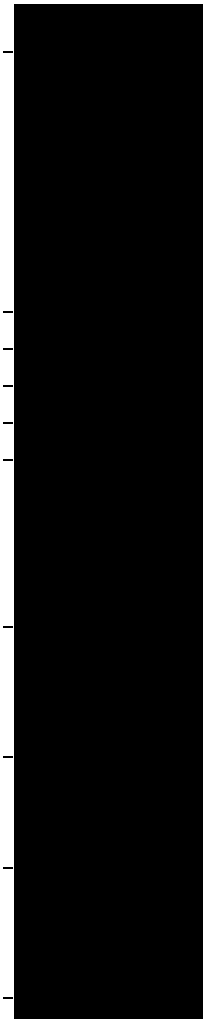
Volume of excavation

Retaining wall

Deduct

Handrail

Deduct



Roof
Roof

Rooflight

Purlins

Verges

Handrails

External walls
Brick faced insulation panels

South elevation

End elevation

North elevation

Curtain walling

South elevation

Deduct door & screen

End elevation

Deduct door & screen

North elevation

Deduct door & screen

South elevation (FF)

End elevation (FF)

North elevation (FF)

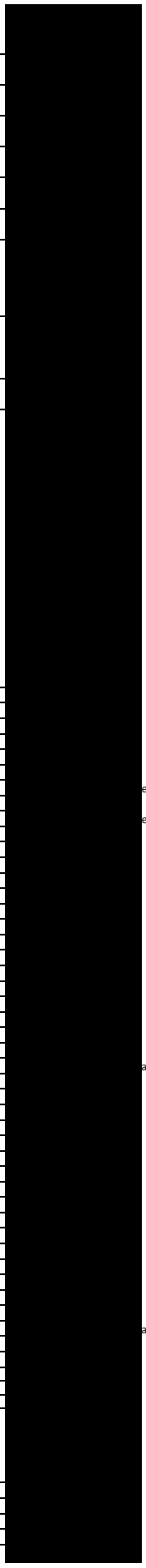
South elevation (Roof)

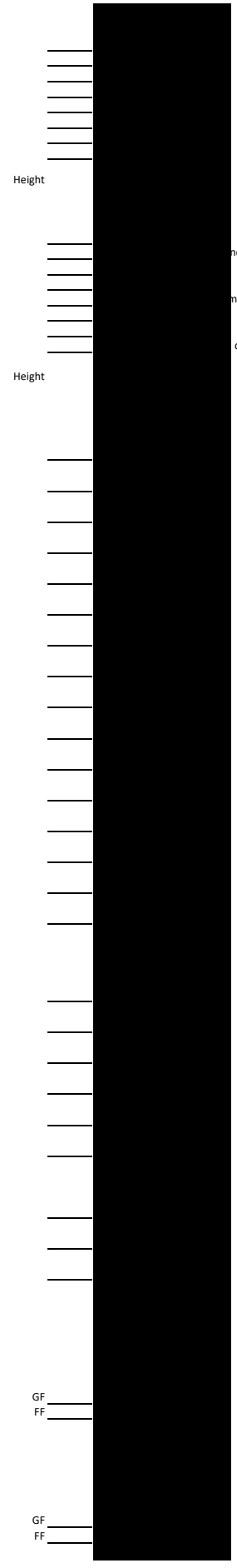
Rain screens

South elevation

End elevation

[redacted]


North elevation
South elevation (FF)
North elevation (FF)
South elevation (Roof)
End elevation (Roof)
North elevation (Roof)
Louvred walls
South elevation
Glazed screens at entrances
Side doors
Main door
External doors
Louvre doors - double
Double doors
GF
FF
Single doors
Single doors in screens
Revolving doors in screens
Internal walls (GF)
Metal stud partitions
eleted in amended plan
eleted in amended plan
amended plan
as amended plan
Height
Masonry


Height
Glazed screens
nded plan
mended plan
ded plan
Height
Internal walls (FF)
Metal stud partitions
Masonry
Glazed screens
Party wall to plant room
Balustrade around atrium
WC cubicles
GF
FF
Shower cubicles
Internal doors
Single
GF
FF

Single; plant rooms

GF

Single; in glazed screens

GF

FF

Double

Acoustic ceiling

Vertical and sloping

Curved

Suspended ceiling

Horizontal

Deduct atrium

Deduct offices

Sanitary appliances

WCs - GF

WCs - FF

Grabs - GF

Grabs - FF

Disabled WC with sink - GF

Disabled WC with sink - FF

WHBs - GF

WHBs - FF

Shower - GF

Disabled shower - GF

Cleaner's sink

Kitchenette for staff

Photovoltaic panels

Area measured

Carpet tiles

Slip resistant sheet

Raised flooring GF

Deduct plant rooms

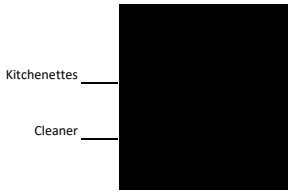
Raised flooring FF

Dust sealer

Wall tiles

Showers

Vanity units

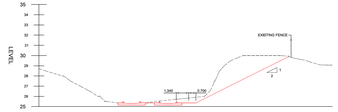

Kitchenettes
Cleaner

HIGH

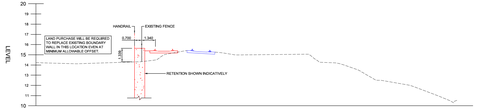
Tunnel 8m diameter x 4km long (plus 1km cuttings at each end)

Tunnels c.8m diameter -cost range £14 million - £33 million per km at 2017 rates Uplifted to 4Q19	4	km	[redacted]	Based on "Benchmarking Tunnelling Costs and Production rates in the UK - Infrastructure and Projects Authority"
Excavate cuttings at either end (including disposal) - say 1km each in rock x 0 - 10m depth	2	km		
Portals - say	2	nr		
Access road for maintenance	1	sum		
Permanent way - single track (including foundations and drains)	6000	m		Rate as Northern line double tracking
OHLE including distribution	6	km		
Modifications at ends	2	nr		
Signalling	6	km		Rate as Northern line double tracking
Telecoms	6	km		Ditto
LV (including trough)	6	km		Ditto
Fencing - to cuttings only. Say post and wire throughout	2	km		
Preliminaries (assume included in tunnel cost)	26%			
OH&P (assume included in tunnel cost)	10%			
Design team costs	16.25%			
Project management team costs	8.25%			
Other costs (local authority fees etc)	1%			
Land purchase - say for cuttings 75% rural/25% urban	1	sum		
Risk	33%			
Inflation	26.24%			
VAT	13.50%			

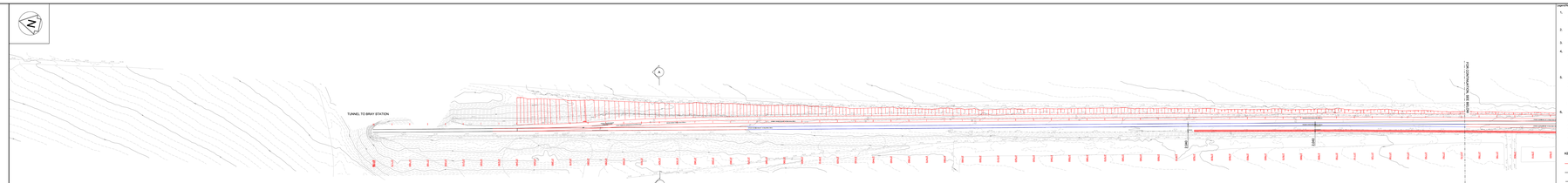
Drawing Number
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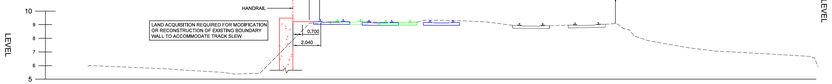
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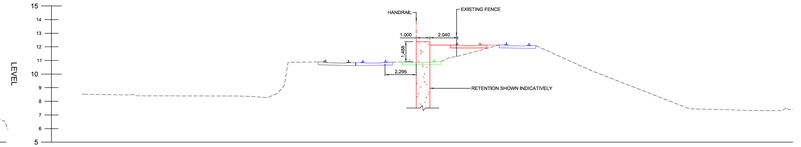
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TUNNEL TO BRAY STATION
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A
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1.5m
1.5m

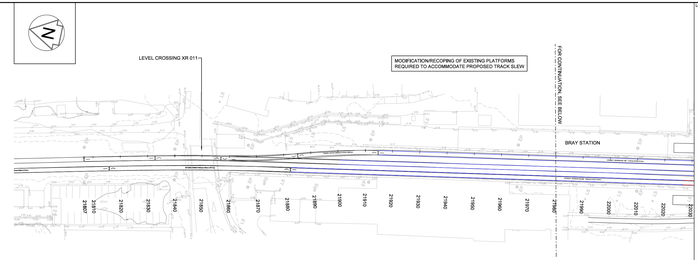
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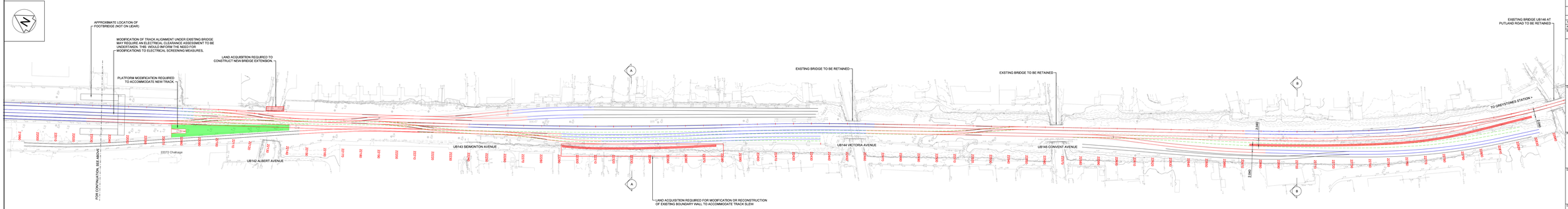


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Legend/Notes

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2. FOR HORIZONTAL P-WAY ALIGNMENT, REFER TO MODEL 32110401-JAC-GCN-XX-M2-TR-0002
3. ALL DIMENSION IN METRES UNLESS OTHERWISE STATED.
4. PROVISIONAL SPATIAL REQUIREMENTS FOR ACCOMMODATING DUAL TRACK ALIGNMENT HAVE BEEN BASED ON THE PROVISION OF A 700MM WIDE WALKING ROUTE, OFFSET 1400MM FROM RUNNING EDGE OF RAIL AS PER IARWY-1101.
5. AN INITIAL RECRASING FEASIBILITY EXERCISE HAS BEEN CARRIED OUT FOR A MAXIMUM ALLOWABLE SLOPE OF 1 IN 2, WHERE THIS IS NOT ACHIEVABLE DUE TO SPATIAL CONSTRAINTS IT HAS BEEN ASSUMED RETENTION WILL BE REQUIRED. WHERE SLOPES HAVE BEEN USED THEY WILL REQUIRE TO BE CONFIRMED BY GEOTECHNICAL INVESTIGATION AT A FUTURE DESIGN STAGE.
6. WHERE RETENTION IS INDICATED SUITABLE SITE INVESTIGATION AND GEOTECHNICAL INVESTIGATION SHOULD BE GATHERED AT FUTURE DESIGN STAGES TO ALLOW APPLICATION OF THE FOLLOWING HIERARCHY;
   1) JUSTIFICATION OF STEEPER SLOPES;
   2) USE OF STABILISATION TECHNIQUES ON STEEPER SLOPES;
   3) USE OF RETENTION MEASURES.

KEY;

- PROPOSED TRACK ALIGNMENT
- EXISTING TRACK
- EXISTING GROUND PROFILE
- RETAINING WALL
- PROPOSED HANDRAIL
- EARTHWORKS CUT (SLOPE @ 1:2)
- EARTHWORKS FILL (SLOPE @ 1:2)

Rev	Date	Description of Revisions	Drawn	Chkd	Appr
P01	08/04/20	FOR INFORMATION			

Status: FOR INFORMATION ONLY

Údarás Naisiúnta Iompair
National Transport Authority

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Project:
DART EXPANSION TECHNICAL OPTION STUDY

Drawing Title:
GREYSTONES SERVICE IMPROVEMENT STUDY GENERAL ARRANGEMENT SHEET 1

		Signed	Date
Designed:			08/04/20
Drawn:			08/04/20
Checked:			08/04/20
Approved:			08/04/20
Scale(s):	1:500	CLR 6 Mileage	x

Alternative Reference: Sheet 1 of 4

Drawing Number: 32110401-JAC-GCN-XX-DR-CE-0001 Revision: P01

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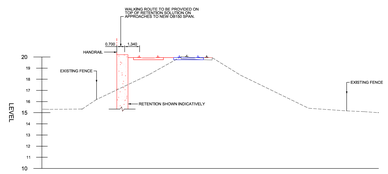
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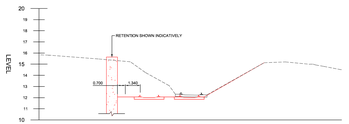
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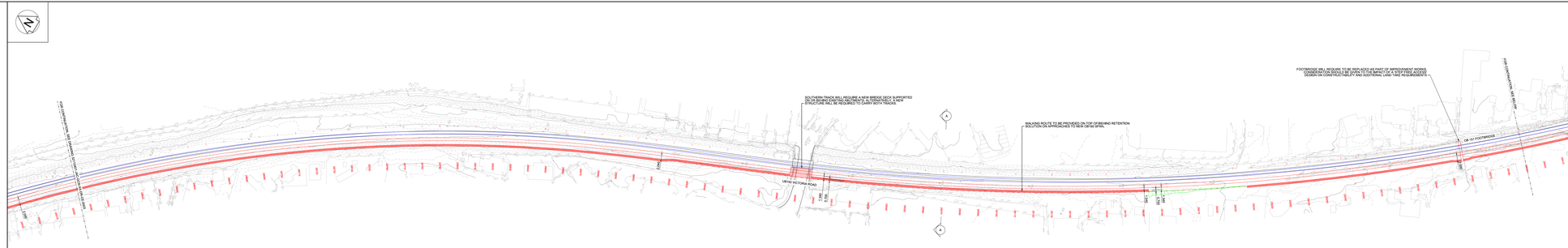
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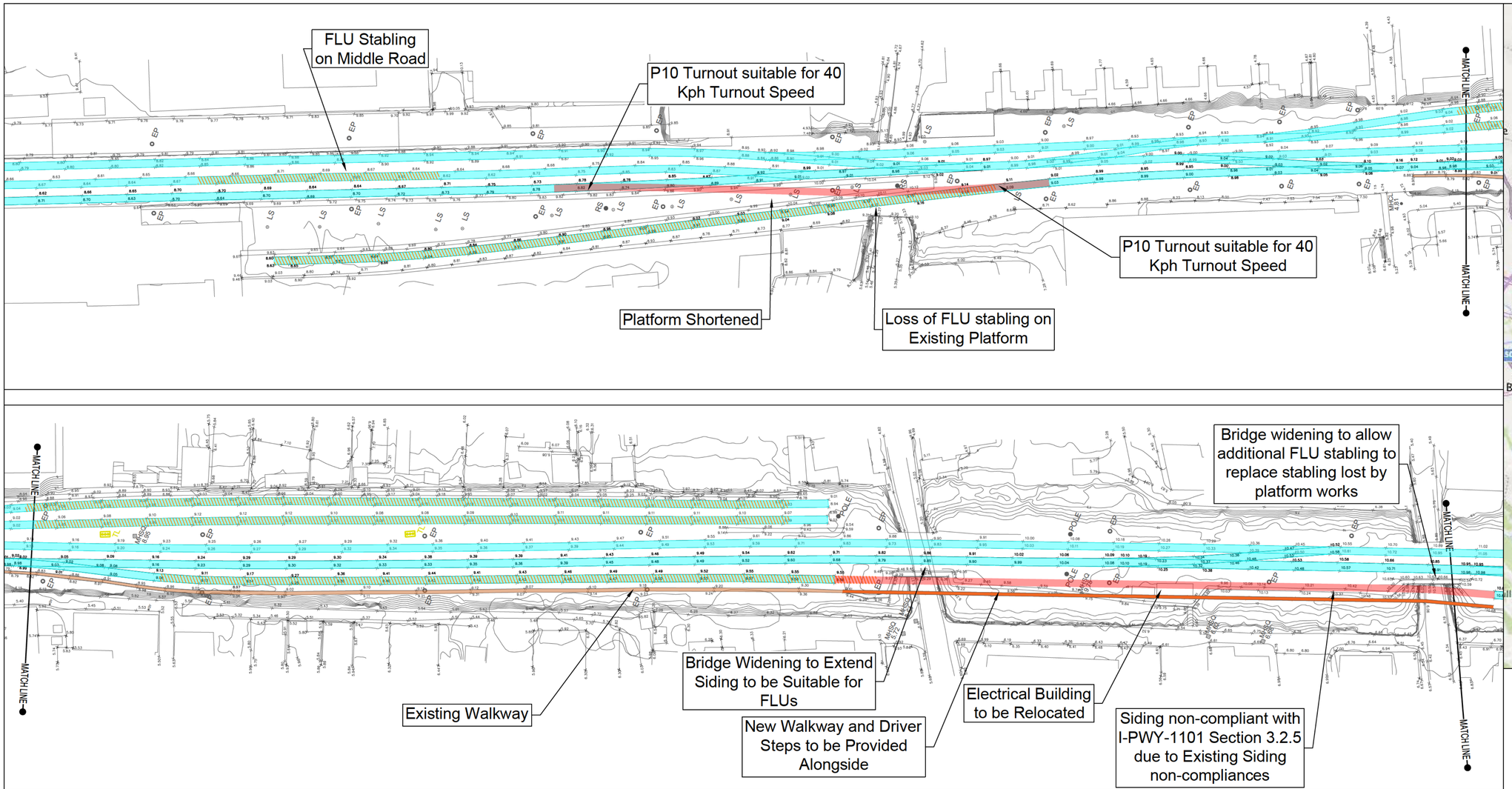
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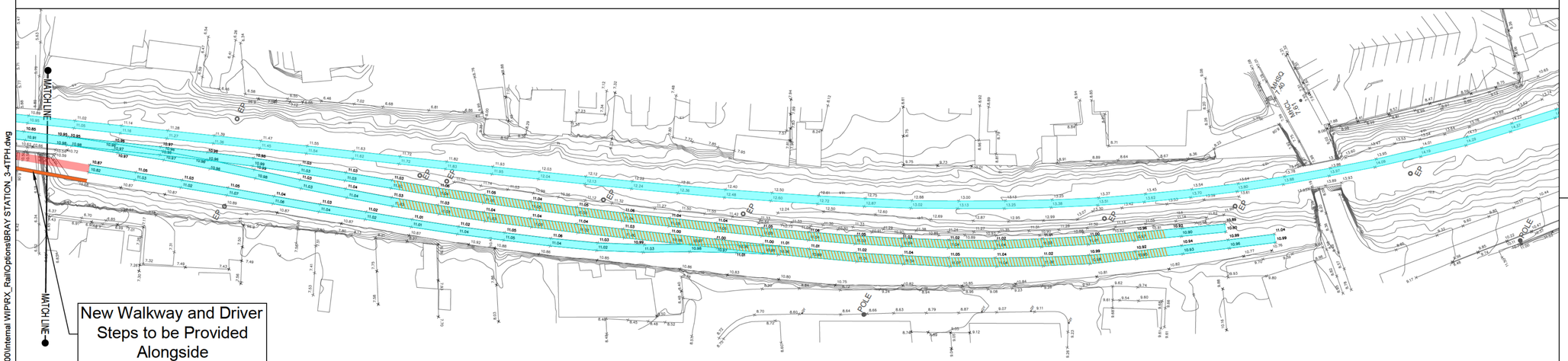


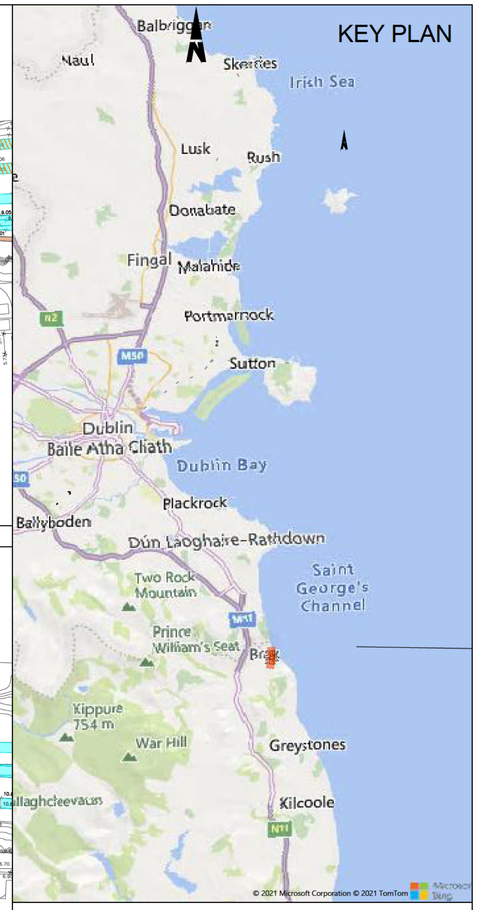
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WALKING ROUTE TO BE PROVIDED ON TOP OF/BEHIND RETENTION SOLUTION OR APPROACHES TO NEW DB/SB SPAN.
FOOTBRIDGE WILL REQUIRE TO BE REPLACED AS PART OF IMPROVEMENT WORKS. PROVISION FOR WHEEL CUP TROUGH AND RAMP OR STEP FREE ACCESS DESIGN ON CONSTRUCTABILITY AND ADDITIONAL LAND TAKE REQUIREMENTS
FOR CONSTRUCTION SEE DRWG 32110401-JAC-GCN-XX-DR-CE-0003
UP
DN
UP
DN
UP
DN







LEGEND:

- EXISTING RAIL TRACK RETAINED
- NEW RAIL TRACK
- EXISTING STABLING LOCATION
- EXISTING WALKWAY
- NEW WALKWAY TO BE PROVIDED
- EXISTING STATION

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DART+ Coastal North

NTA Údarás Náisiúnta Iompair National Transport Authority

Tionscadal Éireann Project Ireland 2040

Rev	Date	Drn	Chk'd	App'd	Description
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Client: Iarnród Éireann Irish Rail

Engineering Designer: ARUP

Date	Scale	Drawn	Checked	Approved
	1:500 @ A1 1:1000 @ A3			

Project Code	Originator Code	QMS Code
	ARP	

Project Title: **DART+ COASTAL NORTH**

Drawing Title: BRAY STATION
GENERAL ARRANGEMENT
OPTION 3 - 4 TPH

Drawing File Name	Sheet Number	Status	Rev
D+WP56-ARP-ZZ-SL-DR-PW-SK0003	1 of 1		

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Iarnród Éireann

DART+ Coastal South

Greystones Capacity Improvements Technical Note

D+WP56-ARP-P2-SL-RP-OP-000001

P03 | 19 January 2022

This report considers the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Document verification

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Job title		DART+ Coastal South		Job number 279933-00
Document title		Greystones Capacity Improvements Technical Note		File reference
Document ref		D+WP56-ARP-P2-SL-RP-OP-000001		
Revision	Date	Filename	Bray to Greystones Operations Review Note.docx	
P01	23 Nov 2021	Description	First issue for IÉ review and comment	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
P02	15 Dec 2021	Filename		
		Description	Updated to suit comments. Costing Infrmation added	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
P03	19 Jan 2022	Filename		
		Description	Naming convention Updated	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
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Appendices

Appendix A

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Cost Estimates

1 Executive Summary

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature.

Following quantitative and qualitative modelling and rail operations investigations into improving service levels between Bray and Greystones DART stations, Arup finds that a 3 TPH service pattern (1 additional train per hour) is the optimal improvement, and can be best achieved through the following package of works:

- the provision of a passing loop from near Bray Head Tunnel Number 4 for 800m towards Greystones; and,
- the addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points.

A loop of 800m is sufficient to enable a passing move with one direction having priority over the other, balancing increased runtime with increased timetable performance and robustness.

Note that the above recommendations are predicated on the delivery of a separate project to replace the legacy ATP protection system between Bray and Greystones with ETCS Level 1, removing the ATP banding speed restriction.

This package of infrastructure and service enhancements will achieve a 50% increase in services, while minimising the possibility of Bray to Greystones services becoming a problematic timetabling constraint to the rest of the DART network. This report proves that there is sufficient platform capacity at Greystones to accommodate a 1 TPH service from Rosslare, in addition to the 3 TPH DART services.

While this report finds it technically possible to achieve a future service level of 4TPH, it does not recommend this choice. A 4 TPH solution would require substantial capital investment compared to a 3 TPH solution, while posing a greater reliability risk, both to Bray to Greystones services, and the wider DART network.

Lastly, this note's recommendation of 3 TPH will impact the parallel Bray Station Turnback optioneering process, as all Bray Station solutions must, at a minimum, be able to handle turning back 9 TPH services.

This note has been produced to allow for a decision on the service specification and principal form of infrastructure interventions to Greystones to be confirmed, which will allow optioneering of the Bray to Greystones area to progress.

2 Introduction

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature. An obvious solution to this problem would be to double track the line; however, this section of railway crosses difficult terrain adjacent to the Irish Sea. Any expansion would require significant civil engineering works, at a capital cost likely not commensurate with the benefits coming from increased capacity and reliability. As such, Arup's task is to examine more cost-effective methods to increase capacity to either 3 or 4 TPH, and evaluate both options in light of the infrastructure they would require, and the impact each frequency would have on the wider DART+ network.

It is worth noting that minimising the run time between Bray and Greystones is not considered an important factor and, as will be seen in the analysis outputs presented below, providing a longer run time has benefits in improving capacity and reliability.

A report by Jacobs in 2020 examined the practical infrastructure enhancement choices and settled on a combination of extending double tracking south from Bray and north from Greystones to minimize the length of single tracking. Arup's investigation uses this study as a starting point, developing further options off the initial proposal.

The purpose of this note is as follows:

1. To present Arup's infrastructure options for providing both a 3 TPH or 4 TPH service to Greystones.
2. To explain the infrastructure requirements, Bray to Greystones performance, and wider DART network impacts of choosing to run either 3 TPH or 4 TPH.
3. To identify infrastructure recommendations.
4. To provide some high-level costings of the infrastructure for a 3 TPH and a 4 TPH service.
5. To advise IÉ to either pursue a 3 TPH or 4 TPH service between Bray to Greystones, and present a preferred set of infrastructure solutions to achieve the recommended service level.

3 Existing Capacity Constraints

In addition to the length of single line section , there are a number of other existing constraints worth noting.

3.1 ATP Speed banding

The current signalling arrangements include automatic train protection (ATP) speed banding which limits the speed a train can travel to a margin lower than the line speed.

Arup understands that IÉ is executing a separate signalling project that will upgrade the current train protection system to ETCS Level 1, removing these limits and allowing trains to run at the line speed.

This note assumes that this signalling work on the Bray-Greystones section is completed, thereby removing the current speed limits caused by (ATP) banding.

Arup analysed a further set of options on the effects of not removing ATP banding, however these have not been included in this note. This analysis concludes that it is essential for the signalling works to be carried out for any 4 TPH scenario. For 3 TPH the results indicate it is marginally possible to provide increased services without the signalling works, but it would require significant other infrastructure upgrades such as double tracking through Greystones.

3.2 Bray 115B Points

The points shown in Figure 1 below are just south of Bray Station and provide a significant operational constraint on the network.

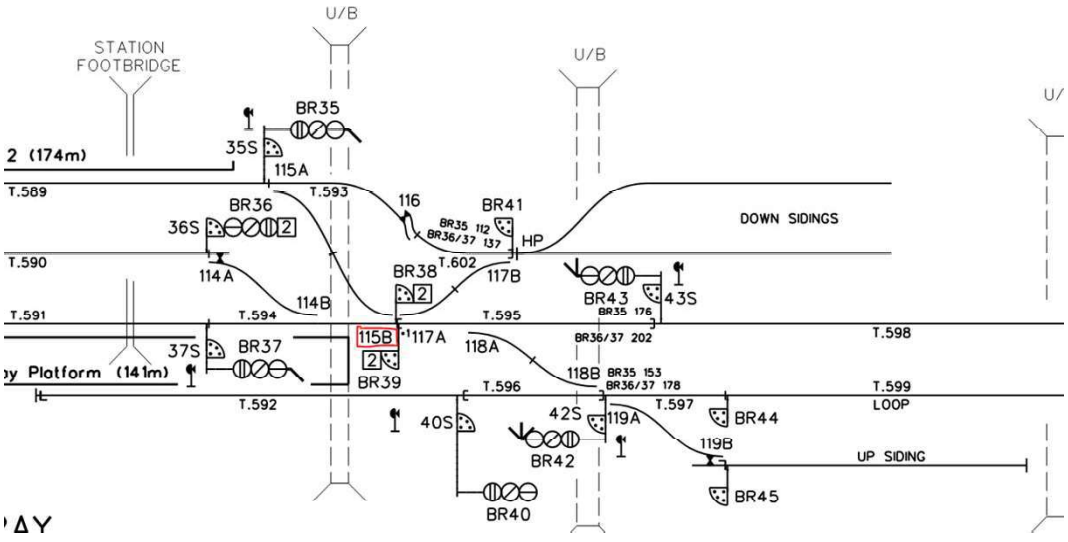


Figure 1: Excerpt from IÉ signalling diagram, showing Bray Station

They provide a single point at which all of the following moves must pass through and will therefore conflict:

- All trains leaving Bray and heading towards Greystones;
- All trains arriving at Bray from Greystones;
- All trains departing the Down sidings and heading to the Bray Platform 1;
- All trains heading to and/or from the Up sidings at Bray.

The signalling design for this area also compounds the operational restriction. The main route for all southbound services passes through the Down platform, whose protecting signal, BR35, has an overlap that stretches beyond points 115B to fully encompass the junction. This means that a train sat or passing through the main Down platform will block any train coming in the opposite direction, preventing any parallel moves through Bray Station.

3.3 Greystones platform Occupancy

The TSS assumes that to provide the additional DART capacity on the Bray to Greystones section the existing Rosslare services will terminate at Greystones. Checks have been undertaken against the options to determine if any additional infrastructure is required at Greystones to provide the required platform capacity for the Rosslare services.

3.4 Line speeds

There are small discrepancies between the start and stop locations of line speed changes provided in the RailSys model to those in the working timetable (WTT). Arup has reviewed these and confirms there is no meaningful difference between the two on the findings of this study.

4 Operational Modelling

Arup undertook RailSys modelling and high level quantitative analysis to examine what infrastructure enhancements would be required to meet the increased frequencies of 3 and 4 TPH. Through an optioneering process, Arup tested a series of design solutions, building the infrastructure in RailSys to test the performance of different track layouts.

Using technical outputs — such as signal occupation/clearance times — Arup undertook a finer grained quantitative analysis in excel, examining performance in light of:

- Capacity Utilisation;
- Runtime;
- Runtime allowance;

- Minimum Time Between Opposing Services.

The below options are based on different permutations of infrastructure options that are deemed viable within the project scope for improving capacity (in essence ruling out double tracking, tunnelling, or extensive work around Bray Head).

The analysis considered five constituent infrastructure components:

- **Component 1 -** A southern headshunt at Greystones Station
- **Component 2 -** Passing Loop from Bray Head Tunnel Number 4 for 800m towards Greystones
- **Component 3-** Removal of the constraint at 115B points through the provision of an additional connection from the Bay platform approach to the Up Bray platform. This allows for a shorter but less expensive extension of double tracking using an existing up loop road.
- **Component 6 -** Double Tracking from Bray Station for 700m to Putland Road.
- **Component 7 -** Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m.

Components 4 and 5, relate to resulting stabling infrastructure changes which are required as a result of other works and are discussed in Section 5

The suffixes provide a shorthand for explaining which combination of constituent infrastructure components each individual option is made up of. For example, Option B(1+6+7) is made up of:

Component 1 (A southern headshunt at Greystones Station)

+

Component 6 (Double Tracking from Bray Station for 700m to Putland Road)

+

Component 7 (Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m)

All options are prefixed with a B, as part of a comprehensive numbering system for all options involving Bray Station, Bray to Greystones, and Greystones Station. Prefix "B" indicates that the option assumes the removal of ATP speed banding.

		Greystones	Greystones	Bray	Signalling

Option Name	Description	Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
B (7)	Double Tracking Greystones	✓	X	X	X	✓
B (2)	Greystones Loop	X	✓	X	X	✓
B (6)	Bray Double Track	X	X	X	✓	✓
B(6+7)	Greystones + Bray Double Tracking	✓	X	X	✓	✓
B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	✓	X	✓	✓	✓
B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	✓	X	✓	✓	✓
B (2+6)	Greystones Loop + Bray Double Track	X	✓	X	✓	✓
B (2+3)	Greystones Loop + Bray Additional Crossover	X	✓	X	✓*	✓

Table 1: Infrastructure options and constituent components

In line with other DART+ Coastal project analyses, Arup used a capacity utilisation value of around 75% to be the cut-off towards failing an option. This is in line with UIC Code 406, which recommends a capacity utilisation rate of at maximum 75% for mixed traffic lines during the peak hour.

For each option, Arup developed a theoretical timetable, with trains leaving at regular intervals. In reality, trains on this section may not be evenly spaced, with arrival and departure times instead dictated by other constraints on different parts of the DART network.

As such, due to the single-track nature of the Bray to Greystones route and the fact that services on this section will be interlined with other DART services in the city centre, Arup considers it necessary to provide the maximum possible spare capacity, thus increasing service reliability and timetabling flexibility. For higher train frequencies of 4 TPH, Arup assumes that a 75% capacity utilisation rate is the hard maximum, with any preferred option ideally having a substantially lower capacity utilisation to allow for some redundancy in timetable planning and in times of delay. For 3 TPH scenarios, Arup assumes that capacity utilisation rates may still be judged as passing even if they are 1-2 % over 75%, due to the

smaller quantum of trains lessening the need to provide substantial timetabling redundancy.

4.1 Results

4.1.1 3 TPH

As can be seen below, all options can provide adequate capacity to enable 3 TPH. Additionally, there is an approximately 1 minute's difference in runtime between the fastest and slowest option, with Option B(1+6+7) providing almost obstruction free runtime, and Option B(7) requiring substantial pathing allowance in order to facilitate passing services in the up and down directions.

Note that for all options involving a loop at Greystones, at least one direction must stop and dwell for 30 seconds in order to enable the passing move. This has a negative effect on runtime, but greatly decreases capacity utilisation. Option B(7) instead requires trains in the Up direction to operate far below the rolling stock's peak performance, allowing for the passing move without necessitating a stop at the end of the double track section.

It should also be noted that the Minimum Opposing Gap is a value showing the closest time in between two services coming into conflict, with a higher value representing a more robust option.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option B (7)	Double Tracking Greystones	PASS	00:09:19	00:00:05	00:07:42	76%		1	17%
Option B (2)	Greystones Loop	PASS	00:08:48	00:00:11	00:07:43	70%		1	17%
Option B (6)	Bray Double Track	PASS	00:08:03	00:02:48	00:08:01	72%		2	45%
Option B (6+7)	Greystones + Bray Double Tracking	PASS	00:08:14	00:01:48	00:08:16	64%		1	17%

Option B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	PASS	00:07:58	00:04:47	00:07:58	59%		2	56%
Option B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:04:17	00:07:58	55%		2	56%
Option B (2+6)	Greystones Loop + Bray Double Track	PASS	00:08:58	00:00:18	00:07:59	57%		1	17%
Option B (2+3)	Greystones Loop + Bray Additional Crossover	PASS	00:08:48	00:00:20	00:07:43	58%		1	17%

Table 3: Performance of options for 3 TPH

4.1.2 4 TPH

Adding an additional train per hour requires significantly higher levels of infrastructure enhancement, as well as creative use of such infrastructure. All successful options include the double tracking from Bray station, and either a loop or double tracking from Greystones. The highest performing options combines a double tracking at Bray and at Greystones with a southern head shunt, as well as a 1 second dwell at the end of the Greystones double tracking.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option B (7)	Double Tracking Greystones	FAIL	00:09:19	-00:02:03	00:07:42	101%		1	17%
Option B (2)	Greystones Loop	FAIL	00:08:48	-00:00:18	00:07:58	94%		1	17%
Option B (6)	Bray Double Track	FAIL	00:08:03	00:00:21	00:08:01	97%		2	64%

Option B (6+7)	Greystones + Bray Double Tracking	FAIL	00:09:30	00:00:02	00:07:58	85%		1	17%
Option B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	FAIL	00:07:58	00:00:07	00:07:58	78%		2	77%
Option B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:01:22	00:07:58	73%		2	73%
Option B (2+6)	Greystones Loop + Bray Double Track	FAIL	00:08:58	00:00:19	00:07:59	77%		1	17%
Option B (2+3)	Greystones Loop + Bray Additional Crossover	FAIL	00:08:48	00:00:20	00:07:43	77%		1	17%

Table 4: Performance of options for 4TPH

Greystones and Rosslare Services

For all 3 TPH options, there is sufficient capacity in the existing two platform layout at Greystones to accommodate a 1 TPH terminating service from Rosslare. For Option B(1+6+7) at 4 TPH, Greystones requires an additional south facing platform to be able to robustly handle both DART and DMU services. All other options at 4 TPH have sufficient capacity in the existing layout to handle the additional 1 TPH Rosslare service without an additional platform.

Note that the capacity utilisation value is calculated as the largest available gap between services, divided by an assumed time of 10 minutes that it would take a Rosslare DMU service to occupy a platform, de-train its passengers, and vacate the platform, including junction margins (6 minute platform re-occupation + 3 minute junction margin + 1 minute runtime).

5 Impact on Bray and TSS 1C

The planned service level to Greystones has a potential impact on the infrastructure required at Bray to deliver TSS 1C. Under TSS 1C it is required to turnback at minimum 10 DARTs at Bray. If additional services are proposed to Greystones the number of turnback services to turnback at Bray will proportionally decrease.

It is considered likely that it will still be operationally beneficial to allow the full 10 DARTs to turnback at Bray, therefore checks have been undertaken on the options to determine if this service pattern can be provided.

Full optioneering of the Bray turnback works have yet to be completed, however to allow for a fair comparison of the Bray to Greystones options the following are applied to the recommended infrastructure and costing assessment that follows.

- The double tracking at Bray for 700m (Component 6) will provide the infrastructure required for turning back 10 TPH at Bray;
- Where the Bray double tracking is not provided in an option infrastructure Component 3 is applied at Bray (i.e., the additional crossover).

The Bray area is also required to accommodate stabling of trains (7 No.). Currently the changes noted above at Bray have the following impacts on stabling:

- Infrastructure component 3 provides a stabling Capacity of 5 FLUs. This can be increased to the required 7 FLUs by the introduction of Infrastructure Component 4.
- **Component 4** is the extension of the Bray Up Sidings (middle and lower part of the drawing D+WP56-ARP-ZZ-SL-DR-PW-SK0003).
- The double tracking at Bray for 700m (Component 6) provides a stabling capacity of 4 FLUs. It is considered this can be increased to 7 FLUs through the inclusions of Infrastructure Component 4 plus the introduction of Infrastructure Component 5.
- **Component 5** is the extension of the Bray Down Sidings (as shown on D+WP56-ARP-ZZ-SL-DR-PW-SK0004).

It is important to note these are not necessarily the recommended stabling works, however are provided to allow for a reasonable comparison of costs.

5.1.1 Operational Reliability

Due to the performance risks inherent in operating a single-track railway, it is imperative that any infrastructure solution offers the greatest possible performance, in order to enhance reliability and flexibility.

Furthermore, the DART+ network is highly interlined, and timetables are already constrained in the following areas:

- Glasnevin Junction;
- Ossory Road Junction;
- Connolly Station Platforms 5-7;
- Turnback services at Bray, Grand Canal Dock, Connolly, Clongriffin, Malahide, and Drogheda;
- Possible passing locations for Enterprise services.

Since Bray-Greystones services will be interlined with wider DART+ services, they could become an additional constraint onto the DART+ timetable. This compounds the reliability risks coming from operating this section of single-track railway.

6 Infrastructure Interventions

In line with the above modelling analysis, this note presents a recommended infrastructure solution to provide the 3 TPH and 4 TPH as follows:

6.1.1 3 TPH Preferred Option

To accommodate a service level of 3 TPH, Arup recommends Option B (2+3):

> **Component 2 -** The provision of a passing loop from Bray Head Tunnel Number 4 for 800m towards Greystones;
> **Component 3 -** The addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points

This combines the relatively high performance of the Bray additional crossover, which unlocks a shorter section of double tracking in the station area, with the high performance and lower relative cost of the Greystones loop.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

Note that this option requires changes in operational assumptions, with trains in the Up direction (towards Dublin) requiring a stop at Bray Head loop for at least 30 seconds. Dwell time at this point can be increased or decreased to regulate train throughput, and regularise service, along with managing the departure time from Greystones. This analysis assumes long dwell times at Greystones, (nearly 16 minutes), allowing for substantial robustness and ability to recover from late arrivals). Increasing the minimum dwell time at Bray Head loop (up to 8 minutes) will increase the minimum opposing gap between services, and subsequently improve performance, while having a negative impact on runtimes.

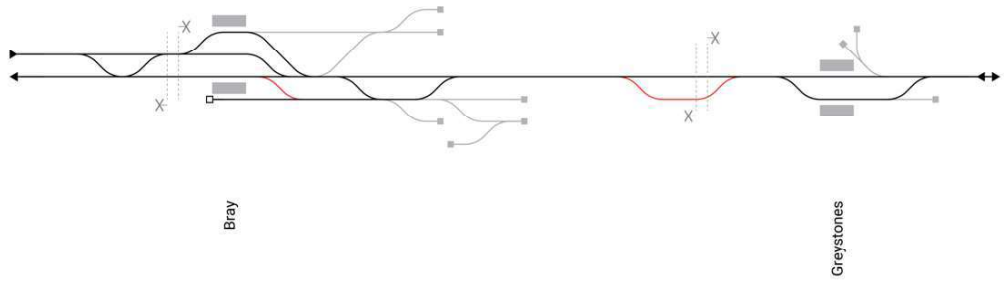


Figure 2: Preferred 3 TPH Option B (2+3)

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking/Bray Crossover	ATP Banding Removed
X	✓	X	✓	✓

Table 6: Option B (2+3) components

4 TPH Preferred Option

To accommodate a service level of 4 TPH, Arup recommends Option B (1+6+7)*:

> **Component 1 -** A southern headshunt at Greystones Station;
> **Component 6 -** The provision of double tracking from Bray station for 700m to Putland Road;
> **Component 7 -** The provision of double tracking from Greystones station to Bray Head Tunnel Number 4 for 2400m;

This option also requires an operation enhancement, with Up direction trains departing Greystones to dwell for 1 second at the end of the Greystones double track section.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

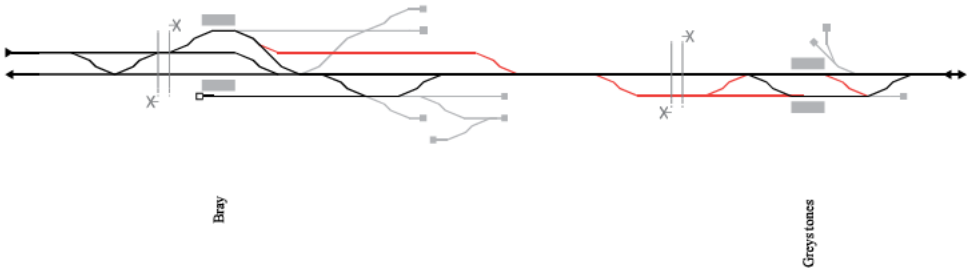


Figure 3: Preferred 4TPH Option B(1+6+7)*

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
✓	X	✓	✓	✓

Table 8:Option B(1+6+7)* components

Since Greystones services will be interlined directly with DART services through the City Centre Loop Line, it is essential that any option provide a substantial level of flexibility and robustness. Service timetabling is already dictated by pathing constraints in other parts of the network as described in 5.1.1; therefore, it is highly preferable that there are no additional timetabling constraints from the Bray to Greystones section. Aiming to operate a 4 TPH service between Bray and Greystones will be challenging; therefore, to minimise performance risk to the rest of the network any feasible option must provide the near maximum level of infrastructure and operational enhancements.

As such, for 4 TPH Arup recommends Option B(1+6+7)*. This option adds all possible infrastructure enhancements, with significant sections of double track, dedicated arrival and departure platforms at Greystones, and with DART services turning back at a separate point on a siding clear of the mainline.

6.1.3 4 TPH Alternatives

Given even running a 4TPH service with the infrastructure highlighted above will be challenging with regards to reliability and performance, two options would be recommended to be investigated further:

1. Introduce of a shuttle service to run to Greystones (either from Bray or from a new south facing termination point south of Conolly) for the additional services to minimise timetable interactions and hence performance risk.
2. Budget and business case for a full double tracking between Bray and Greystones, noting the considerable cost and need to do so with cognisance of coastal erosion.

7 Cost Analysis

Cost estimates have been produced for the various components discussed above and are summarised in Table 6. These estimates are for comparative purposes only and represent the high-level nature of this study.

Full cost breakdown information has been provided separately.

Sketches and drawings used for costing are included in Appendix A.

7.1 General

Table 10: Estimate Summaries

Component	Description	Estimate
Component 1	Greystones Southern Turnback	[redacted]
Component 2	Greystones Loop	
Component 3	Bray Reconfiguration	
Component 4	Bray Up Sidings Extension	
Component 5	Bray Down Sidings Extension	
Component 6	Bray Double Tracking (Jacobs design)	
Component 7	Greystones Double Tracking (Jacobs design)	

Note that the costs associated with the signalling changes to remove the ATP banding are not included as they are assumed to be undertaken by a separate project. These works are, however, required for the service improvements to occur.

7.2 3 trains per hour

For 3 TPH the following components are recommended to be included in the estimate

- Component 2
- Component 3

- Component 4

This yields an estimate of [redacted]

7.3 4 trains per hour

For 4 TPH the following components are recommended to be included in the estimate:

- Component 1
- Component 4
- Component 5
- Component 6
- Component 7

This yields an estimate [redacted]

8 Conclusion

Due to the need to provide a more than normal level of robustness and capacity and the fact that a service level of 4 TPH only works with the most intensive of infrastructure interventions (and even then only with a small margin of robustness) Arup proposes that IÉ aim to provide a service level of 3 TPH between Bray and Greystones.

There are two fundamental reasons Arup recommends operating 3 TPH rather than 4 TPH:

1. Introducing a 4 TPH service on to this section of line will introduce another critical constraint on the DART network. The network already has a number of other critical junctions and constraints which pose challenges for timetable planning and for providing a reliable service. The introduction of a 4 TPH service where there is little room flexibility will result in challenges keeping a reliable service.
2. The Cost of the Infrastructure required for 4 TPH is significantly greater than that of the 3 TPH.

To achieve a 3 TPH service, Arup recommends adopting Option B(2+3): Greystones Loop with Bray Additional Crossover. This option provides a good level of operational robustness, while minimising capital construction costs and disruption.

8.1 Next Steps

Following a decision on whether to proceed with 3 TPH or 4 TPH for the chosen Greystones service, the design and optioneering can be developed in conjunction with the TSS and stabling requirements at Bray.

Detailed signalling and permanent way design will be required to refine Option B(2+3) into a viable constructable project. Future sensitivity analysis can also be undertaken to understand the balance on the works required at Bray while still meeting the capacity requirements of 3 TPH.

Iarnród Éireann

DART+ Coastal South

Greystones Capacity Improvements Technical Note

D+WP56-ARP-P2-SL-RP-OP-000001

P04 | 3 March 2022

This report considers the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Document verification

ARUP

Job title		DART+ Coastal South		**Job number** 279933-00
Document title		Greystones Capacity Improvements Technical Note		**File reference**
Document ref		D+WP56-ARP-P2-SL-RP-OP-000001		
Revision	**Date**	**Filename**	Bray to Greystones Operations Review Note.docx	
P01	23 Nov 2021	Description	First issue for IÉ review and comment	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]
		Signature		
P02	15 Dec 2021	Filename		
		Description	Updated to suit comments. Costing Information added	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]
		Signature		
P03	19 Jan 2022	Filename		
		Description	Naming convention updated	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]
		Signature		
P04	3 March 2022	Filename		
		Description	Robust 4TPH solution text and costing added following IÉ commets	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	[redacted]k
		Signature		[redacted]
				Issue Document verification with document	✓

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Appendices

Appendix A

Sketches

Appendix B

Cost Estimates

1 Executive Summary

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature.

Following quantitative and qualitative modelling and rail operations investigations into improving service levels between Bray and Greystones DART stations, Arup finds that a 3 TPH service pattern (1 additional train per hour) is the optimal improvement, and can be best achieved through the following package of works:

- the provision of a passing loop from near Bray Head Tunnel Number 4 for 800m towards Greystones; and,
- the addition of a crossover at Bray Station from the Bray platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points.

A loop of 800m is sufficient to enable a passing move with one direction having priority over the other, balancing increased runtime with increased timetable performance and robustness.

Note that the above recommendations are predicated on the delivery of a separate project to replace the legacy ATP protection system between Bray and Greystones with ETCS Level 1, removing the ATP banding speed restriction.

This package of infrastructure and service enhancements will achieve a 50% increase in services, while minimising the possibility of Bray to Greystones services becoming a problematic timetabling constraint to the rest of the DART network. This report proves that there is sufficient platform capacity at Greystones to accommodate a 1 TPH service from Rosslare, in addition to the 3 TPH DART services.

While this report finds it technically possible to achieve a future service level of 4TPH, it does not recommend this choice. A 4 TPH solution would require substantial capital investment compared to a 3 TPH solution, while posing a greater reliability risk, both to Bray to Greystones services, and the wider DART network.

Lastly, this note's recommendation of 3 TPH will impact the parallel Bray Station Turnback optioneering process, as all Bray Station solutions must, at a minimum, be able to handle turning back 9 TPH services.

This note has been produced to allow for a decision on the service specification and principal form of infrastructure interventions to Greystones to be confirmed, which will allow optioneering of the Bray to Greystones area to progress.

2 Introduction

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature. An obvious solution to this problem would be to double track the line; however, this section of railway crosses difficult terrain adjacent to the Irish Sea. Any expansion would require significant civil engineering works, at a capital cost likely not commensurate with the benefits coming from increased capacity and reliability. As such, Arup's task is to examine more cost-effective methods to increase capacity to either 3 or 4 TPH, and evaluate both options in light of the infrastructure they would require, and the impact each frequency would have on the wider DART+ network.

It is worth noting that minimising the run time between Bray and Greystones is not considered an important factor and, as will be seen in the analysis outputs presented below, providing a longer run time has benefits in improving capacity and reliability.

A report by Jacobs in 2020 examined the practical infrastructure enhancement choices and settled on a combination of extending double tracking south from Bray and north from Greystones to minimize the length of single tracking. Arup's investigation uses this study as a starting point, developing further options off the initial proposal.

The purpose of this note is as follows:

1. To present Arup's infrastructure options for providing both a 3 TPH or 4 TPH service to Greystones.
2. To explain the infrastructure requirements, Bray to Greystones performance, and wider DART network impacts of choosing to run either 3 TPH or 4 TPH.
3. To identify infrastructure recommendations.
4. To provide some high-level costings of the infrastructure for a 3 TPH and a 4 TPH service.
5. To advise IÉ to either pursue a 3 TPH or 4 TPH service between Bray to Greystones, and present a preferred set of infrastructure solutions to achieve the recommended service level.

3 Existing Capacity Constraints

In addition to the length of single line section , there are a number of other existing constraints worth noting.

3.1 ATP Speed banding

The current signalling arrangements include automatic train protection (ATP) speed banding which limits the speed a train can travel to a margin lower than the line speed.

Arup understands that IÉ is executing a separate signalling project that will upgrade the current train protection system to ETCS Level 1, removing these limits and allowing trains to run at the line speed.

This note assumes that this signalling work on the Bray-Greystones section is completed, thereby removing the current speed limits caused by (ATP) banding.

Arup analysed a further set of options on the effects of not removing ATP banding, however these have not been included in this note. This analysis concludes that it is essential for the signalling works to be carried out for any 4 TPH scenario. For 3 TPH the results indicate it is marginally possible to provide increased services without the signalling works, but it would require significant other infrastructure upgrades such as double tracking through Greystones.

3.2 Bray 115B Points

The points shown in Figure 1 below are just south of Bray Station and provide a significant operational constraint on the network.

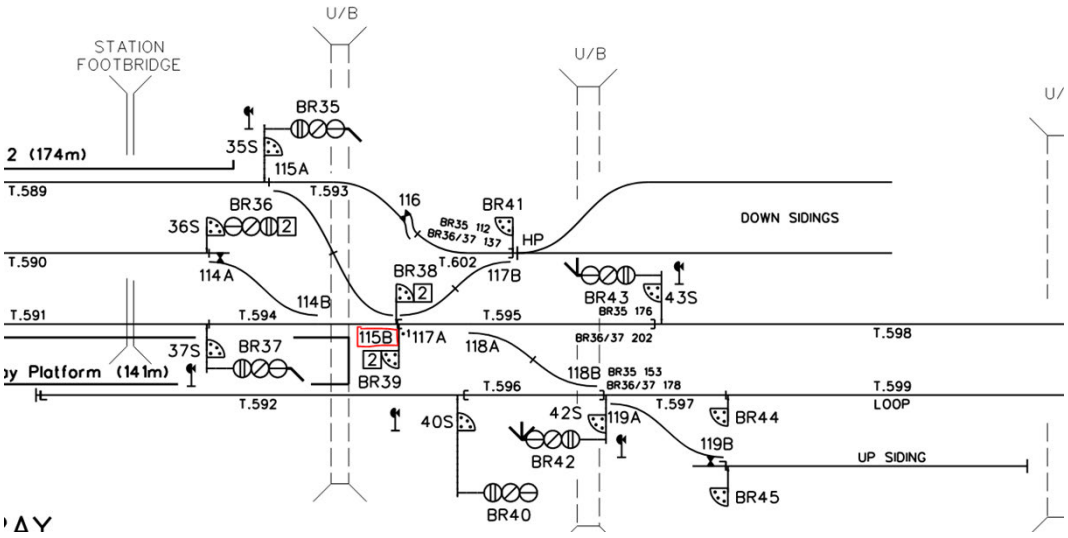


Figure 1: Excerpt from IÉ signalling diagram, showing Bray Station

They provide a single point at which all of the following moves must pass through and will therefore conflict:

- All trains leaving Bray and heading towards Greystones;
- All trains arriving at Bray from Greystones;
- All trains departing the Down sidings and heading to the Bray Platform 1;
- All trains heading to and/or from the Up sidings at Bray.

The signalling design for this area also compounds the operational restriction. The main route for all southbound services passes through the Down platform, whose protecting signal, BR35, has an overlap that stretches beyond points 115B to fully encompass the junction. This means that a train sat or passing through the main Down platform will block any train coming in the opposite direction, preventing any parallel moves through Bray Station.

3.3 Greystones platform Occupancy

The TSS assumes that to provide the additional DART capacity on the Bray to Greystones section the existing Rosslare services will terminate at Greystones. Checks have been undertaken against the options to determine if any additional infrastructure is required at Greystones to provide the required platform capacity for the Rosslare services.

3.4 Line speeds

There are small discrepancies between the start and stop locations of line speed changes provided in the RailSys model to those in the working timetable (WTT). Arup has reviewed these and confirms there is no meaningful difference between the two on the findings of this study.

4 Operational Modelling

Arup undertook RailSys modelling and high level quantitative analysis to examine what infrastructure enhancements would be required to meet the increased frequencies of 3 and 4 TPH. Through an optioneering process, Arup tested a series of design solutions, building the infrastructure in RailSys to test the performance of different track layouts.

Using technical outputs — such as signal occupation/clearance times — Arup undertook a finer grained quantitative analysis in excel, examining performance in light of:

- Capacity Utilisation;
- Runtime;
- Runtime allowance;

- Minimum Time Between Opposing Services.

The below options are based on different permutations of infrastructure options that are deemed viable within the project scope for improving capacity (in essence ruling out double tracking, tunnelling, or extensive work around Bray Head).

The analysis considered five constituent infrastructure components:

- **Component 1 -** A southern headshunt at Greystones Station
- **Component 2 -** Passing Loop from Bray Head Tunnel Number 4 for 800m towards Greystones
- **Component 3-** Removal of the constraint at 115B points through the provision of an additional connection from the Bay platform approach to the Up Bray platform. This allows for a shorter but less expensive extension of double tracking using an existing up loop road.
- **Component 6 -** Double Tracking from Bray Station for 700m to Putland Road.
- **Component 7 -** Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m.

Components 4 and 5, relate to resulting stabling infrastructure changes which are required as a result of other works and are discussed in Section 5

The suffixes provide a shorthand for explaining which combination of constituent infrastructure components each individual option is made up of. For example, Option B(1+6+7) is made up of:

Component 1 (A southern headshunt at Greystones Station)

+

Component 6 (Double Tracking from Bray Station for 700m to Putland Road)

+

Component 7 (Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m)

All options are prefixed with a B, as part of a comprehensive numbering system for all options involving Bray Station, Bray to Greystones, and Greystones Station. Prefix “B” indicates that the option assumes the removal of ATP speed banding.

		Greystones	Greystones	Bray	Signalling

Option Name	Description	Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
B (7)	Double Tracking Greystones	✓	X	X	X	✓
B (2)	Greystones Loop	X	✓	X	X	✓
B (6)	Bray Double Track	X	X	X	✓	✓
B(6+7)	Greystones + Bray Double Tracking	✓	X	X	✓	✓
B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	✓	X	✓	✓	✓
B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	✓	X	✓	✓	✓
B (2+6)	Greystones Loop + Bray Double Track	X	✓	X	✓	✓
B (2+3)	Greystones Loop + Bray Additional Crossover	X	✓	X	✓*	✓

Table 1: Infrastructure options and constituent components

In line with other DART+ Coastal project analyses, Arup used a capacity utilisation value of around 75% to be the cut-off towards failing an option. This is in line with UIC Code 406, which recommends a capacity utilisation rate of at maximum 75% for mixed traffic lines during the peak hour.

For each option, Arup developed a theoretical timetable, with trains leaving at regular intervals. In reality, trains on this section may not be evenly spaced, with arrival and departure times instead dictated by other constraints on different parts of the DART network.

As such, due to the single-track nature of the Bray to Greystones route and the fact that services on this section will be interlined with other DART services in the city centre, Arup considers it necessary to provide the maximum possible spare capacity, thus increasing service reliability and timetabling flexibility. For higher train frequencies of 4 TPH, Arup assumes that a 75% capacity utilisation rate is the hard maximum, with any preferred option ideally having a substantially lower capacity utilisation to allow for some redundancy in timetable planning and in times of delay. For 3 TPH scenarios, Arup assumes that capacity utilisation rates may still be judged as passing even if they are 1-2 % over 75%, due to the

smaller quantum of trains lessening the need to provide substantial timetabling redundancy.

4.1 Results

4.1.1 3 TPH

As can be seen below, all options can provide adequate capacity to enable 3 TPH. Additionally, there is an approximately 1 minute's difference in runtime between the fastest and slowest option, with Option B(1+6+7) providing almost obstruction free runtime, and Option B(7) requiring substantial pathing allowance in order to facilitate passing services in the up and down directions.

Note that for all options involving a loop at Greystones, at least one direction must stop and dwell for 30 seconds to enable the passing move. This has a negative effect on runtime, but greatly decreases capacity utilisation. Option B(7) instead requires trains in the Up direction to operate far below the rolling stock's peak performance, allowing for the passing move without necessitating a stop at the end of the double track section.

It should also be noted that the Minimum Opposing Gap is a value showing the closest time in between two services coming into conflict, with a higher value representing a more robust option.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option B (7)	Double Tracking Greystones	PASS	00:09:19	00:00:05	00:07:42	76%		1	17%
Option B (2)	Greystones Loop	PASS	00:08:48	00:00:11	00:07:43	70%		1	17%
Option B (6)	Bray Double Track	PASS	00:08:03	00:02:48	00:08:01	72%		2	45%
Option B (6+7)	Greystones + Bray Double Tracking	PASS	00:08:14	00:01:48	00:08:16	64%		1	17%

Option B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	PASS	00:07:58	00:04:47	00:07:58	59%		2	56%
Option B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:04:17	00:07:58	55%		2	56%
Option B (2+6)	Greystones Loop + Bray Double Track	PASS	00:08:58	00:00:18	00:07:59	57%		1	17%
Option B (2+3)	Greystones Loop + Bray Additional Crossover	PASS	00:08:48	00:00:20	00:07:43	58%		1	17%

Table 2: Performance of options for 3 TPH

4.1.2 4 TPH

Adding an additional train per hour requires significantly higher levels of infrastructure enhancement, as well as creative use of such infrastructure. All successful options include the double tracking from Bray station, and either a loop or double tracking from Greystones. The highest performing options combines a double tracking at Bray and at Greystones with a southern head shunt, as well as a 1 second dwell at the end of the Greystones double tracking.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option B (7)	Double Tracking Greystones	FAIL	00:09:19	-00:02:03	00:07:42	101%		1	17%
Option B (2)	Greystones Loop	FAIL	00:08:48	-00:00:18	00:07:58	94%		1	17%
Option B (6)	Bray Double Track	FAIL	00:08:03	00:00:21	00:08:01	97%		2	64%

Option B (6+7)	Greystones + Bray Double Tracking	FAIL	00:09:30	00:00:02	00:07:58	85%		1	17%
Option B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	FAIL	00:07:58	00:00:07	00:07:58	78%		2	77%
Option B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:01:22	00:07:58	73%		2	73%
Option B (2+6)	Greystones Loop + Bray Double Track	FAIL	00:08:58	00:00:19	00:07:59	77%		1	17%
Option B (2+3)	Greystones Loop + Bray Additional Crossover	FAIL	00:08:48	00:00:20	00:07:43	77%		1	17%

Table 3: Performance of options for 4TPH

4.1.3 Greystones and Rosslare Services

For all 3 TPH options, there is sufficient capacity in the existing two platform layout at Greystones to accommodate a 1 TPH terminating service from Rosslare. For Option B(1+6+7) at 4 TPH, Greystones requires an additional south facing platform to be able to robustly handle both DART and DMU services. All other options at 4 TPH have sufficient capacity in the existing layout to handle the additional 1 TPH Rosslare service without an additional platform.

Note that the capacity utilisation value is calculated as the largest available gap between services, divided by an assumed time of 10 minutes that it would take a Rosslare DMU service to occupy a platform, de-train its passengers, and vacate the platform, including junction margins (6 minute platform re-occupation + 3 minute junction margin + 1 minute runtime).

5 Impact on Bray and TSS 1C

The planned service level to Greystones has a potential impact on the infrastructure required at Bray to deliver TSS 1C. Under TSS 1C it is required to turnback at minimum 10 DARTs at Bray. If additional services are proposed to Greystones the number of turnback services to turnback at Bray will proportionally decrease.

It is considered likely that it will still be operationally beneficial to allow the full 10 DARTs to turnback at Bray, therefore checks have been undertaken on the options to determine if this service pattern can be provided.

Full optioneering of the Bray turnback works have yet to be completed, however to allow for a fair comparison of the Bray to Greystones options the following are applied to the recommended infrastructure and costing assessment that follows.

- The double tracking at Bray for 700m (Component 6) will provide the infrastructure required for turning back 10 TPH at Bray;
- Where the Bray double tracking is not provided in an option infrastructure Component 3 is applied at Bray (i.e., the additional crossover).

The Bray area is also required to accommodate stabling of trains (7 No.). Currently the changes noted above at Bray have the following impacts on stabling:

- Infrastructure component 3 provides a stabling Capacity of 5 FLUs. This can be increased to the required 7 FLUs by the introduction of Infrastructure Component 4.
- **Component 4** is the extension of the Bray Up Sidings (middle and lower part of the drawing D+WP56-ARP-ZZ-SL-DR-PW-SK0003).
- The double tracking at Bray for 700m (Component 6) provides a stabling capacity of 4 FLUs. It is considered this can be increased to 7 FLUs through the inclusions of Infrastructure Component 4 plus the introduction of Infrastructure Component 5.
- **Component 5** is the extension of the Bray Down Sidings (as shown on D+WP56-ARP-ZZ-SL-DR-PW-SK0004).

It is important to note these are not necessarily the recommended stabling works, however are provided to allow for a reasonable comparison of costs.

5.1.1 Operational Reliability

Due to the performance risks inherent in operating a single-track railway, it is imperative that any infrastructure solution offers the greatest possible performance, in order to enhance reliability and flexibility.

Furthermore, the DART+ network is highly interlined, and timetables are already constrained in the following areas:

- Glasnevin Junction;
- Ossory Road Junction;
- Connolly Station Platforms 5-7;
- Turnback services at Bray, Grand Canal Dock, Connolly, Clongriffin, Malahide, and Drogheda;
- Possible passing locations for Enterprise services.

Since Bray-Greystones services will be interlined with wider DART+ services, they could become an additional constraint onto the DART+ timetable. This compounds the reliability risks coming from operating this section of single-track railway.

6 Infrastructure Interventions

In line with the above modelling analysis, this note presents a recommended infrastructure solution to provide the 3 TPH and 4 TPH as follows:

6.1.1 3 TPH Preferred Option

To accommodate a service level of 3 TPH, Arup recommends Option B (2+3):

> **Component 2 -** The provision of a passing loop from Bray Head Tunnel Number 4 for 800m towards Greystones;
> **Component 3 -** The addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points

This combines the relatively high performance of the Bray additional crossover, which unlocks a shorter section of double tracking in the station area, with the high performance and lower relative cost of the Greystones loop.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

Note that this option requires changes in operational assumptions, with trains in the Up direction (towards Dublin) requiring a stop at Bray Head loop for at least 30 seconds. Dwell time at this point can be increased or decreased to regulate train throughput, and regularise service, along with managing the departure time from Greystones. This analysis assumes long dwell times at Greystones, (nearly 16 minutes), allowing for substantial robustness and ability to recover from late arrivals). Increasing the minimum dwell time at Bray Head loop (up to 8 minutes) will increase the minimum opposing gap between services, and subsequently improve performance, while having a negative impact on runtimes.

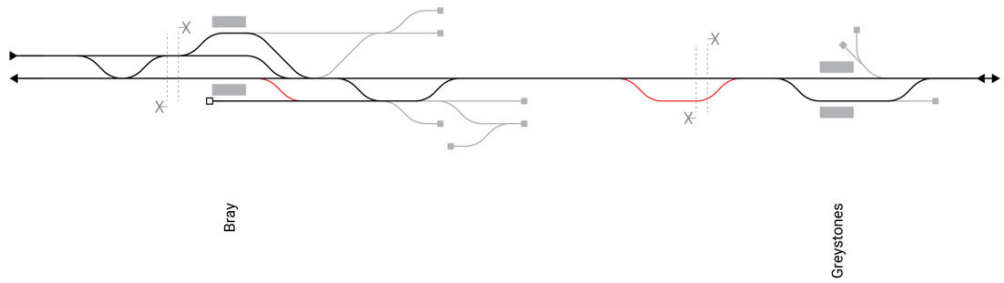


Figure 2: Preferred 3 TPH Option B (2+3)

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking/Bray Crossover	ATP Banding Removed
X	✓	X	✓	✓

Table 4: Option B (2+3) components

6.1.2 4 TPH Preferred Option

To accommodate a service level of 4 TPH, Arup recommends Option B (1+6+7)*:

> **Component 1** - A southern headshunt at Greystones Station;
> **Component 6 -** The provision of double tracking from Bray station for 700m to Putland Road;
> **Component 7** - The provision of double tracking from Greystones station to Bray Head Tunnel Number 4 for 2400m;

This option also requires an operation enhancement, with Up direction trains departing Greystones to dwell for 1 second at the end of the Greystones double track section.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

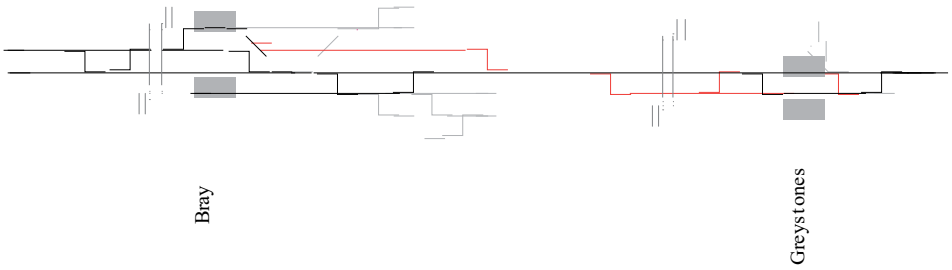


Figure 3: Preferred 4TPH Option B(1+6+7)*

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
✓	X	✓	✓	✓

Table 5:Option B(1+6+7)* components

Since Greystones services will be interlined directly with DART services through the City Centre Loop Line, it is essential that any option provide a substantial level of flexibility and robustness. Service timetabling is already dictated by pathing constraints in other parts of the network as described in 5.1.1; therefore, it is highly preferable that there are no additional timetabling constraints from the Bray to Greystones section. Aiming to operate a 4 TPH service between Bray and Greystones will be challenging; therefore, to minimise performance risk to the rest of the network any feasible option must provide the near maximum level of infrastructure and operational enhancements.

As such, for 4 TPH Arup recommends Option B(1+6+7)*. This option adds all possible infrastructure enhancements, with significant sections of double track, dedicated arrival and departure platforms at Greystones, and with DART services turning back at a separate point on a siding clear of the mainline.

6.1.3 4 TPH Alternatives

Given even running a 4TPH service with the infrastructure highlighted above will be challenging with regards to reliability and performance, two options would be recommended to be investigated further:

1. Introduce of a shuttle service to run to Greystones (either from Bray or from a new south facing termination point south of Connolly) for the additional services to minimise timetable interactions and hence performance risk.
2. Budget and business case for a full double tracking between Bray and Greystones, noting the considerable cost and need to do so with cognisance of coastal erosion.

On the basis following correspondence with IÉ that option 1 is not the sought after solution then we consider the approach to removing this timetable constraint (which is the item that causes a robustness issue due to the multiple timetable constraints on the DART network through the centre of Dublin and beyond) and provide a truly reliable service is to provide continuous double tracking between Bray and Greystones.

Whilst you could extend the double tracking part way around Bray head to create a planned 4TPH service, the resulting shorter length of single track would continue to act as a timetabling constraint and create a robustness problem which would provide constant risk to the DART coastal service reliability. Furthermore extending the double tracking around Bray head even for a short distance would be extremely challenging, disruptive, costly and remain at risk from coastal erosion. For these reasons extending double tracking part way around Bray head is not recommended.

Undertaking continuous double tracking around Bray head would not be recommended for similar reasons. Even though it would remove the timetabling constraints, construction would be extremely challenging, require extensive closures of the existing line to build and be subject to ongoing challenges from coastal erosion. It would be expected to be very difficult to substitute the level of investment required given the risk associated with damage from the line from coastal erosion (even if coastal erosion upgrades were included as part of this scheme).

Therefore, if a fully robust solution for 4TPH or more is required a new tunnel further inland through Bray Head could be proposed as the ideal long-term solution. This would require a substantial investment and likely a challenging business case. A high-level estimate of the potential cost of such a solution would be [redacted]. Please refer to Appendix B for further workings and assumptions with regards to this figure.

7 Cost Analysis

Cost estimates have been produced for the various components discussed above and are summarised in Table 6. These estimates are for comparative purposes only and represent the high-level nature of this study.

Full cost breakdown information has been provided separately.

Sketches and drawings used for costing are included in Appendix A.

7.1 General

Table 6: Estimate Summaries

Component	Description	Estimate
Component 1	Greystones Southern Turnback	[redacted]
Component 2	Greystones Loop	[redacted]
Component 3	Bray Reconfiguration	[redacted]
Component 4	Bray Up Sidings Extension	[redacted]
Component 5	Bray Down Sidings Extension	[redacted]
Component 6	Bray Double Tracking (Jacobs design)	[redacted]
Component 7	Greystones Double Tracking (Jacobs design)	[redacted]

Note that the costs associated with the signalling changes to remove the ATP banding are not included as they are assumed to be undertaken by a separate project. These works are, however, required for the service improvements to occur.

7.2 3 trains per hour

For 3 TPH the following components are recommended to be included in the estimate

- Component 2
- Component 3

- Component 4

This yields an estimate of [redacted]

7.3 4 trains per hour

For 4 TPH the following components are recommended to be included in the estimate:

- Component 1
- Component 4
- Component 5
- Component 6
- Component 7

This yields an estimate of [redacted]

8 Conclusion

Due to the need to provide a more than normal level of robustness and capacity and the fact that a service level of 4 TPH only works with the most intensive of infrastructure interventions (and even then only with a small margin of robustness) Arup proposes that IÉ aim to provide a service level of 3 TPH between Bray and Greystones.

There are two fundamental reasons Arup recommends operating 3 TPH rather than 4 TPH:

1. Introducing a 4 TPH service on to this section of line will introduce another critical constraint on the DART network. The network already has a number of other critical junctions and constraints which pose challenges for timetable planning and for providing a reliable service. The introduction of a 4 TPH service where there is little room flexibility will result in challenges keeping a reliable service.
2. The Cost of the Infrastructure required for 4 TPH is significantly greater than that of the 3 TPH.

To achieve a 3 TPH service, Arup recommends adopting Option B(2+3): Greystones Loop with Bray Additional Crossover. This option provides a good level of operational robustness, while minimising capital construction costs and disruption.

8.1 Next Steps

Following a decision on whether to proceed with 3 TPH or 4 TPH for the chosen Greystones service, the design and optioneering can be developed in conjunction with the TSS and stabling requirements at Bray.

Detailed signalling and permanent way design will be required to refine Option B(2+3) into a viable constructable project. Future sensitivity analysis can also be undertaken to understand the balance on the works required at Bray while still meeting the capacity requirements of 3 TPH.

Appendix A

Sketches

A1 Costing sketches

The following sketches/drawings have been used to provide the cost estimate

Drawing Reference	Description	Component
D+WP56-ARP-ZZ-SL-DR-PW-SK0001	Greystones Southern Turnback	1
D+WP56-ARP-ZZ-SL-DR-PW-SK0002	Greystones Loop	2
D+WP56-ARP-ZZ-SL-DR-PW-SK0003	Bray re-configuration (upper part of the drawing)	3
	Bray Up Sidings Extension (middle and lower part of the drawing)	4
D+WP56-ARP-ZZ-SL-DR-PW-SK0004	Bray Dn Sidings Extension	5
32110404-JAC-GCN-XX-DR-CE-0001	Jacobs design, Bray Double tracking	6
32110404-JAC-GCN-XX-DR-CE-0003 32110404-JAC-GCN-XX-DR-CE-0004	Jacobs design, Greystones Double tracking	7

Appendix B

Cost Estimates

Iarnród Éireann

DART+ Coastal South

Greystones Capacity Improvements Technical Note

D+WP56-ARP-P2-SL-RP-OP-000001

P05 | 7 April 2022

This report considers the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Document verification

ARUP

Job title		DART+ Coastal South		Job number 279933-00
Document title		Greystones Capacity Improvements Technical Note		File reference
Document ref		D+WP56-ARP-P2-SL-RP-OP-000001		
Revision	Date	Filename	Bray to Greystones Operations Review Note.docx	
P02	15 Dec 2021	Description	Updated to suit comments. Costing Information added	
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
P03	19 Jan 2022	Filename			
			Naming convention updated		
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
P04	3 March 2022	Filename			
		Description	Robust 4TPH solution text and costing added following IÉ comments		
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	
		Signature			
P05	7 April 2022	Filename			
		Description	Minor updates to suit comments		
			Prepared by	Checked by	Approved by
		Name	Various	[redacted]	[redacted]
		Signature		[redacted]	
				Issue Document verification with document	✓

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Appendices

Appendix A

Sketches

Appendix B

Cost Estimates

1 Executive Summary

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature.

Following quantitative and qualitative modelling and rail operations investigations into improving service levels between Bray and Greystones DART stations, Arup finds that a 3 TPH service pattern (1 additional train per hour) is the optimal improvement, and can be best achieved through the following package of works:

- the provision of a passing loop from near Bray Head Tunnel Number 4 for 800m towards Greystones; and,
- the addition of a crossover at Bray Station from the Bray platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points.

A loop of 800m is sufficient to enable a passing move with one direction having priority over the other, balancing increased runtime with increased timetable performance and robustness.

Note that the above recommendations are predicated on the delivery of a separate project to replace the legacy ATP protection system between Bray and Greystones with ETCS Level 1, removing the ATP banding speed restriction.

This package of infrastructure and service enhancements will achieve a 50% increase in services, while minimising the possibility of Bray to Greystones services becoming a problematic timetabling constraint to the rest of the DART network. This report proves that there is sufficient platform capacity at Greystones to accommodate a 1 TPH service from Rosslare, in addition to the 3 TPH DART services.

While this report finds it technically possible to achieve a future service level of 4TPH, it does not recommend this choice. A 4 TPH solution would require substantial capital investment compared to a 3 TPH solution, while posing a greater reliability risk, both to Bray to Greystones services, and the wider DART network.

This report identifies that to achieve a reliable 4TPH (or more) service to Greystones, full twin tracking and tunnelling works are likely to be required and high-level costs are provided to indicate the level of investment that would be required. No detailed studies on this proposal have been carried out.

Lastly, this note's recommendation of 3 TPH will impact the parallel Bray Station Turnback optioneering process, as all Bray Station solutions must, at a minimum, be able to handle turning back 9 TPH services.

This note has been produced to allow for a decision on the service specification and principal form of infrastructure interventions to Greystones to be confirmed, which will allow optioneering of the Bray to Greystones area to progress.

2 Introduction

As part of the DART+ Costal South project, Iarnród Éireann (IÉ) tasked Arup with examining the possibility of enhancing services on the single-track section of the DART network between Bray and Greystones. This section currently supports a maximum of 2 trains per hour (TPH), with any increase in service frequency being limited by the line's single-track nature. An obvious solution to this problem would be to double track the line; however, this section of railway crosses difficult terrain adjacent to the Irish Sea. Any expansion would require significant civil engineering works, at a capital cost likely not commensurate with the benefits coming from increased capacity and reliability. As such, Arup's task is to examine more cost-effective methods to increase capacity to either 3 or 4 TPH, and evaluate both options in light of the infrastructure they would require, and the impact each frequency would have on the wider DART+ network.

It is worth noting that minimising the run time between Bray and Greystones is not considered an important factor and, as will be seen in the analysis outputs presented below, providing a longer run time has benefits in improving capacity and reliability.

A report by Jacobs in 2020 examined the practical infrastructure enhancement choices and settled on a combination of extending double tracking south from Bray and north from Greystones to minimize the length of single tracking. Arup's investigation uses this study as a starting point, developing further options off the initial proposal.

The purpose of this note is as follows:

1. To present Arup's infrastructure options for providing both a 3 TPH or 4 TPH service to Greystones.
2. To explain the infrastructure requirements, Bray to Greystones performance, and wider DART network impacts of choosing to run either 3 TPH or 4 TPH.
3. To identify infrastructure recommendations.
4. To provide some high-level costings of the infrastructure for a 3 TPH and a 4 TPH service.
5. To advise IÉ to either pursue a 3 TPH or 4 TPH service between Bray to Greystones, and present a preferred set of infrastructure solutions to achieve the recommended service level.

3 Existing Capacity Constraints

In addition to the length of single line section , there are a number of other existing constraints worth noting.

3.1 ATP Speed banding

The current signalling arrangements include automatic train protection (ATP) speed banding which limits the speed a train can travel to a margin lower than the line speed.

Arup understands that IÉ is executing a separate signalling project that will upgrade the current train protection system to ETCS Level 1, removing these limits and allowing trains to run at the line speed.

This note assumes that this signalling work on the Bray-Greystones section is completed, thereby removing the current speed limits caused by (ATP) banding.

Arup analysed a further set of options on the effects of not removing ATP banding, however these have not been included in this note. This analysis concludes that it is essential for the signalling works to be carried out for any 4 TPH scenario. For 3 TPH the results indicate it is marginally possible to provide increased services without the signalling works, but it would require significant other infrastructure upgrades such as double tracking through Greystones.

3.2 Bray 115B Points

The points shown in Figure 1 below are just south of Bray Station and provide a significant operational constraint on the network.

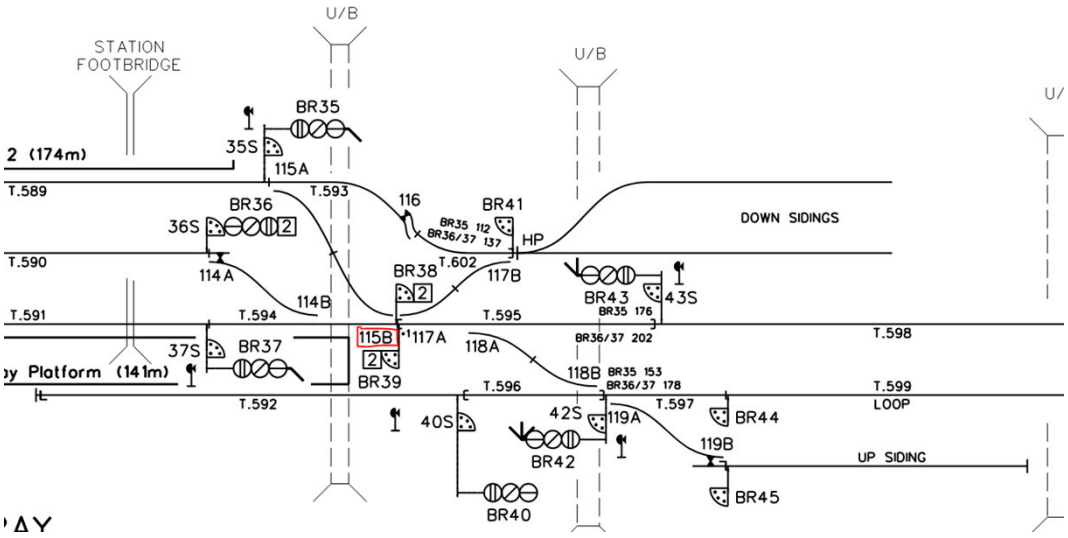


Figure 1: Excerpt from IÉ signalling diagram, showing Bray Station

They provide a single point at which all of the following moves must pass through and will therefore conflict:

- All trains leaving Bray and heading towards Greystones;
- All trains arriving at Bray from Greystones;
- All trains departing the Down sidings and heading to the Bray Platform 1;
- All trains heading to and/or from the Up sidings at Bray.

The signalling design for this area also compounds the operational restriction. The main route for all southbound services passes through the Down platform, whose protecting signal, BR35, has an overlap that stretches beyond points 115B to fully encompass the junction. This means that a train sat or passing through the main Down platform will block any train coming in the opposite direction, preventing any parallel moves through Bray Station.

3.3 Greystones platform Occupancy

The TSS assumes that to provide the additional DART capacity on the Bray to Greystones section the existing Rosslare services will terminate at Greystones. Checks have been undertaken against the options to determine if any additional infrastructure is required at Greystones to provide the required platform capacity for the Rosslare services.

3.4 Line speeds

There are small discrepancies between the start and stop locations of line speed changes provided in the RailSys model to those in the working timetable (WTT). Arup has reviewed these and confirms there is no meaningful difference between the two on the findings of this study.

4 Operational Modelling

Arup undertook RailSys modelling and high level quantitative analysis to examine what infrastructure enhancements would be required to meet the increased frequencies of 3 and 4 TPH. Through an optioneering process, Arup tested a series of design solutions, building the infrastructure in RailSys to test the performance of different track layouts. Full twin tracking from Bray to Greystones was not assessed as by observation this would be able to meet and significantly exceed the frequency enhancements required.

Using technical outputs — such as signal occupation/clearance times — Arup undertook a finer grained quantitative analysis in excel, examining performance in light of:

- Capacity Utilisation;
- Runtime;

- Runtime allowance;
- Minimum Time Between Opposing Services.

The below options are based on different permutations of infrastructure options that are deemed viable within the project scope for improving capacity (in essence ruling out double tracking, tunnelling, or extensive work around Bray Head).

The analysis considered five constituent infrastructure components:

- **Component 1 -** A southern headshunt at Greystones Station
- **Component 2 -** Passing Loop from Bray Head Tunnel Number 4 for 800m towards Greystones
- **Component 3-** Removal of the constraint at 115B points through the provision of an additional connection from the Bay platform approach to the Up Bray platform. This allows for a shorter but less expensive extension of double tracking using an existing up loop road.
- **Component 6 -** Double Tracking from Bray Station for 700m to Putland Road.
- **Component 7 -** Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m.

Components 4 and 5, relate to resulting stabling infrastructure changes which are required as a result of other works and are discussed in Section 5

The suffixes provide a shorthand for explaining which combination of constituent infrastructure components each individual option is made up of. For example, Option B(1+6+7) is made up of:

Component 1 (A southern headshunt at Greystones Station)

+

Component 6 (Double Tracking from Bray Station for 700m to Putland Road)

+

Component 7 (Double Tracking from Greystones Station to Bray Head Tunnel Number 4 for 2400m)

All options are prefixed with a B, as part of a comprehensive numbering system for all options involving Bray Station, Bray to Greystones, and Greystones Station. Prefix “B” indicates that the option assumes the removal of ATP speed banding.

		Greystones		Greystones	Bray	Signalling
Option Name	Description	Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
B (7)	Double Tracking Greystones	✓	X	X	X	✓
B (2)	Greystones Loop	X	✓	X	X	✓
B (6)	Bray Double Track	X	X	X	✓	✓
B(6+7)	Greystones + Bray Double Tracking	✓	X	X	✓	✓
B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	✓	X	✓	✓	✓
B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	✓	X	✓	✓	✓
B (2+6)	Greystones Loop + Bray Double Track	X	✓	X	✓	✓
B (2+3)	Greystones Loop + Bray Additional Crossover	X	✓	X	✓*	✓

Table 1: Infrastructure options and constituent components

In line with other DART+ Coastal project analyses, Arup used a capacity utilisation value of around 75% to be the cut-off towards failing an option. This is in line with UIC Code 406, which recommends a capacity utilisation rate of at maximum 75% for mixed traffic lines during the peak hour.

For each option, Arup developed a theoretical timetable, with trains leaving at regular intervals. In reality, trains on this section may not be evenly spaced, with arrival and departure times instead dictated by other constraints on different parts of the DART network.

As such, due to the single-track nature of the Bray to Greystones route and the fact that services on this section will be interlined with other DART services in the city centre, Arup considers it necessary to provide the maximum possible spare capacity, thus increasing service reliability and timetabling flexibility. For higher train frequencies of 4 TPH, Arup assumes that a 75% capacity utilisation

rate is the hard maximum, with any preferred option ideally having a substantially lower capacity utilisation to allow for some redundancy in timetable planning and in times of delay. For 3 TPH scenarios, Arup assumes that capacity utilisation rates may still be judged as passing even if they are 1-2 % over 75%, due to the smaller quantum of trains lessening the need to provide substantial timetabling redundancy.

4.1 Results

4.1.1 3 TPH

As can be seen below, all options can provide adequate capacity to enable 3 TPH. Additionally, there is an approximately 1 minute's difference in runtime between the fastest and slowest option, with Option B(1+6+7) providing almost obstruction free runtime, and Option B(7) requiring substantial pathing allowance in order to facilitate passing services in the up and down directions.

Note that for all options involving a loop at Greystones, at least one direction must stop and dwell for 30 seconds to enable the passing move. This has a negative effect on runtime, but greatly decreases capacity utilisation. Option B(7) instead requires trains in the Up direction to operate far below the rolling stock's peak performance, allowing for the passing move without necessitating a stop at the end of the double track section.

It should also be noted that the Minimum Opposing Gap is a value showing the closest time in between two services coming into conflict, with a higher value representing a more robust option.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option B (7)	Double Tracking Greystones	PASS	00:09:19	00:00:05	00:07:42	76%		1	17%
Option B (2)	Greystones Loop	PASS	00:08:48	00:00:11	00:07:43	70%		1	17%
Option B (6)	Bray Double Track	PASS	00:08:03	00:02:48	00:08:01	72%		2	45%
Option B (6+7)	Greystones + Bray Double Tracking	PASS	00:08:14	00:01:48	00:08:16	64%		1	17%

Option B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	PASS	00:07:58	00:04:47	00:07:58	59%		2	56%
Option B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:04:17	00:07:58	55%		2	56%
Option B (2+6)	Greystones Loop + Bray Double Track	PASS	00:08:58	00:00:18	00:07:59	57%		1	17%
Option B (2+3)	Greystones Loop + Bray Additional Crossover	PASS	00:08:48	00:00:20	00:07:43	58%		1	17%

Table 2: Performance of options for 3 TPH

4.1.2 4 TPH

Adding an additional train per hour requires significantly higher levels of infrastructure enhancement, as well as creative use of such infrastructure. All successful options include the double tracking from Bray station, and either a loop or double tracking from Greystones. The highest performing options combines a double tracking at Bray and at Greystones with a southern head shunt, as well as a 1 second dwell at the end of the Greystones double tracking.

Option Name	Option Description	Verdict	Up Runtime	Minimum Opposing Gap	Down Runtime	Capacity Utilization		Minimum Greystones Platforms Required	Greystones Platform Occupancy
Option B (7)	Double Tracking Greystones	FAIL	00:09:19	-00:02:03	00:07:42	101%		1	17%
Option B (2)	Greystones Loop	FAIL	00:08:48	-00:00:18	00:07:58	94%		1	17%
Option B (6)	Bray Double Track	FAIL	00:08:03	00:00:21	00:08:01	97%		2	64%

Option B (6+7)	Greystones + Bray Double Tracking	FAIL	00:09:30	00:00:02	00:07:58	85%		1	17%
Option B (1+6+7)	Greystones + Bray Double Tracking + South Turnback	FAIL	00:07:58	00:00:07	00:07:58	78%		2	77%
Option B (1+6+7)*	Greystones Double Tracking + Bray Double Track + South Turnback + Stop at Double Track	PASS	00:08:28	00:01:22	00:07:58	73%		2	73%
Option B (2+6)	Greystones Loop + Bray Double Track	FAIL	00:08:58	00:00:19	00:07:59	77%		1	17%
Option B (2+3)	Greystones Loop + Bray Additional Crossover	FAIL	00:08:48	00:00:20	00:07:43	77%		1	17%

Table 3: Performance of options for 4TPH

4.1.3 Greystones and Rosslare Services

For all 3 TPH options, there is sufficient capacity in the existing two platform layout at Greystones to accommodate a 1 TPH terminating service from Rosslare. For Option B(1+6+7) at 4 TPH, Greystones requires an additional south facing platform to be able to robustly handle both DART and DMU services. All other options at 4 TPH have sufficient capacity in the existing layout to handle the additional 1 TPH Rosslare service without an additional platform.

Note that the capacity utilisation value is calculated as the largest available gap between services, divided by an assumed time of 10 minutes that it would take a Rosslare DMU service to occupy a platform, de-train its passengers, and vacate the platform, including junction margins (6 minute platform re-occupation + 3 minute junction margin + 1 minute runtime).

5 Impact on Bray and TSS 1C

The planned service level to Greystones has a potential impact on the infrastructure required at Bray to deliver TSS 1C. Under TSS 1C it is required to turnback at minimum 10 DARTs at Bray. If additional services are proposed to Greystones the number of turnback services to turnback at Bray will proportionally decrease.

It is considered likely that it will still be operationally beneficial to allow the full 10 DARTs to turnback at Bray, therefore checks have been undertaken on the options to determine if this service pattern can be provided.

Full optioneering of the Bray turnback works have yet to be completed, however to allow for a fair comparison of the Bray to Greystones options the following are applied to the recommended infrastructure and costing assessment that follows.

- The double tracking at Bray for 700m (Component 6) will provide the infrastructure required for turning back 10 TPH at Bray;
- Where the Bray double tracking is not provided in an option infrastructure Component 3 is applied at Bray (i.e., the additional crossover).

The Bray area is also required to accommodate stabling of trains (7 No.). Currently the changes noted above at Bray have the following impacts on stabling:

- Infrastructure component 3 provides a stabling Capacity of 5 FLUs. This can be increased to the required 7 FLUs by the introduction of Infrastructure Component 4.
- **Component 4** is the extension of the Bray Up Sidings (middle and lower part of the drawing D+WP56-ARP-ZZ-SL-DR-PW-SK0003).
- The double tracking at Bray for 700m (Component 6) provides a stabling capacity of 4 FLUs. It is considered this can be increased to 7 FLUs through the inclusions of Infrastructure Component 4 plus the introduction of Infrastructure Component 5.
- **Component 5** is the extension of the Bray Down Sidings (as shown on D+WP56-ARP-ZZ-SL-DR-PW-SK0004).

It is important to note these are not necessarily the recommended stabling works, however are provided to allow for a reasonable comparison of costs.

5.1.1 Operational Reliability

Due to the performance risks inherent in operating a single-track railway, it is imperative that any infrastructure solution offers the greatest possible performance, in order to enhance reliability and flexibility.

Furthermore, the DART+ network is highly interlined, and timetables are already constrained in the following areas:

- Glasnevin Junction;
- Ossory Road Junction;
- Connolly Station Platforms 5-7;
- Turnback services at Bray, Grand Canal Dock, Connolly, Clongriffin, Malahide, and Drogheda;
- Possible passing locations for Enterprise services.

Since Bray-Greystones services will be interlined with wider DART+ services, they could become an additional constraint onto the DART+ timetable. This compounds the reliability risks coming from operating this section of single-track railway.

6 Infrastructure Interventions

In line with the above modelling analysis, this note presents a recommended infrastructure solution to provide the 3 TPH and 4 TPH as follows:

6.1.1 3 TPH Preferred Option

To accommodate a service level of 3 TPH, Arup recommends Option B (2+3):

> **Component 2 -** The provision of a passing loop from Bray Head Tunnel Number 4 for 800m towards Greystones;
> **Component 3 -** The addition of a crossover at Bray Station from the Bay platform approach road to Platform 1 (Up), removing the constraint at Bray 115B Points

This combines the relatively high performance of the Bray additional crossover, which unlocks a shorter section of double tracking in the station area, with the high performance and lower relative cost of the Greystones loop.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

Note that this option requires changes in operational assumptions, with trains in the Up direction (towards Dublin) requiring a stop at Bray Head loop for at least 30 seconds. Dwell time at this point can be increased or decreased to regulate train throughput, and regularise service, along with managing the departure time from Greystones. This analysis assumes long dwell times at Greystones, (nearly 16 minutes), allowing for substantial robustness and ability to recover from late arrivals). Increasing the minimum dwell time at Bray Head loop (up to 8 minutes) will increase the minimum opposing gap between services, and subsequently improve performance, while having a negative impact on runtimes.

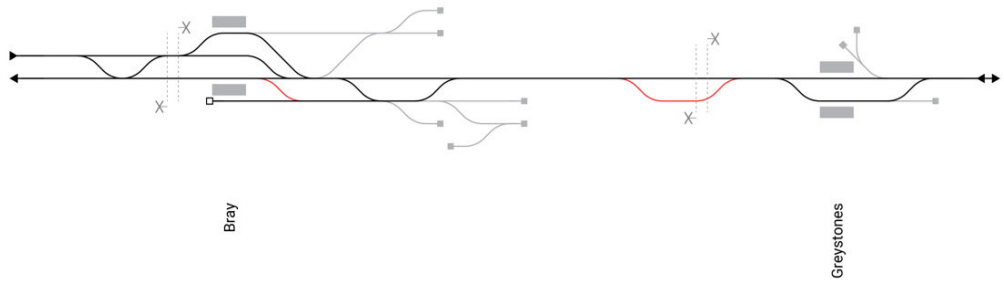


Figure 2: Preferred 3 TPH Option B (2+3)

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking/Bray Crossover	ATP Banding Removed
X	✓	X	✓	✓

Table 4: Option B (2+3) components

6.1.2 4 TPH Preferred Option

To accommodate a service level of 4 TPH, Arup recommends Option B (1+6+7)*:

> **Component 1** - A southern headshunt at Greystones Station;
> **Component 6 -** The provision of double tracking from Bray station for 700m to Putland Road;
> **Component 7** - The provision of double tracking from Greystones station to Bray Head Tunnel Number 4 for 2400m;

This option also requires an operation enhancement, with Up direction trains departing Greystones to dwell for 1 second at the end of the Greystones double track section.

This option also requires additional stabling changes at Bray to meet the TSS— these remain to be developed.

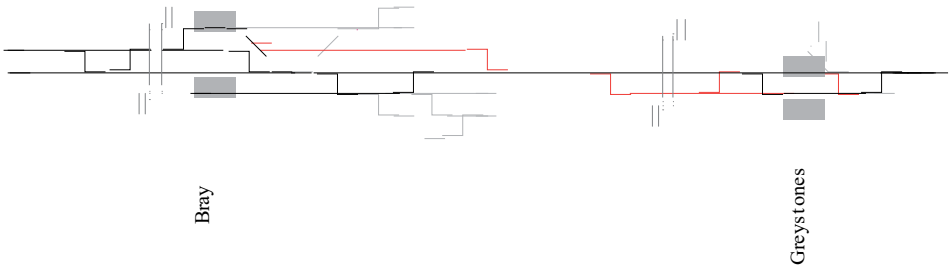


Figure 3: Preferred 4TPH Option B(1+6+7)*

Components				
Greystones		Greystones	Bray	Signalling
Double Tracking	Loop	South Turnback	Double Tracking	ATP Banding Removed
✓	X	✓	✓	✓

Table 5:Option B(1+6+7)* components

Since Greystones services will be interlined directly with DART services through the City Centre Loop Line, it is essential that any option provide a substantial level of flexibility and robustness. Service timetabling is already dictated by pathing constraints in other parts of the network as described in 5.1.1; therefore, it is highly preferable that there are no additional timetabling constraints from the Bray to Greystones section. Aiming to operate a 4 TPH service between Bray and Greystones will be challenging; therefore, to minimise performance risk to the rest of the network any feasible option must provide the near maximum level of infrastructure and operational enhancements.

As such, for 4 TPH Arup recommends Option B(1+6+7)*. This option adds all possible infrastructure enhancements, with significant sections of double track, dedicated arrival and departure platforms at Greystones, and with DART services turning back at a separate point on a siding clear of the mainline.

6.1.3 4 TPH Alternatives

Given even running a 4TPH service with the infrastructure highlighted above will be challenging with regards to reliability and performance, two options would be recommended to be investigated further:

1. Introduce of a shuttle service to run to Greystones (either from Bray or from a new south facing termination point south of Connolly) for the additional services to minimise timetable interactions and hence performance risk. Correspondence with IÉ is that this option is not the sought after solution and is therefore not considered further.
2. Budget and business case for a full double tracking between Bray and Greystones, noting the considerable cost and need to do so with cognisance of coastal erosion.

Full double tracking between Bray and Greystones

As identified earlier the reliability issues largely stem from multiple timetable constraints on the DART network through the centre of Dublin and beyond. To reliably increase the service to Greystones it needs to do so without causing a timetabling constraint. To achieve this double tracking between Bray and Greystones would be required.

Undertaking continuous double tracking around Bray head would remove the timetabling constraints but construction would be extremely challenging, require extensive closures of the existing line to build and be subject to ongoing challenges from coastal erosion. It would be expected to be very difficult to substantiate the level of investment required given the risk associated with damage from the line from coastal erosion (even if coastal erosion upgrades were included as part of this scheme).

Therefore, if a fully robust solution for 4TPH or more is required a new tunnel further inland through Bray Head could be proposed as the ideal long-term solution. This would require a substantial investment and likely a challenging business case. A high-level estimate of the potential cost of such a solution would be [redacted] Please refer to Appendix B for further workings and assumptions with regards to this figure.

7 Cost Analysis

Cost estimates have been produced for the various components discussed above and are summarised in Table 6. These estimates are for comparative purposes only and represent the high-level nature of this study.

Full cost breakdown information has been provided separately.

Sketches and drawings used for costing are included in Appendix A.

7.1 General

Table 6: Estimate Summaries

Component	Description	Estimate
Component 1	Greystones Southern Turnback	[redacted]
Component 2	Greystones Loop	[redacted]
Component 3	Bray Reconfiguration	[redacted]
Component 4	Bray Up Sidings Extension	[redacted]
Component 5	Bray Down Sidings Extension	[redacted]
Component 6	Bray Double Tracking (Jacobs design)	[redacted]
Component 7	Greystones Double Tracking (Jacobs design)	[redacted]

Note that the costs associated with the signalling changes to remove the ATP banding are not included as they are assumed to be undertaken by a separate project. These works are, however, required for the service improvements to occur.

7.2 3 trains per hour

For 3 TPH the following components are recommended to be included in the estimate

- Component 2
- Component 3

- Component 4

This yields an estimate of [redacted]

7.3 4 trains per hour

For 4 TPH the following components are recommended to be included in the estimate:

- Component 1
- Component 4
- Component 5
- Component 6
- Component 7

This yields an estimate of [redacted]

8 Conclusion

Due to the need to provide a more than normal level of robustness and capacity and the fact that a service level of 4 TPH only works with the most intensive of infrastructure interventions (and even then only with a small margin of robustness) Arup proposes that IÉ aim to provide a service level of 3 TPH between Bray and Greystones.

There are two fundamental reasons Arup recommends operating 3 TPH rather than 4 TPH:

1. Introducing a 4 TPH service on to this section of line will introduce another critical constraint on the DART network. The network already has a number of other critical junctions and constraints which pose challenges for timetable planning and for providing a reliable service. The introduction of a 4 TPH service where there is little room flexibility will result in challenges keeping a reliable service.
2. The cost of the infrastructure required for a low performance/reliable 4 TPH is significantly greater than that of the 3 TPH.

As outlined earlier, providing a reliable 4TPH service would likely need to involve continuous double tracking between Bray and Greystones, tunnelling and significant capital works requiring additional investment and business case assessment. This goes beyond the scope of this study and conclusions.

To achieve a 3 TPH service, Arup recommends adopting Option B(2+3): Greystones Loop with Bray Additional Crossover. This option provides a good level of operational robustness, while minimising capital construction costs and disruption.

8.1 Next Steps

Following a decision on whether to proceed with 3 TPH or 4 TPH for the chosen Greystones service, the design and optioneering can be developed in conjunction with the TSS and stabling requirements at Bray.

Detailed signalling and permanent way design will be required to refine Option B(2+3) into a viable constructable project. Future sensitivity analysis can also be undertaken to understand the balance on the works required at Bray while still meeting the capacity requirements of 3 TPH.

Appendix A

Sketches

A1 Costing sketches

The following sketches/drawings have been used to provide the cost estimate

Drawing Reference	Description	Component
D+WP56-ARP-ZZ-SL-DR-PW-SK0001	Greystones Southern Turnback	1
D+WP56-ARP-ZZ-SL-DR-PW-SK0002	Greystones Loop	2
D+WP56-ARP-ZZ-SL-DR-PW-SK0003	Bray re-configuration (upper part of the drawing)	3
	Bray Up Sidings Extension (middle and lower part of the drawing)	4
D+WP56-ARP-ZZ-SL-DR-PW-SK0004	Bray Dn Sidings Extension	5
32110404-JAC-GCN-XX-DR-CE-0001	Jacobs design, Bray Double tracking	6
32110404-JAC-GCN-XX-DR-CE-0003 32110404-JAC-GCN-XX-DR-CE-0004	Jacobs design, Greystones Double tracking	7

Appendix B

Cost Estimates

ARUP

Iarnród Éireann

DART+ Coastal

Performance Modelling Results

Reference: D+WP56-ARP-ZZ-AL-RP-OP-000001

P02 | 14 April 2023

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Document Verification

Project title	DART+ Coastal
Document title	Performance Modelling Results
Job number	279933-00
Document ref	D+WP56-ARP-ZZ-AL-RP-OP-000001
File reference	D+WP56-ARP-ZZ-AL-RP-OP-000001.docx

Revision	Date		
P01	31/01/2023	**Filename**	D+WP56-ARP-ZZ-AL-RP-OP-000001
		Description	First Issue

	Prepared by	Checked by	Approved by
Name	[redacted]		
Signature			

P02	14/04/23	**Filename** D+WP56-ARP-ZZ-AL-RP-OP-000001
		Description Incorporating IE comments

	Prepared by	Checked by	Approved by
Name	[redacted]		
Signature			

		Filename
		Description

	Prepared by	Checked by	Approved by
Name			
Signature			

Issue Document Verification with Document ✓

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A.2 TSS1c Service Diagram A-3

1. Introduction

This report summarises the modelling work undertaken to review the infrastructure for the DART+ Coastal project for the proposed train service specification.

The modelling acts as a robust summary of how a future timetable with a full 20tph intensity may behave given a nominal level of perturbation. However, it should be noted that it does not represent the expected performance on day one of operation as the development of a full day timetable and specific service interactions will evolve during the course of the project.

2. Methodology

The modelling work has been undertaken using the agreed method and assumptions as outlined in the document *D+WP56-ARP-ZZ-AL-FN-OP-000001 Performance Modelling Assumptions Note.*

Modelling was undertaken in RailSys with the model provided to Arup by Irish Rail. The primary updates to the model include:

- Infrastructure includes proposed schemes;
- Rolling stock updated to reflect the Xtrapolis unit performance;
- Signalling updated on the Northern Line to represent concept design;
- The timetable TSS 1C remains the same except for several small alterations to account for rolling stock change, the achievement of a minimum turnround time of 6 minutes, the new station at Woodbrook and the extension of 3 services per hour between Bray and Greystones.

Three levels of perturbation are applied to the modelling as shown in Table 2-1.

Table 2-1. Nominal delay distributions

	I. Small . max. 2 min (_1_2)	II. Medium max. 5 min (_2_5)	III. Large max. 10 min (_2_10)
Type	Negative exponential distribution	Negative exponential distribution	Negative exponential distribution
Proportion of train stops to which delays are applied	10%	10%	10%
Average lateness (min)	1	2	2
Maximum lateness (min)	2	5	10

The medium and large distributions have the same overall average delay but the large has delays over 5 minutes.

Calibration of these perturbations against the existing network was not carried out as part of this exercise.

3. Timetable Structure and Recovery Opportunity

There is the opportunity for service recovery in three elements of the timetable:

- Dwell time at intermediate stations – If the minimum dwell at the station is lower than the scheduled dwell, services have an opportunity to recover lateness at station stops. The TSS1C typically has either 30 or 60s station dwell and this is assumed as both the minimum and scheduled values so there is no opportunity to recover from late running within the station dwell.
- Recovery in running time scheduled vs technical capability – If the technical running time is lower than the scheduled running time, services have an opportunity to recover lateness between stations. The TSS1C has on average about 15s between station ranging from 0 to 30s. This is important in absorbing delays along the line of route.
- Turnround at the end of the route – If the planning minimum turnround time is lower than the scheduled turnround, services have an opportunity to recover lateness at the ends of their route. The TSS1C has additional turnround time at all turnback locations on the route, above the minimum of 6 minutes.

During more significant delays signaller or control room interventions may be required to alter the route, stopping pattern or final location of train services. These are discussed as part of the report but not included in modelling.

The level of perturbation input to the model means that at each station stop a percentage of trains pick up a delay from the distribution which overall meets the average delay. In the instance of the small distribution this equates to an average primary delay of 6s per train per station; for the medium and large distributions this equates to an average of 12s per train per station. Overall a Bray to Drogheda service stopping at 35 stations may expect to pick up on average 3 minutes 30s or 7 minutes delay depending on the distribution.

Due to the nature of the network and the high frequency of service, the primary delays are likely to quickly propagate as secondary delays to impact on following trains. The modelling evaluates the impact of the primary delays, secondary delays and the level of recovery in the timetable to predict the overall network performance.

3.1 Turnround Operations

Delays are absorbed by recovery in the timetable at the following locations:

- Drogheda
- Malahide
- Clongriffin
- Dublin Conolly
- Howth & Howth Junction
- Bray
- Greystones.

In the following figures the left-hand side shows for each platform (column) the arrival, pass and departure time of trains (diagonal dash) and the turnround connection (shaded). On the right-hand side the figure shows the track layout schematic.

3.1.1 Drogheda

As shown in Figure 3-1, at Drogheda there are 5 services which are turning back and 3 services running through. The diagram below shows the occupation on each platform with DART services using Platforms 1, 2 and 4 to turnback. Through services operate northbound through Platform 3 and southbound through Platform 2.

For services turning back there is on average just over 10 minutes of recovery time.

The average turnround time is just over 16minutes. 3tph have over 20 minutes and 2tph have just over 7 or 11 minutes.

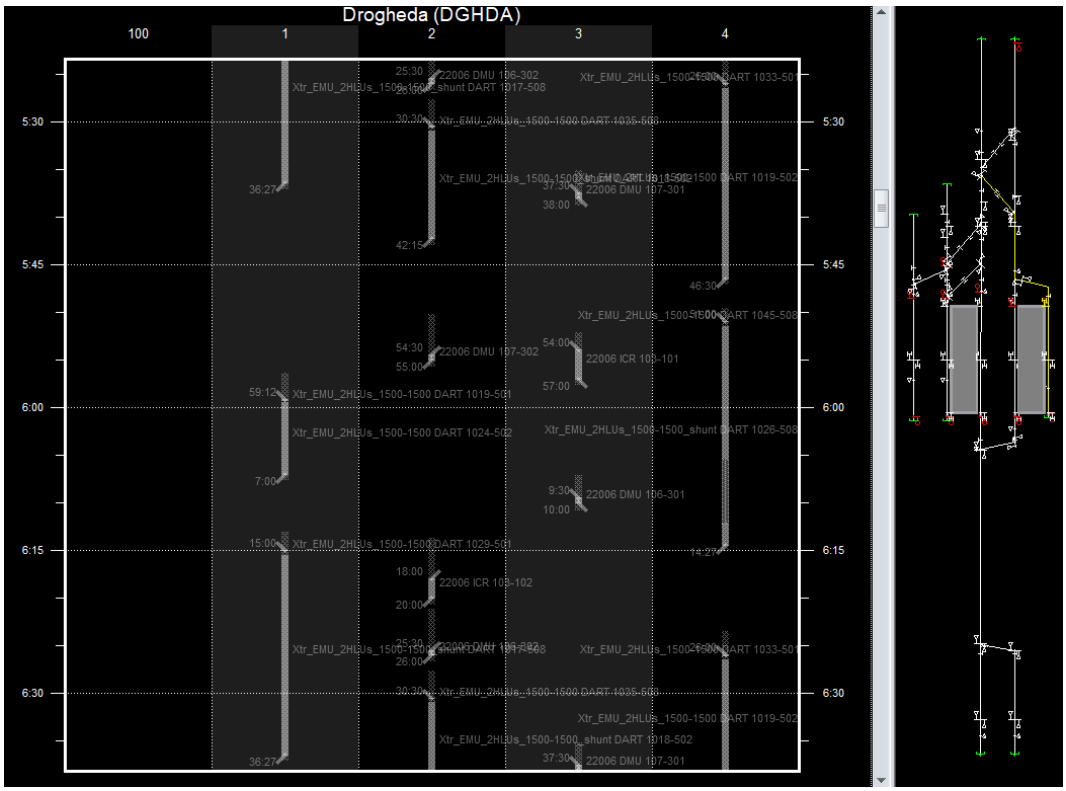


Figure 3-1. Platform diagram at Drogheda

3.1.2 Malahide

As shown in Figure 3-2, at Malahide Station there are 10 services running through the platforms, 2 of these turnback in the siding north of the station. The diagram below shows the occupation of the 2 trains in the turnback siding. Through services operate northbound through Platform 1 and southbound through Platform 2.

For services turning back there is on average just over 3 minutes of recovery time.

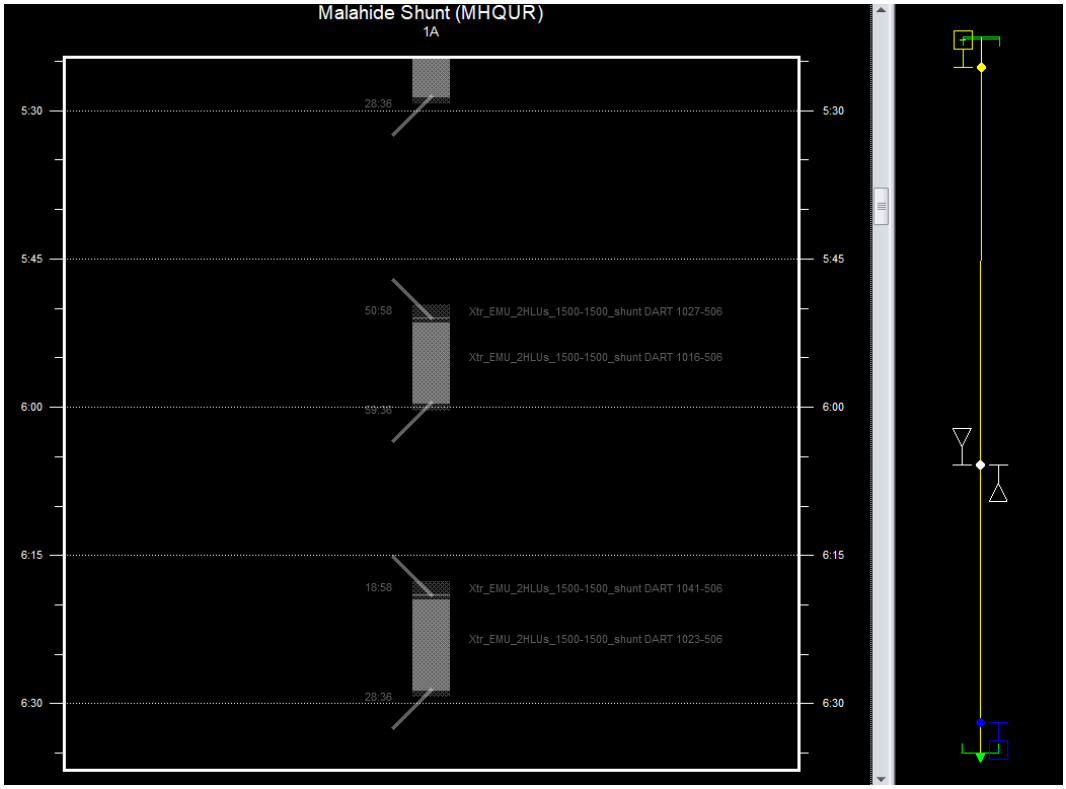


Figure 3-2. Platform occupancy at Malahide turnback

3.1.3 Clongriffin

As shown in Figure 3-3, at Clongriffin there are 2 services which are turning back and 10 services running through. The diagram below shows the occupation on each platform with DART services using Platform 3 to turnback. Through services operate northbound through Platform 1 and southbound through Platform 4. Northbound non-stop services operate through Platform 3.

For services turning back there is on average just over 17 minutes of recovery time.

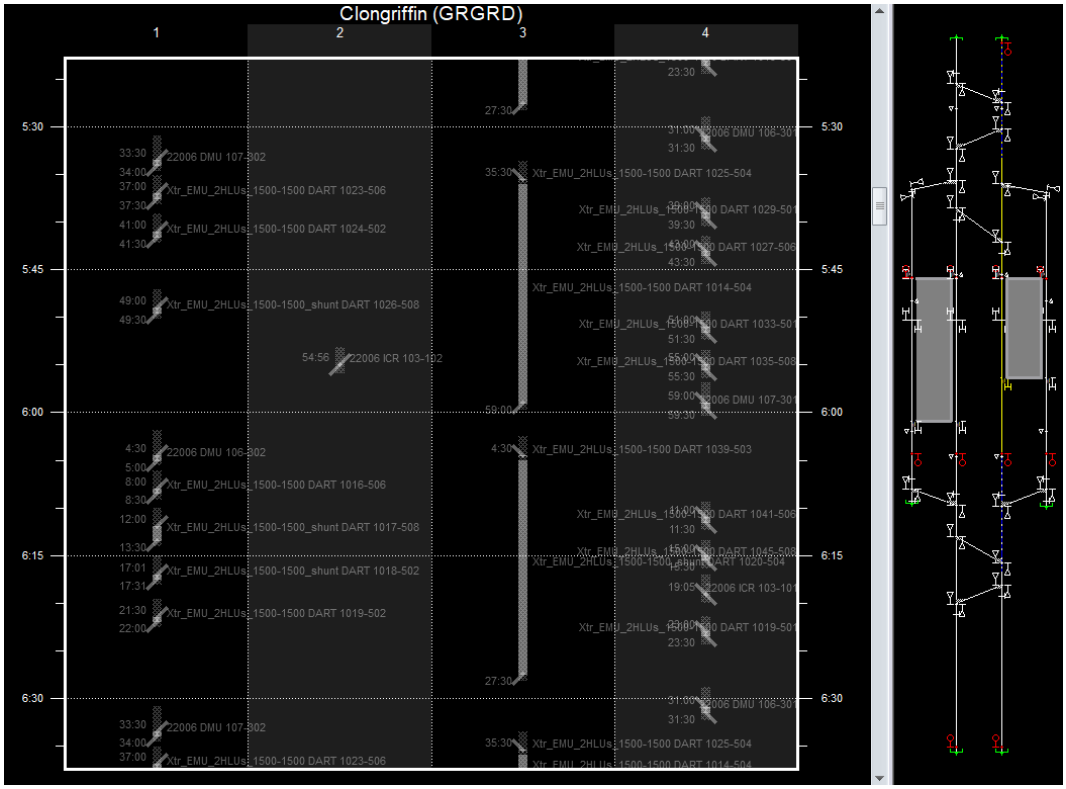


Figure 3-3. Platform diagram at Clongriffin

3.1.4 Connolly

As shown in Figure 3-4, at Connolly there are 5 services which are turning back and 15 services running through. The diagram below shows the occupation on each platform with non-DART services using Platforms 1 to 4 to turnback. Through services operate northbound through Platform 7 and southbound through Platforms 5 &6.

For services turning back there is on average over 19 minutes of recovery time; this includes the Belfast, Dundalk and Sligo services.

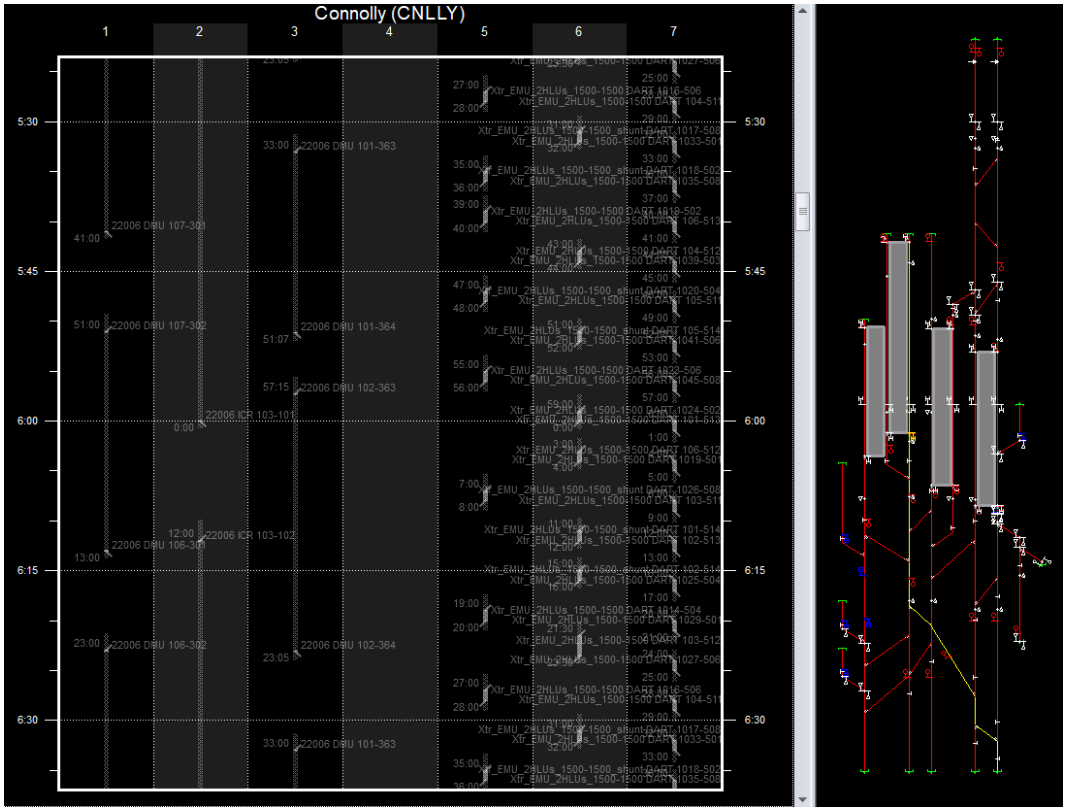


Figure 3-4. Platform diagram at Connolly

3.1.5 Howth & Howth Junction

The Howth Branch operates independently of the main line with a single platform at Howth Junction and two platforms at Howth.

For services turning back at Howth there is on average over 9 minutes of recovery.

For services turning back at Howth Junction there is on average 30 seconds of recovery.

3.1.6 Bray

As shown in Figure 3-5, at Bray there are 9 services which are turning back and 3 services running through. The diagram below shows the occupation on each turnback siding platform. Through and turnback services operate northbound through Platform 2 and southbound through Platform 3.

For services turning back there is on average just over 7 minutes of recovery time.

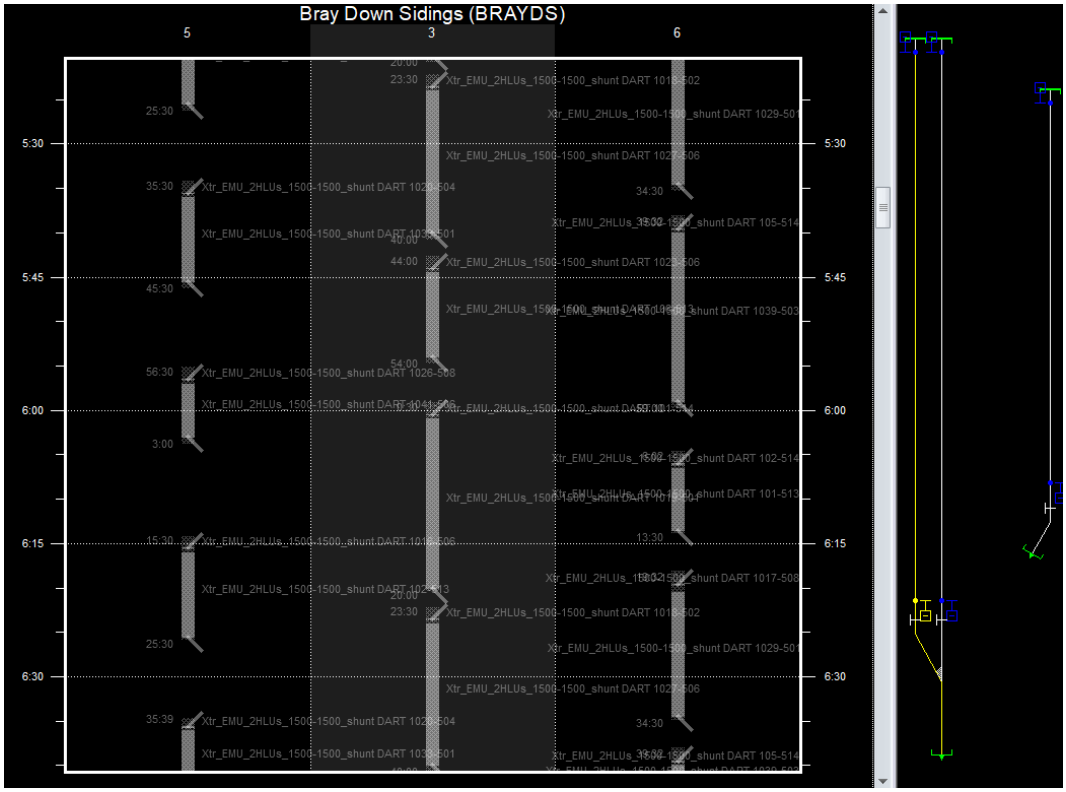


Figure 3-5. Platform diagram at Bray Down Sidings

3.1.7 Greystones

As shown in Figure 3-6, at Greystones there are 3 DART services which are turning back from the north and 1 Rosslare service turning back from the south. The diagram below shows the occupation on each platform with DART services using Platform 1 to turnback. The Rosslare services turns back in Platform 2.

For services turning back there is on average over 8 minutes of recovery time.

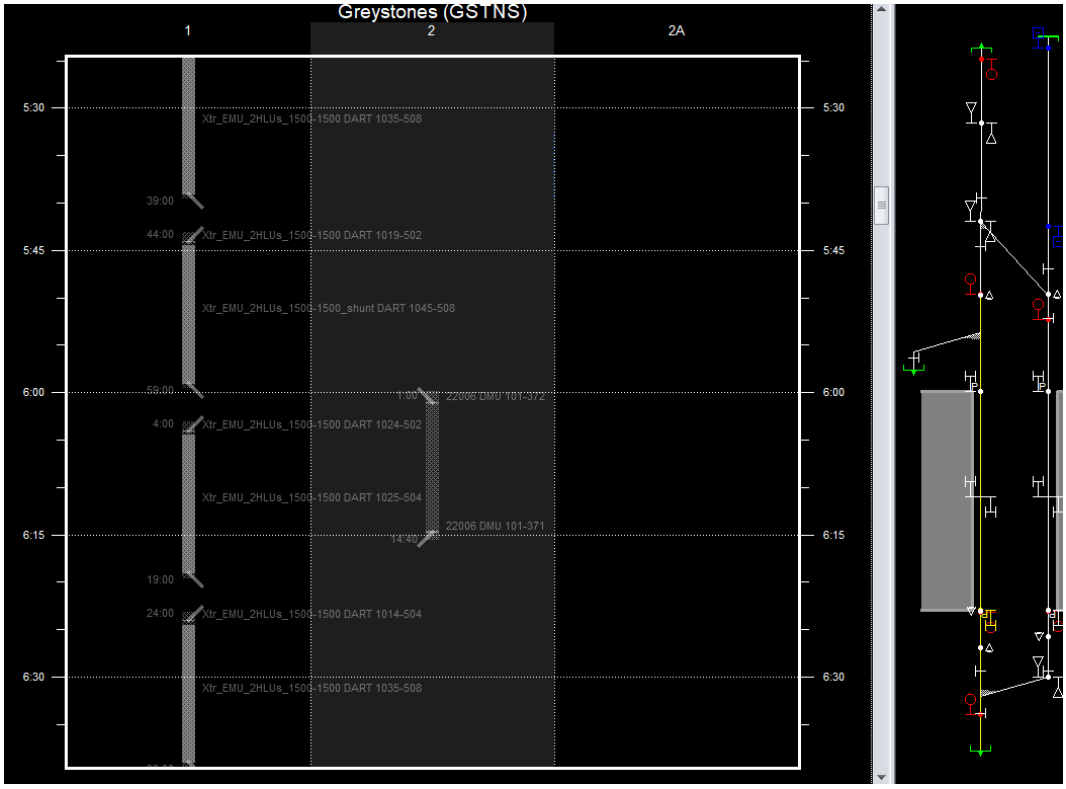


Figure 3-6. Platform diagram at Greystones

4. Results

4.1 Feasible operation

Dynamic RailSys simulation of the service specification without any delay perturbations shows that the TSS1C can operate on the infrastructure provided. The maximum lateness is 42 seconds - well below the Network Rail recommendation of less than 300s.

This concludes that it is feasible to operate the TSS1C with the infrastructure provided.

4.2 Normal perturbed operation (by main service groups)

This section provides lateness and punctuality results for the line of route of each of the main service groups. The left-hand axis refers to the average lateness bar graphs while the right-hand axis refers to the punctuality line graph. The three different perturbations are shown in blue (small) orange (medium) and purple (large). The x-axis describes the location at which delay is measured and shows the number of trains passing the location during the modelled peak hour.

4.2.1 DART+ Northbound

The performance results for this service group are shown in Figure 4-1.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality.

For the medium perturbation (orange) the services start from Greystones and Bray with just over 1 minute average lateness. These services continue to accumulate delay along their route even beyond the turnback of the Clongriffin and Malahide services arriving into Drogheda with over 5 minutes of average lateness.

For the large perturbation (purple) we see a similar behaviour to the medium distribution; however, although the average delay is the same the increased maximum lateness value highlights the impact of more secondary delays where trains delay each other more significantly.

The propagation of lateness shows how accumulated delay is tied to the structure of the timetable and network where services are following behind each other with no opportunity to overtake. It also highlights a trigger point at which the primary delays along the route and their secondary delay impact become greater than the amount of recovery time inherent in the running times. This level of delay will inform any signaller / control room interventions.

For the operation of the network with either a medium or high level of perturbation it would be recommended to intervene to the timetable operation to recover some of the lateness by cancelling or turning back services.

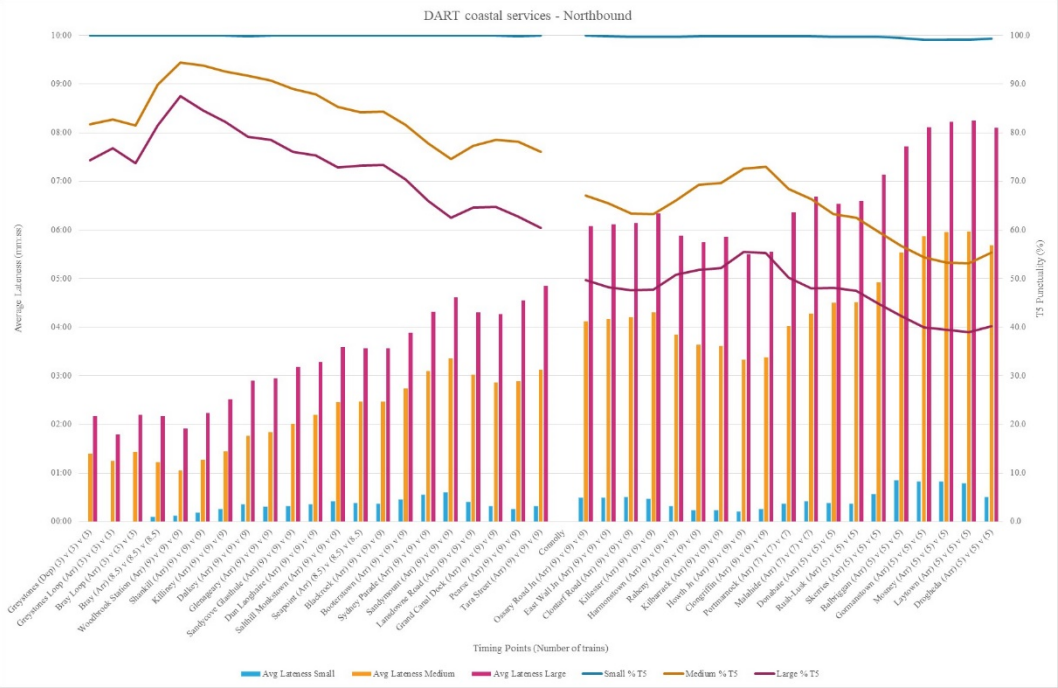


Figure 4-1. Performance results DART+ Northbound

The turnround time at Drogheda allows trains to recover from an average lateness of over 5 minutes on arrival to just over 1 minute on departure demonstrating the value of longer turnrounds at this location.

4.2.2 DART+ Southbound

The performance results for this service group are shown in Figure 4-2.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality.

For the medium perturbation (orange) the services start from Drogheda, with over 1 minute average lateness. These services continue to accumulate delay along their route as the Malahide and Clongriffin services join the route, arriving into Bray with just over 4 minutes of average lateness. Access to the single line section to Greystones causes a further increase in lateness.

For the large perturbation (purple) we see a similar behaviour to the medium distribution however although the average delay is the same the increased maximum lateness value highlights the impact of more secondary delays where trains delay each other more significantly.

For the operation of the network with either a medium or high level of perturbation it would be recommended to intervene the timetable operation to recover some of the lateness by cancelling or turning back services.

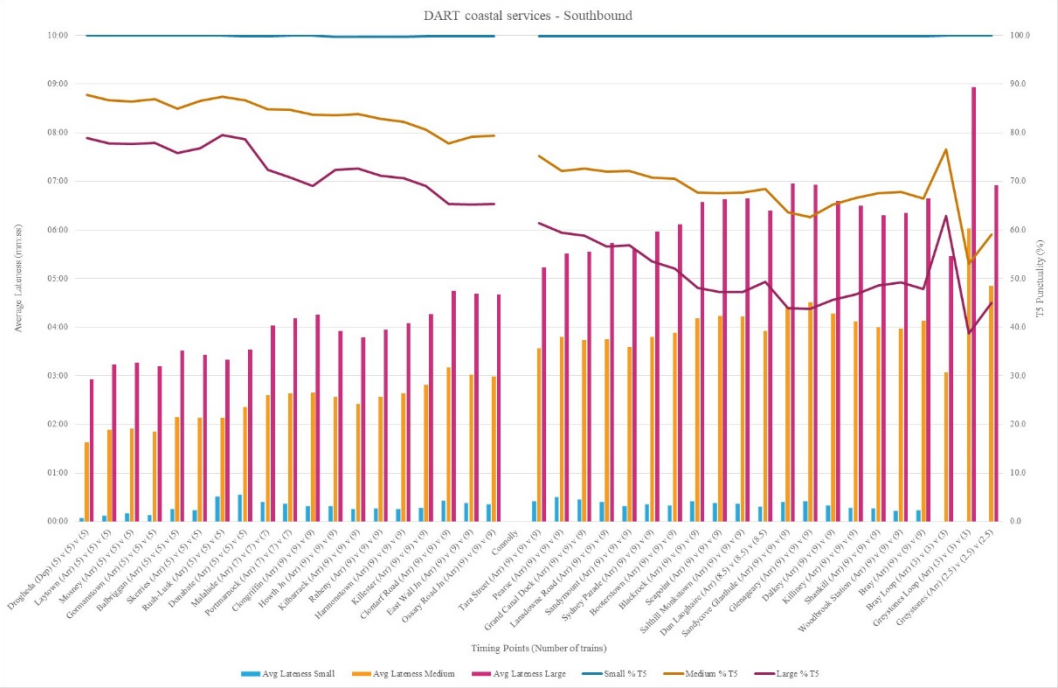


Figure 4-2. Performance results DART+ Southbound

The turnround time at Bray allows trains to recover from an average lateness of over 4 minutes on arrival to just over 1 minute on departure demonstrating the value of longer turnrounds at this location.

The graphs show that the single line section between Bray and Greystones is very sensitive to delay. Under non-perturbed conditions, the single line between Bray Loop and Greystones Loop is occupied for 48 minutes every hour (80%), which is close to the maximum recommended by the UIC (see UIC 406, Table 1) for suburban passenger services. Once a delay occurs at either side trains must wait until the line is unoccupied. Directional differences can be observed due to the following reasons:

- Southbound services must wait at Greystones Loop for the platform in Greystones to become available. Northbound services thus must leave Greystones before Southbound services can arrive.
- Southbound services arrive with delay accumulated across the network. They don't have much recovery time at Bray. In some instances, they must wait to depart Bray depending on ECS movements in the southern station throat at Bray. Of the 15 minutes turnround time at Greystones, with a minimum required turnround time of six minutes Northbound services have nine minutes recovery time at Greystones.
- Under real operations, the control room would likely intervene and terminate a heavily delayed service to Greystones at Bray to regulate the service. RailSys is not capable to reflect control room interventions.

4.2.3 Express Northbound

The performance results for this service group are shown in Figure 4-3.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality.

For the medium perturbation (orange) the services start from Connelly, with about 30 seconds average lateness. These services are able to merge between potentially late running DART services at East Wall Junction and run in line with them until Drogheda. The services accumulate delay along their route as the Malahide and Clongriffin services leave the route arriving into Drogheda with about 2 minutes 30 seconds of average lateness.

For the large perturbation (purple) we see a similar behaviour to the medium distribution but with a greater impact of secondary delays.

These express services have more recovery time in their timings where they are not stopping at all stations helping to maintain performance.

For the operation of the network with a high level of perturbation it is expected that measure to improve the performance of the DART service from the south would improve these services too as the lateness is caused by secondary delays.

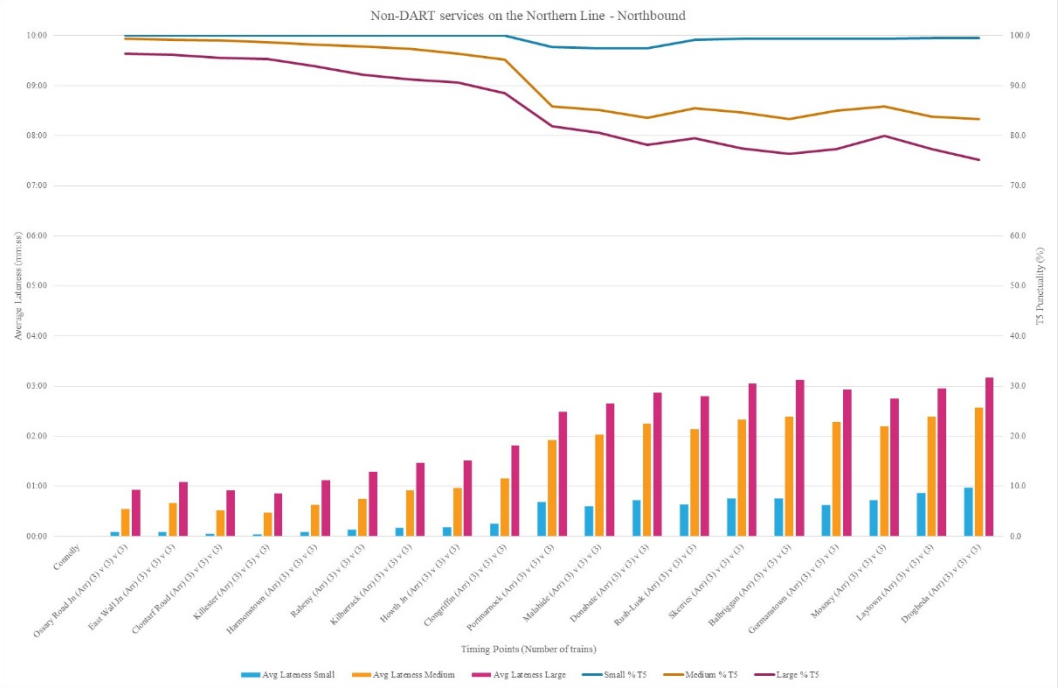


Figure 4-3. Performance results Express trains Northbound

The northbound average lateness of about 2 minutes 30s at Drogheda could impact of services timing to Dundalk and Dublin.

4.2.4 Express Southbound

The performance results for this service group are shown in Figure 4-4.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality.

For the medium perturbation (orange) the services start from Drogheda with just under 1 minute average lateness. These services are able to merge between potentially late running DART services at Drogheda and run in line with them until East Wall Junction. The services accumulate delay along their route as the Malahide and Clongriffin services join the route arriving into Connolly with less than 2 minutes of average lateness.

For the large perturbation (purple) we see a similar behaviour to the medium distribution but with a greater impact of secondary delays.

These express services have more recovery time in their timings where they are not stopping at all stations helping to maintain performance.

For the operation of the network with a high level of perturbation it is expected that measure to improve the performance of the DART service from the south would improve these fast services too as the lateness is caused by secondary delays.

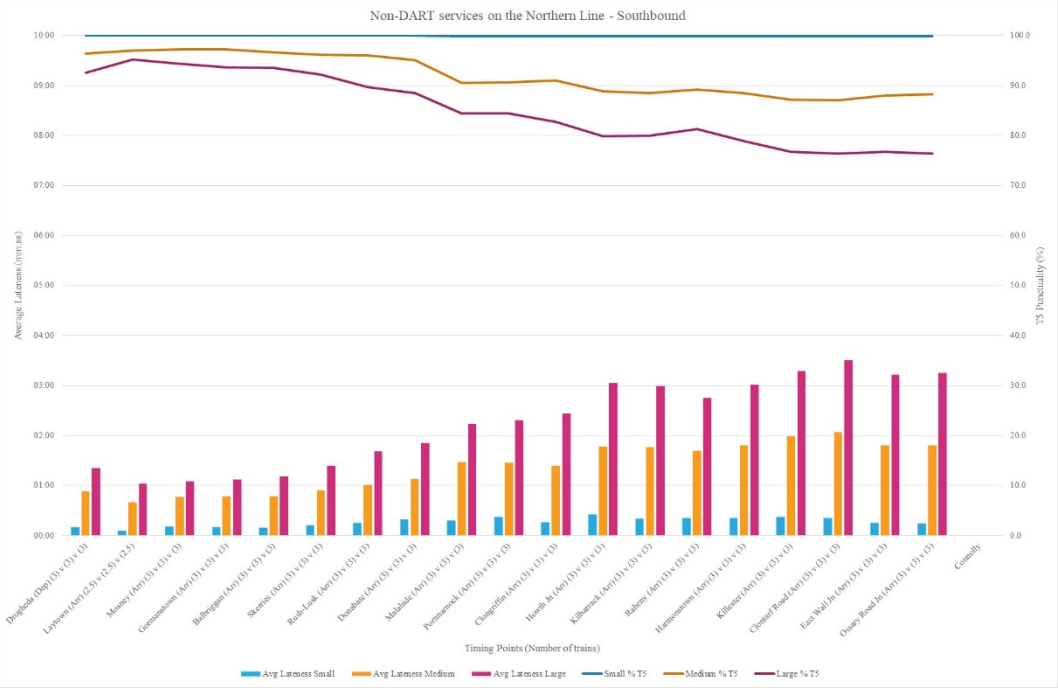


Figure 4-4. Performance results Express trains Southbound

Modelling assumes that southbound services from Dublin and Dundalk enter the modelling area broadly on time.

4.2.5 Howth Eastbound and Westbound

The performance results for this service group are shown in Figure 4-5 (Eastbound) and Figure 4-6 (Westbound).

The independent operation of the Howth branch provides isolation from accumulating delays on the main line. In all three perturbation options the level of delay build up is minimal and the large turnround recovery on the two platforms at Howth is easily sufficient to recover any lateness.

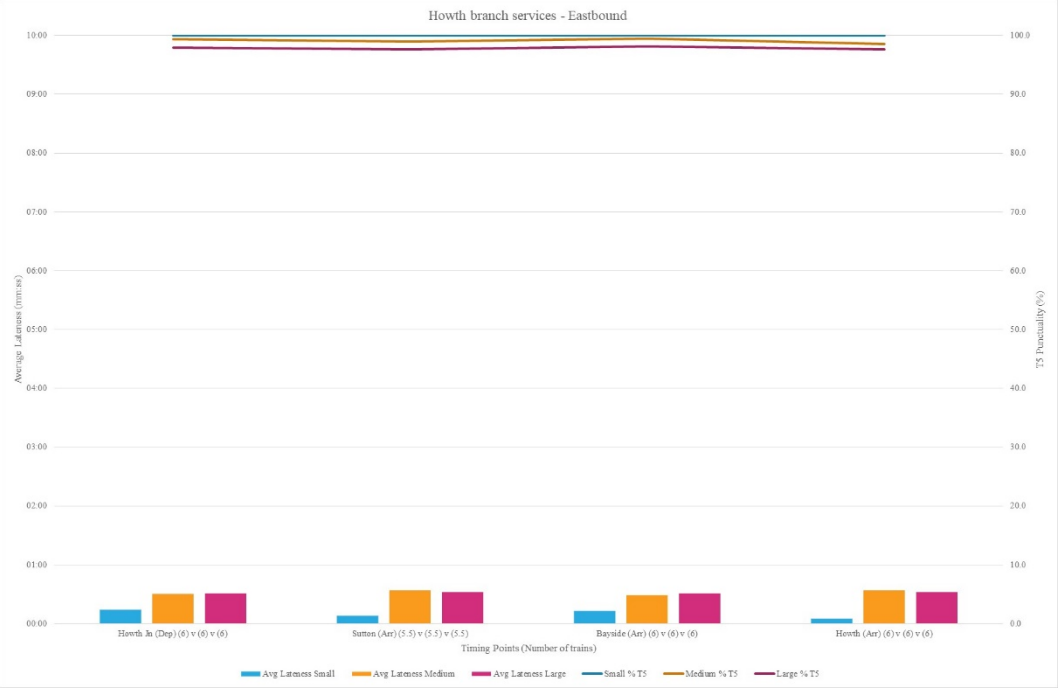


Figure 4-5. Performance results Howth branch Eastbound

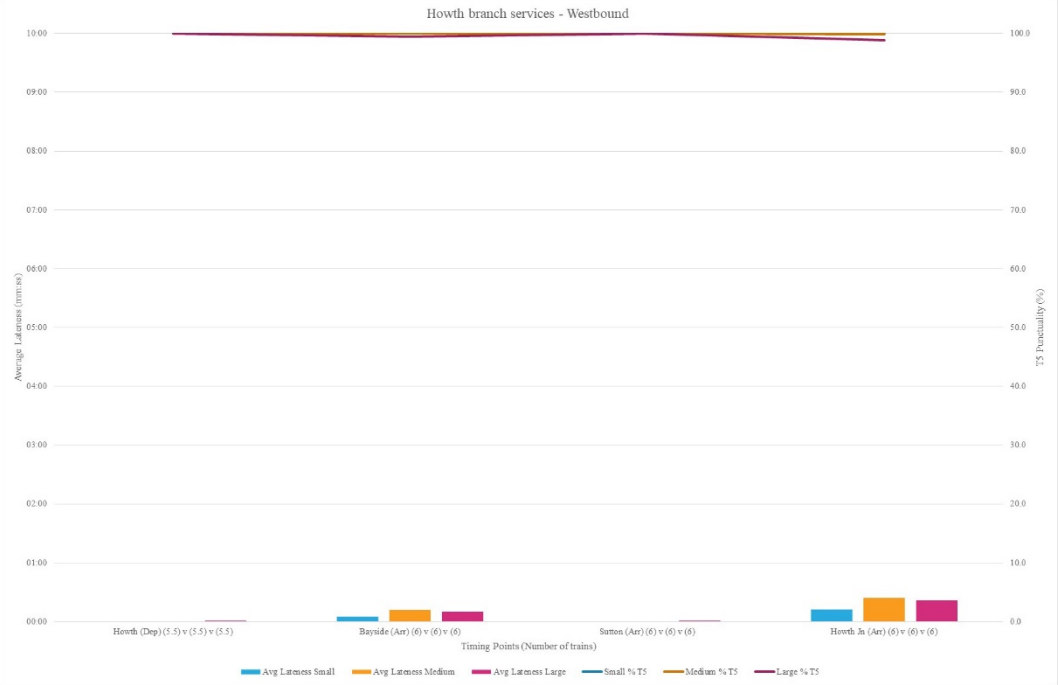


Figure 4-6. Performance results Howth branch Westbound

4.3 Normal perturbed operation (by turnround groups)

4.3.1 Trains turning round at Greystones

The performance results for this service group are shown in Figure 4-7 for terminating trains and in Figure 4-8 for trains starting at Greystones.

Three services per hour turn round at Greystones, two starting at Drogheda and one starting at Clongriffin.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality. There is no knock-on effect on the single-line section between Bray and Greystones

For the medium and large perturbation, a high level of delay can be seen between Bray and Greystones. This is aggravated through the high occupancy rate of the single-line section between Bray and Greystones even

under normal operations, acting as a bottleneck under bigger delay and causing secondary delay to arriving and departing trains. Both perturbations show similar trends, with the large perturbation experiencing more delay than the medium perturbation. These services have the longest route and are therefore more impacted by the accumulation of delay.

The drop in northbound performance at Clongriffin is a result of services forming the northbound services to Drogheda being prone to depart delayed at Greystones, reflecting reactionary delay from southbound services arriving at Greystones from Clongriffin. The reason for the delayed arrival at Greystones is further explained in section 4.3.3.

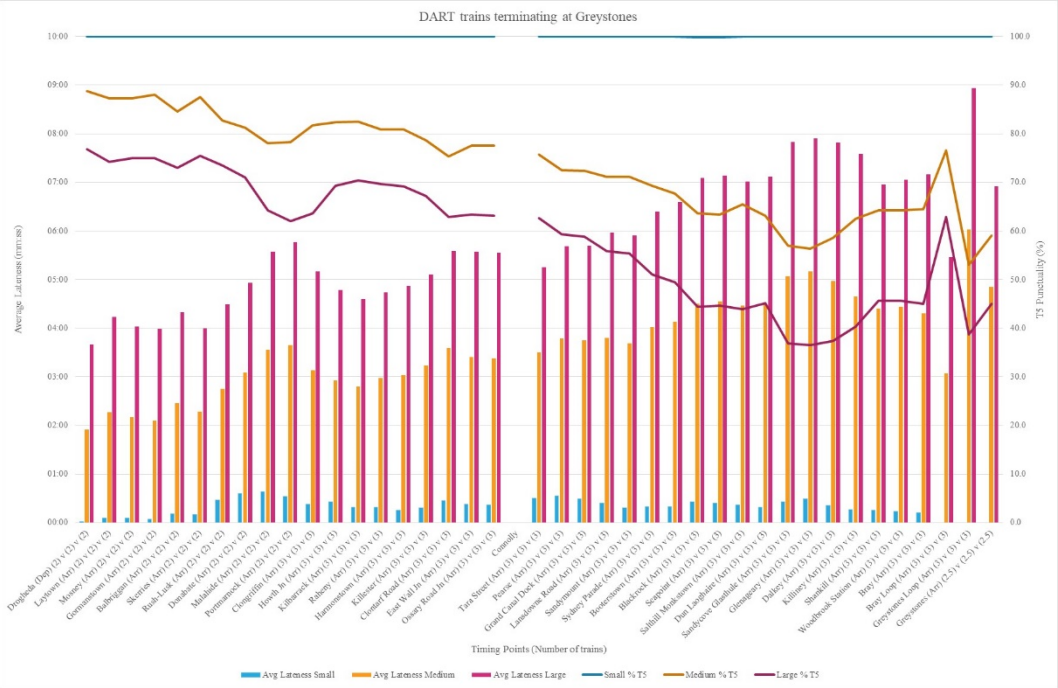


Figure 4-7. Performance results for trains terminating at Greystones

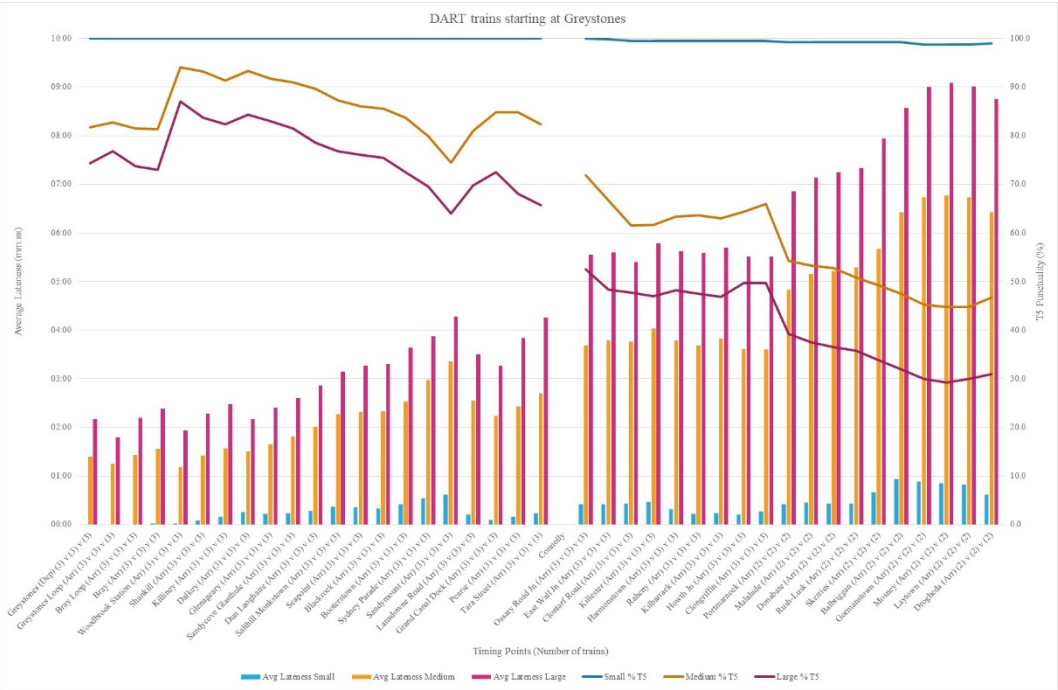


Figure 4-8. Performance results for trains starting at Greystones

4.3.2 Trains turning round at Bray

The performance results for this service group are shown in Figure 4-9 for terminating trains and in Figure 4-10 for trains starting at Bray.

All three perturbations show similar trends on delay and recovery.

For the medium perturbation, the average recovery of lateness is from just under 4 minutes arriving to 1.5 minutes departing. The large perturbation shows a difference from 6 minutes to just under 3 minutes.

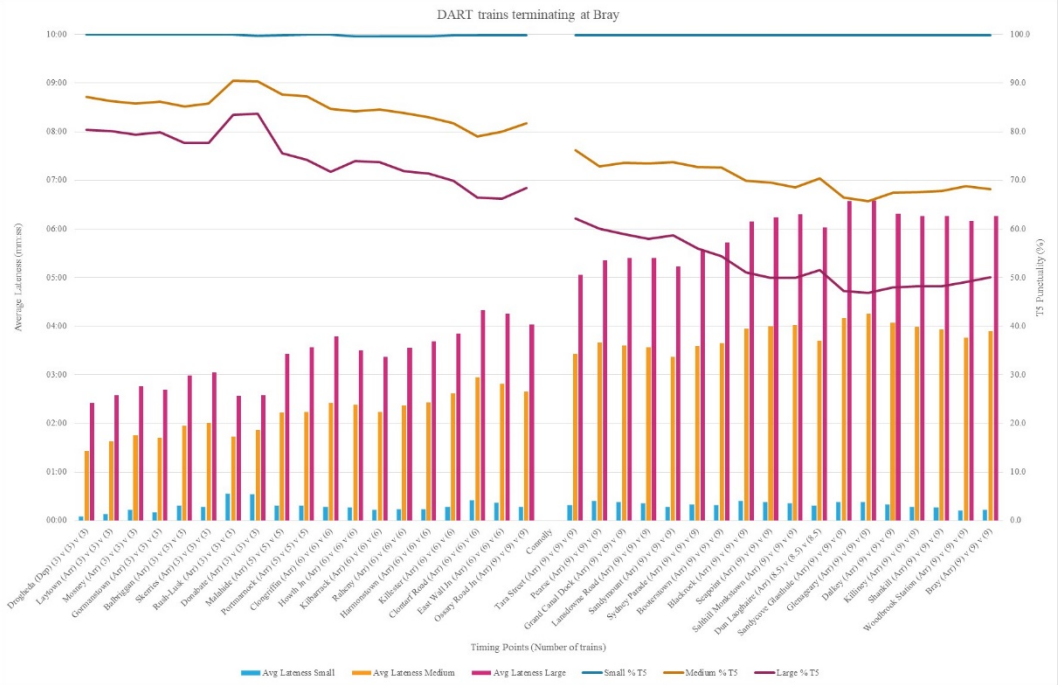


Figure 4-9. Performance results for trains terminating at Bray

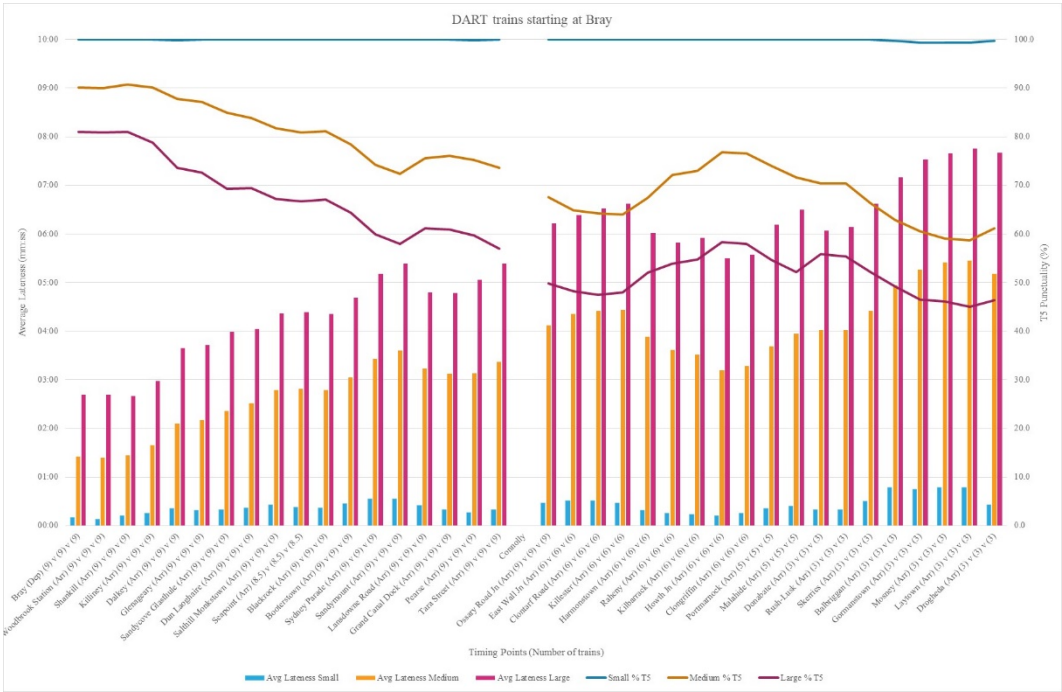


Figure 4-10. Performance results for trains starting at Bray

4.3.3 Trains turning round at Clongriffin

The performance results for this service group are shown in Figure 4-11 for terminating trains and in Figure 4-12 for trains starting at Clongriffin.

Trains terminating at Clongriffin have and average lateness of 2.5 (medium) and 4.5 (large) minutes. In this instance, the departing trains following the turnround in both instances have little delay, which can be attributed to the long turnround times at Clongriffin.

A spike in delay can be observed for services from Clongriffin in Figure 4-12. Southbound services from Clongriffin have 2.5 minutes regulatory dwell time at Bray, compared to 4.5 minutes regulatory dwell time for services from Drogheda. This means services from Clongriffin have less delay recovery time and are more prone to departing Bray station later than scheduled compared to Drogheda services. Due to the high occupancy rate of the single line between Bray and Greystones Loops, delayed Southbound services from Clongriffin are more likely to have to wait for the single line to become available after being occupied by northbound services.

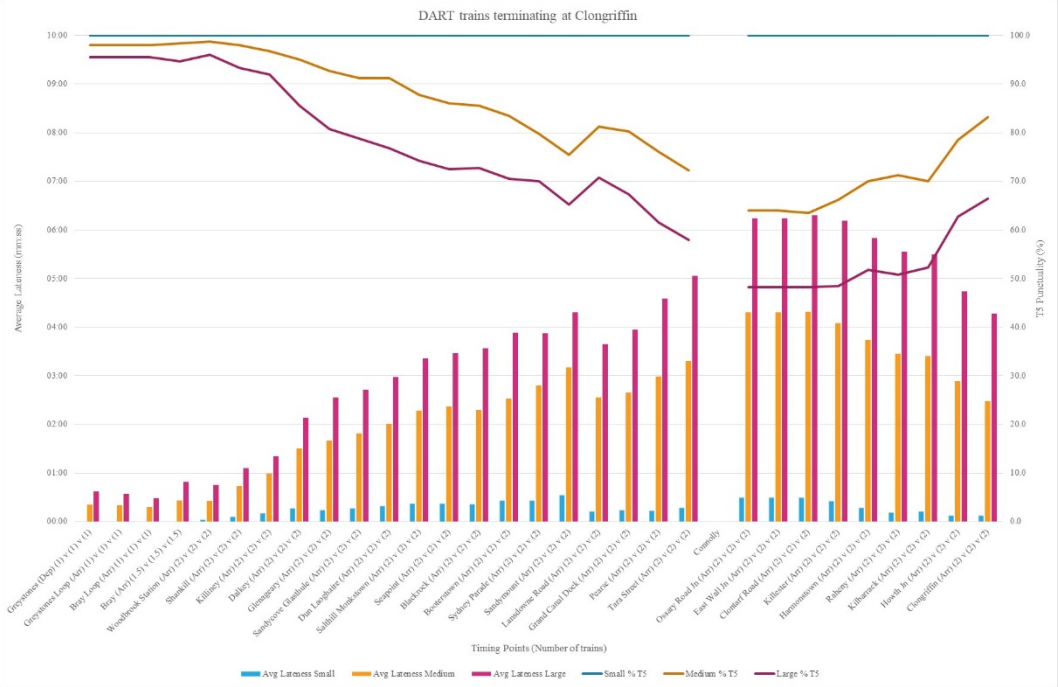


Figure 4-11. Performance results for trains terminating at Clongriffin

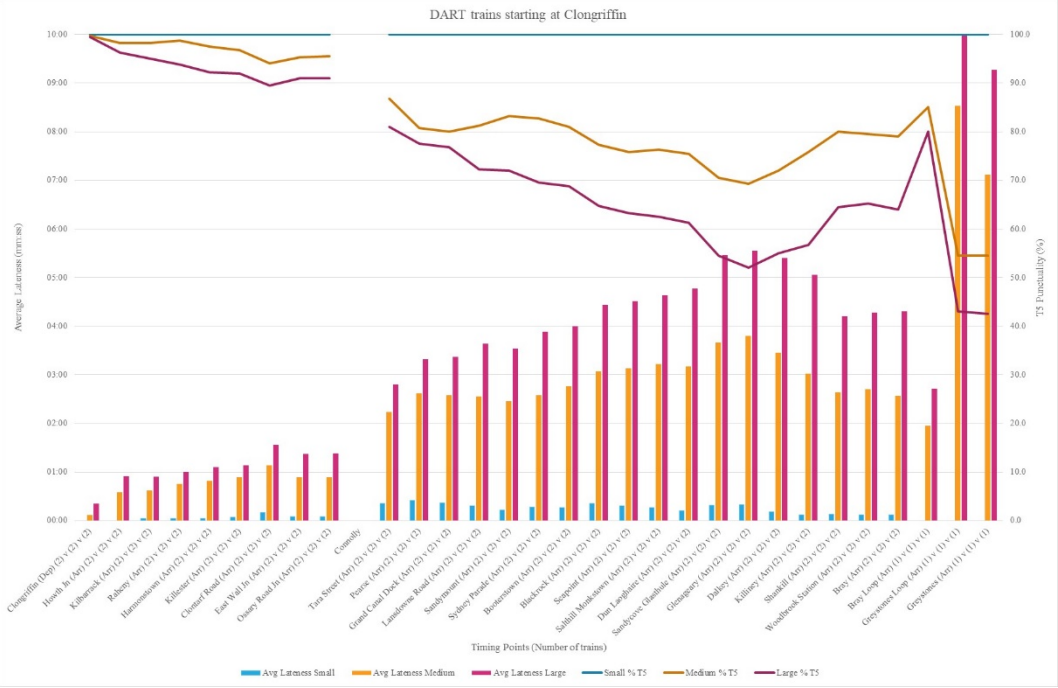


Figure 4-12. Performance results for trains starting at Clongriffin

4.3.4 Trains turning round at Malahide

The performance results for this service group are shown in Figure 4-13 for terminating trains and in Figure 4-14 for trains starting at Malahide.

All three perturbations show similar trends on delay and recovery.

For the medium perturbation, the average recovery of lateness is from just under 4 minutes arriving to just under 2 minutes departing. The large perturbation shows a difference from 6 minutes to just under 4 minutes.

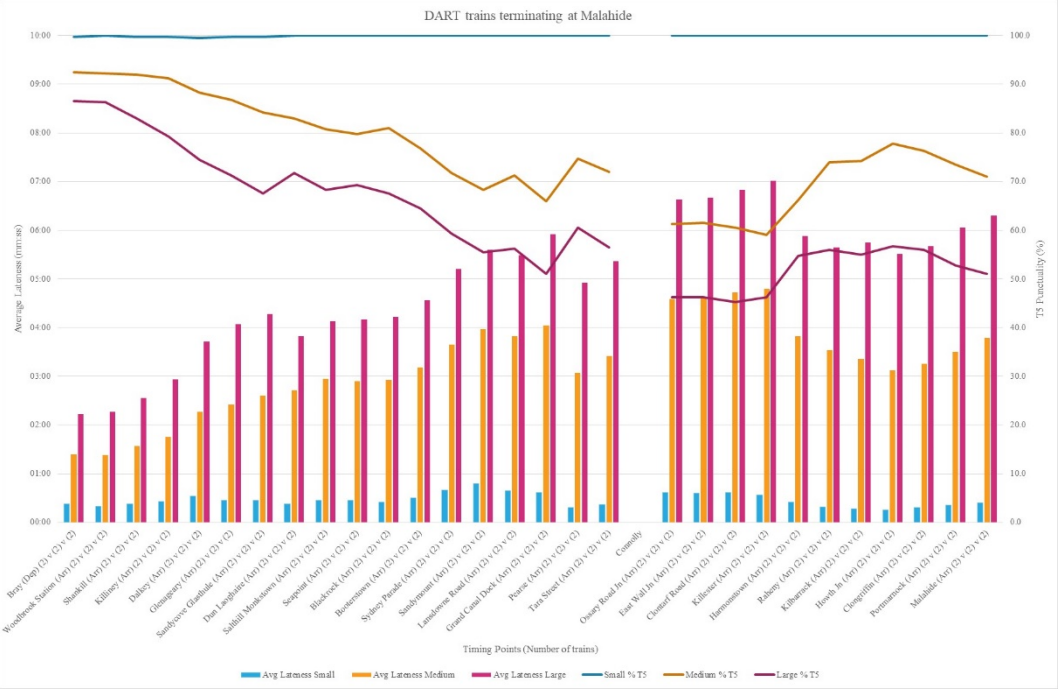


Figure 4-13. Performance results for trains terminating at Malahide

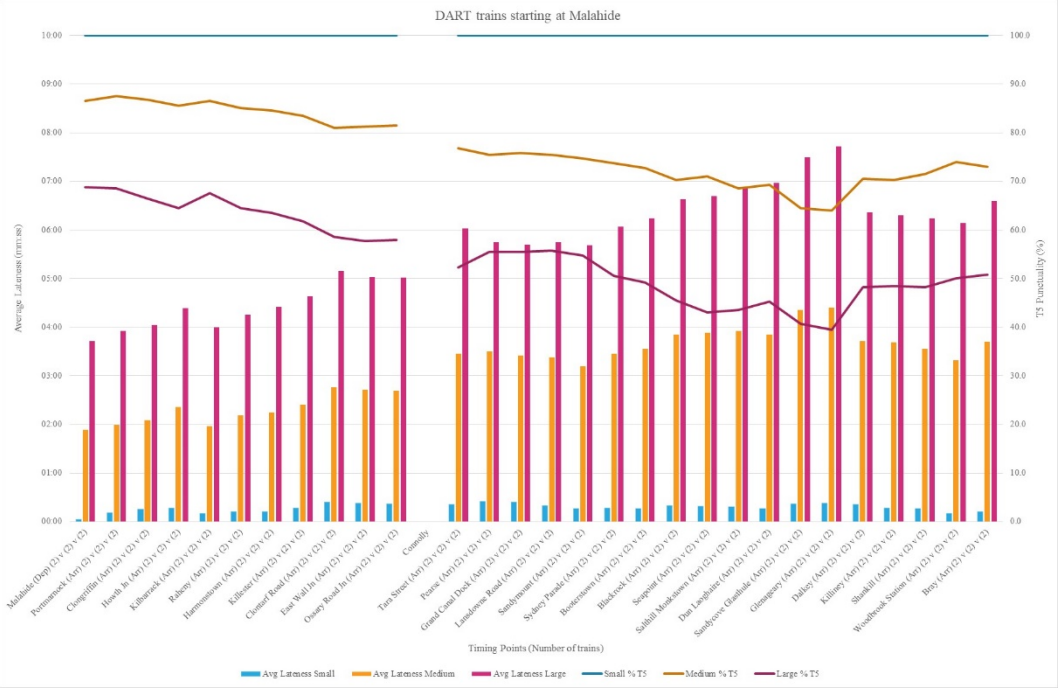


Figure 4-14. Performance results for trains starting at Malahide

4.3.5 Trains turning round at Drogheda

The performance results for this service group are shown in Figure 4-15 for terminating trains and in Figure 4-16 for trains starting at Drogheda.

All three perturbations show similar trends on delay and recovery.

For the medium perturbation, the average recovery of lateness is from just under 5.5 minutes arriving to 2.5 minutes departing. The large perturbation shows a difference from 8 minutes to just under 3 minutes.

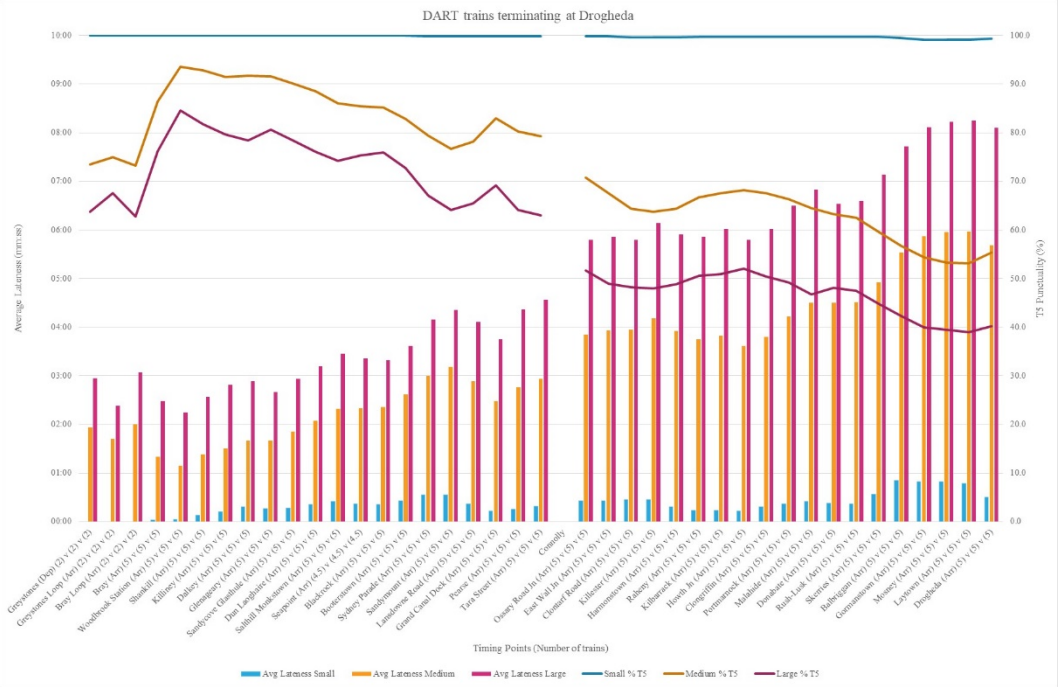


Figure 4-15. Performance results for trains terminating at Drogheda

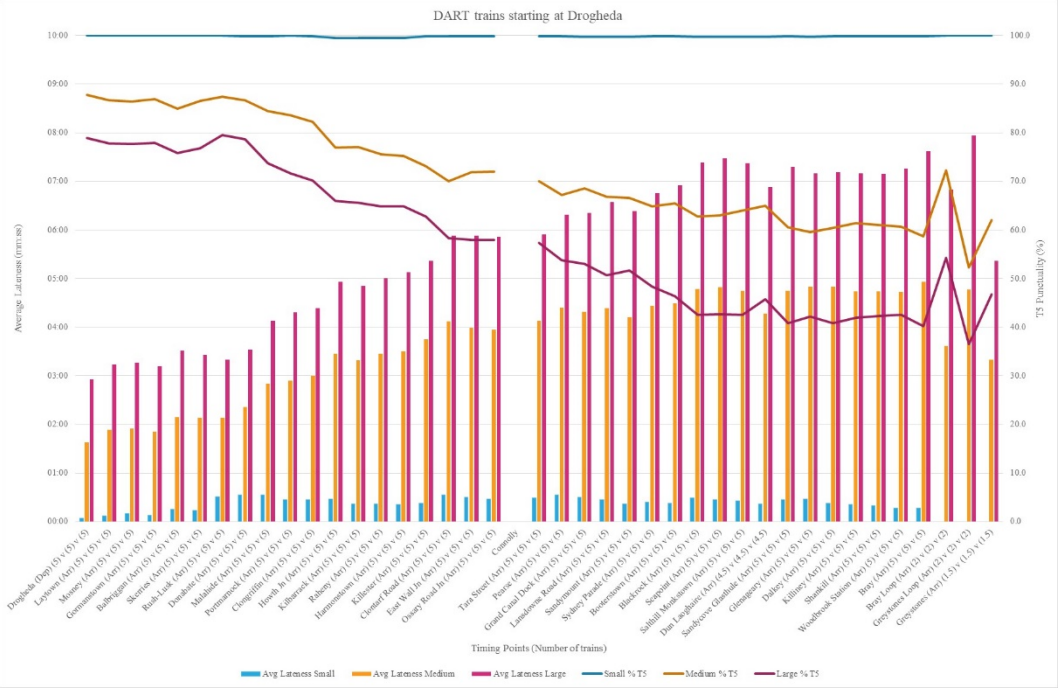


Figure 4-16. Performance results for trains starting at Drogheda

4.4 Perturbed Operation

During large perturbations or significant incidents the following options could be considered for timetable lateness recovery:

Malahide Turnback – The Malahide turnback is used by 2tph turning back. It is envisaged that a further 2tph late running northbound services could be turned back at this location to allow southbound services to be 'stepped back' and run on-time.

Clongriffin Turnback – Clongriffin Platforms 2 and 3 are used by 2tph turning back. It is envisaged that a further 6tph late running northbound services could be turned back at this location to allow southbound services to be 'stepped back' and run on-time.

Connolly – Dublin Connolly Platforms 1 to 4 are used by 5tph turning back from the north. It is envisaged that a further 4tph late running southbound services could be turned back at this location to allow northbound services to be 'stepped back' and run on-time.

Dun Laoghaire – Dun Laoghaire has two platforms that are not used for normal timetable operation. It is envisaged that between 4 to 8tph late running southbound services could be turned back at this location to allow northbound services to be 'stepped back' and run on-time.

Bray – At Bray station the 3 turnback sidings are used by 9tph turning back. It is envisaged that should the single line not be available an additional 1tph could be turned back at this location.

This table summarises the turnback locations.

Location	Number of turnback platforms	Number of trains planned to turnback	Average recovery time in turnback	Perturbed operation addition trains to turnback
Drogheda	3	5 tph	~10 minutes	n/a
Malahide	1	2 tph	~3 minutes	2 tph
Clongriffin	2	2 tph	~17 minutes	2 to 6 tph
Howth	2	6 tph	~ 9 minutes	2 tph
Howth Junction	1	6 tph	30 seconds	2 tph
Connolly	7	5 tph	~ 19 minutes	2 to 4 tph
Don Laoghaire	1	0 tph	n/a	2 to 4 tph
Bray	3	9 tph	~7 minutes	1 tph
Greystones	1 (+1)	3 tph	~8 minutes	n/a

There are other elements that will alter how services operate differently from today:

The repeat pattern with frequent services will allow for potentially easier interventions to the timetable during operation, using the above locations to turnback early and restart service on to an on-time path.

The alteration of the timetable and intervention to the rolling stock diagrams will be simplified with the uniform rolling stock fleet for example swapping services between different destinations more easily.

The higher level of service will require a more systematic approach to service intervention, creating a trigger location for given lateness at which point a standard contingency plan for that situation could be implemented. For example, if a southbound service to Greystones is more that X minutes late it should be turned back and Bray and used to form a return northbound Greystones service into an on-time path. These plans will need development and review by the operator prior to implementation of the timetable, so signallers and control staff understand how to implement them.

4.5 Commentary on the increase in units required as a result of timetable amendments

As outlined in the document *D+WP56-ARP-ZZ-AL-FN-OP-000001 Performance Modelling Assumptions Note*, the following changes were applied to DART services in TSSC1:

- Review of the interworking of services at Bray following the provision of a third hourly service between Bray and Greystones
- An additional stop at Woodbrook station for all passing services
- Stepping back of services at Howth to allow for a minimum turnround time of six minutes
- Re-platforming and reviewing the interworking at Drogheda to reflect the current design station layout

The changes to TSS1C have increased platform utilisation under non-perturbed conditions from 29% to 76% at Howth and decreased from 71% to 48% at Greystones. The platform occupancy rate at Howth Junction remains unchanged. Data for Drogheda cannot be compared as services in the received model were not platformed.

A definite number of required rolling stock units cannot be derived due to the following reasons:

- TSS1C is not a fully developed timetable that represents a full operational day. It is a perpetually repeating representation of the AM peak hour.
- DART trains running along the coastal network are interworked with services on the Kildare and Maynooth lines, which are out of scope of this assessment.

Comparing the total combined run time of all hourly services provides an indication of the increase in number of units required under perpetual operation of the AM peak hour. This number will change depending on the timetable structure as it is developed to represent a full operational day.

Services along the Northern and Southern line are currently forming an irregular rolling stock diagram and are not directly comparable. Taking the sum of all combined run times for the hourly AM peak service (cutting services leaving and entering the model boundaries at Ossory Road Junction), an increase of 3 hours train run time per peak hour can be observed.

For the shuttle service on the Howth Branch, it is likely an increase from 3 to 4 units is required to comply with the minimum turnround time assumed for this analysis, although noting this is indicative due to the above reasons.

5. Summary and Conclusions

The TSS1C timetable is feasible to operate on the infrastructure in a theoretical non-perturbed scenario. The impact of external perturbation across the day can be assessed as indicated below.

For the small perturbation the services can recover lateness along the line of route and maintain a good level of punctuality without signaller / control room interventions.

With the medium or large perturbation some signaller / control room interventions would be required to prevent delays from accumulating.

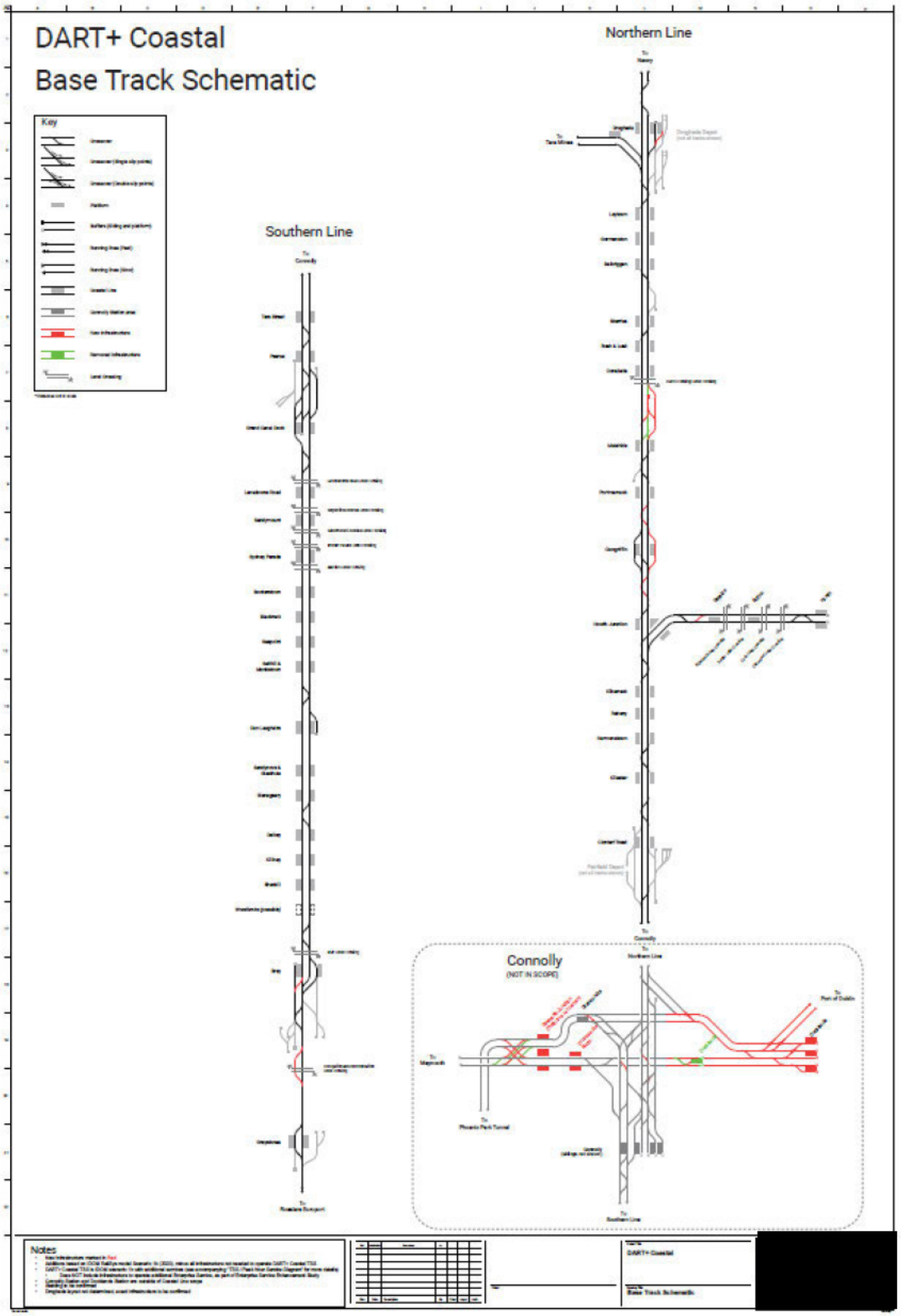
Some caveats should be considered when reviewing this analysis that has followed the approach used for the previous study. It has been undertaken for a standard pattern peak period and therefore does not consider the transition to and from peak service of start and end of service. As the service intensity reduces then the timetable would be expected to be more robust.

The timetable used for the modelling was developed as the theoretical construct which may not fully represent the final timetable implemented. Development of the timetable can consider how to plan turnround recovery at terminal station and the timings of services over flat junctions.

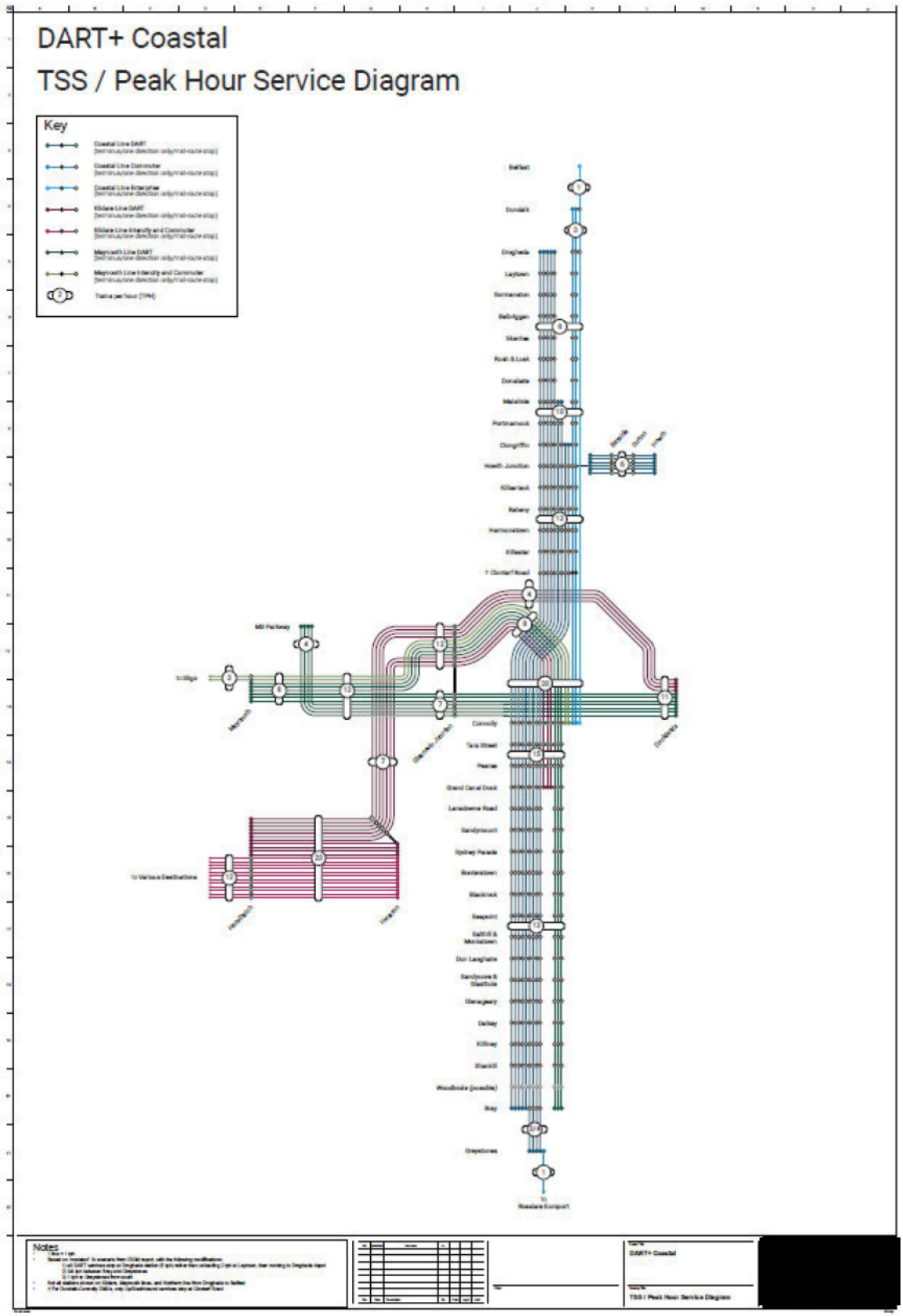
The modelling acts as a robust summary of how a future timetable with a full 20tph intensity at Connolly may behave given a nominal level of perturbation.

Appendix A

A.1 Track Layout Diagram



A.2 TSS1c Service Diagram



ARUP

Iarnród Éireann

DART+ Coastal

Performance Modelling Results

Reference: D+WP56-ARP-ZZ-AL-RP-OP-000001

P01 | 31 January 2023

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Document Verification

Project title	DART+ Coastal
Document title	Performance Modelling Results
Job number	279933-00
Document ref	D+WP56-ARP-ZZ-AL-RP-OP-000001
File reference	D+WP56-ARP-ZZ-AL-RP-OP-000001.docx

Revision	**Date**	**Filename**	D+WP56-ARP-ZZ-AL-RP-OP-000001		
P01	31/01/2023	**Description**	First Issue		
			Prepared by	**Checked by**	**Approved by**
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A.2 TSS1c Service Diagram A-3

1. Introduction

This report summarises the modelling work undertaken to review the infrastructure for the DART+ Costal project for the proposed train service specification.

The modelling acts as a robust summary of how a future timetable with a full 20tph intensity may behave given a nominal level of perturbation. However it should be noted that it does not represent the expected performance on day one of operation as the development of a full day timetable and specific service interactions will evolved during the course of the project.

2. Methodology

The modelling work as undertaken using the agree method and assumptions as outlined in the document *D+WP56-ARP-ZZ-AL-FN-OP-000001 Performance Modelling Assumptions Note*

Modelling was undertaken in RailSys with the model provided to Arup by Irish Rail. The primary updates to the model include

- Infrastructure includes proposed schemes
- Rolling stock updated to reflect the Xtrapolis unit performance
- Signalling updated on the Northern Line to represent concept design
- The timetable TSS 1C remains the same except for several small alterations to account for rolling stock change, the achievement of a minimum turnround time of 6 minutes, the new station at Woodbrook and the extension of 3 services per hour between Bray and Greystones.

Three levels of perturbation are applied to the modelling as shown in Table 2-1.

Table 2-1. Nominal delay distributions

	I. Small . max. 2 min (_1_2)	II. Medium max. 5 min (_2_5)	III. Large max. 10 min (_2_10)
Type	Negative exponential distribution	Negative exponential distribution	Negative exponential distribution
Proportion of train stops to which delays are applied	10%	10%	10%
Average lateness (min)	1	2	2
Maximum lateness (min)	2	5	10

The medium and large distributions have the same overall average delay but the large has delays over 5 minutes.

Calibration of these perturbations against the existing network was not carried out as part of this exercise.

3. Timetable Structure and Recovery Opportunity

There is the opportunity for service recovery in three elements of the timetable:

- Dwell time at intermediate stations – If the minimum dwell at the station is lower than the scheduled dwell services have an opportunity to recover lateness at station stops. The TSS1C typically has either 30 or 60s station dwell and this is assumed as both the minimum and scheduled values to there is no opportunity to recover from late running within the station dwell.
- Recovery in running time scheduled vs technical capability – If the technical running time is lower than the scheduled running time services have an opportunity to recover lateness between stations. The TSS1C has on average about 15s between station ranging from 0 to 30s. This is important in absorbing delays along the line of route.
- Turnround at the end of the route – If the planning minimum turnround time is lower than the scheduled turnround services have an opportunity to recover lateness at the ends of their route. The TSS1C has additional turnround time at all turnback locations on the route, above the minimum of 6 minutes.

During more significant delays signaller or control room interventions may be required to alter the route, stopping pattern or final location of train services. These are discussed as part of the report but not included in modelling.

The level of perturbation input to the model means that at each station stop a percentage of train pick up a delay from the distribution which overall meets the average delay. In the instance of the small distribution this equates to an average primary delay of 6s per train per station, for the medium and large distributions this equates to an average of 12s per train per station. So overall a Bray to Drogheda service stopping at 35 stations may expect to pick up on average 3 minutes 30s or 7 minutes delay depending on the distribution.

Due to the nature of the network and the high frequency of service the primary delays are likely to quickly propagate as secondary delays to impact on following trains. The modelling evaluates the impact of the primary delays, secondary delays and the level of recovery in the timetable to predict the overall network performance.

3.1 Turnround Operations

Delays are absorbed by recovery in the timetable at the following locations:

- Drogheda
- Malahide
- Clongriffin
- Dublin Conolly
- Howth & Howth Junction
- Bray
- Greystones

In the following figures the left-hand side shows for each platform (column) the arrival, pass and departure time of trains (diagonal dash) and the turnround connection (shaded). On the right-hand side the figure shows the track layout schematic.

3.1.1 Drogheda

As shown in Figure 3-1, at Drogheda there are 5 services which are turning back and 3 services running through. The diagram below shows the occupation on each platform with DART services using platforms 1, 2 and 4 to turnback. Through services operate Northbound through platform 3 and southbound through platform 2.

For services turning back there is on average just over 10 minutes of recovery time.

The average turnround time is just over 16minutes, 3tph have over 20 minutes and 2tph have just over 7 or 11 minutes. If these are operated by BEMU services requiring a minimum 18 minute turnround to allow for battery recharging the services timings will need revising and the level of recovery will reduce very significantly at this location.

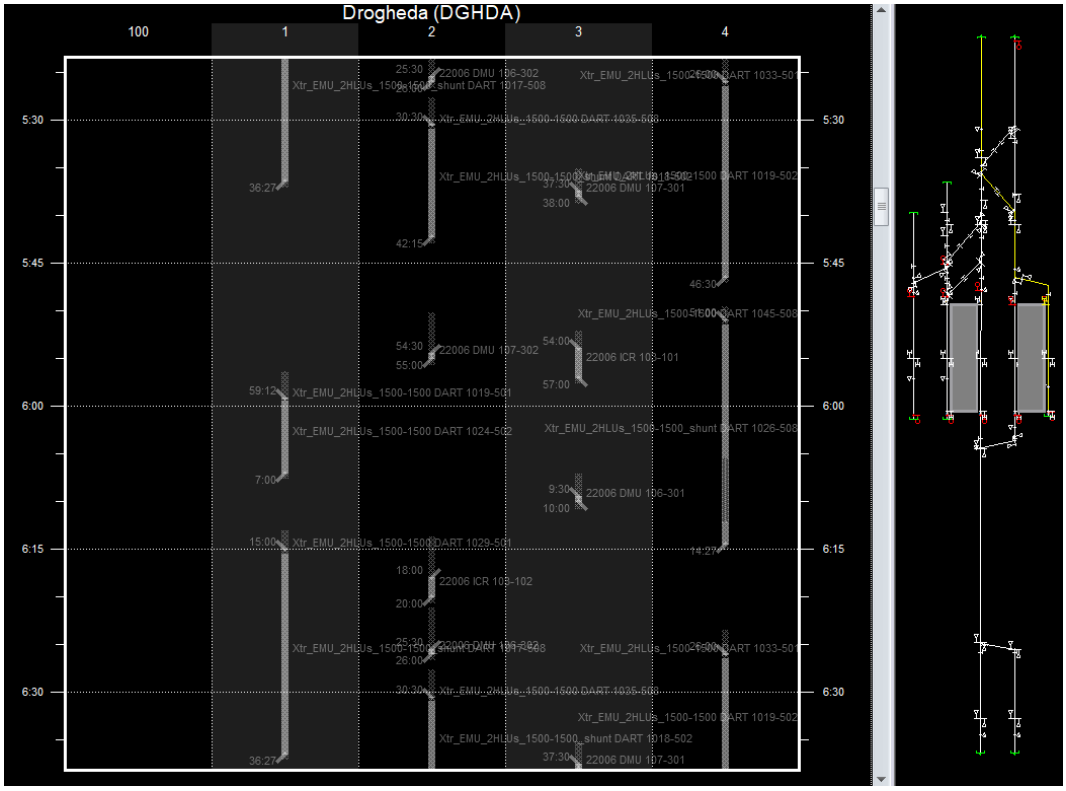


Figure 3-1. Platform diagram at Drogheda

3.1.2 Malahide

As shown in Figure 3-2, at Malahide station there are 10 services running through the platforms, 2 of these turnback in the siding north of the station. The diagram below shows the occupation of the 2 trains in the turnback siding. Through services operate Northbound through platform 1 and southbound through platform 2.

For services turning back there is on average just over 3 minutes of recovery time.

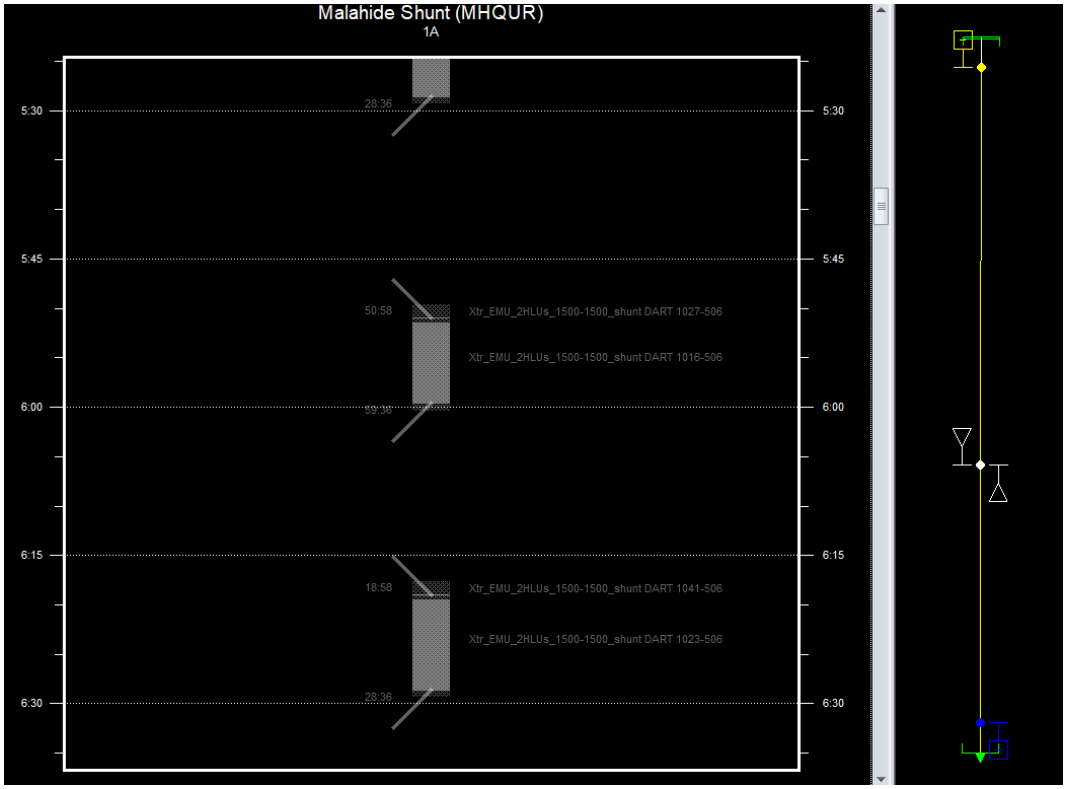


Figure 3-2. Platform occupancy at Malahide turnback

3.1.3 Clongriffin

As shown in Figure 3-3, at Clongriffin there are 2 services which are turning back and 10 services running through. The diagram below shows the occupation on each platform with DART services using platform 3 to turnback. Through services operate Northbound through platform 1 and southbound through platform 4. Northbound non-stop services operate through platform 3.

For services turning back there is on average just over 17 minutes of recovery time.

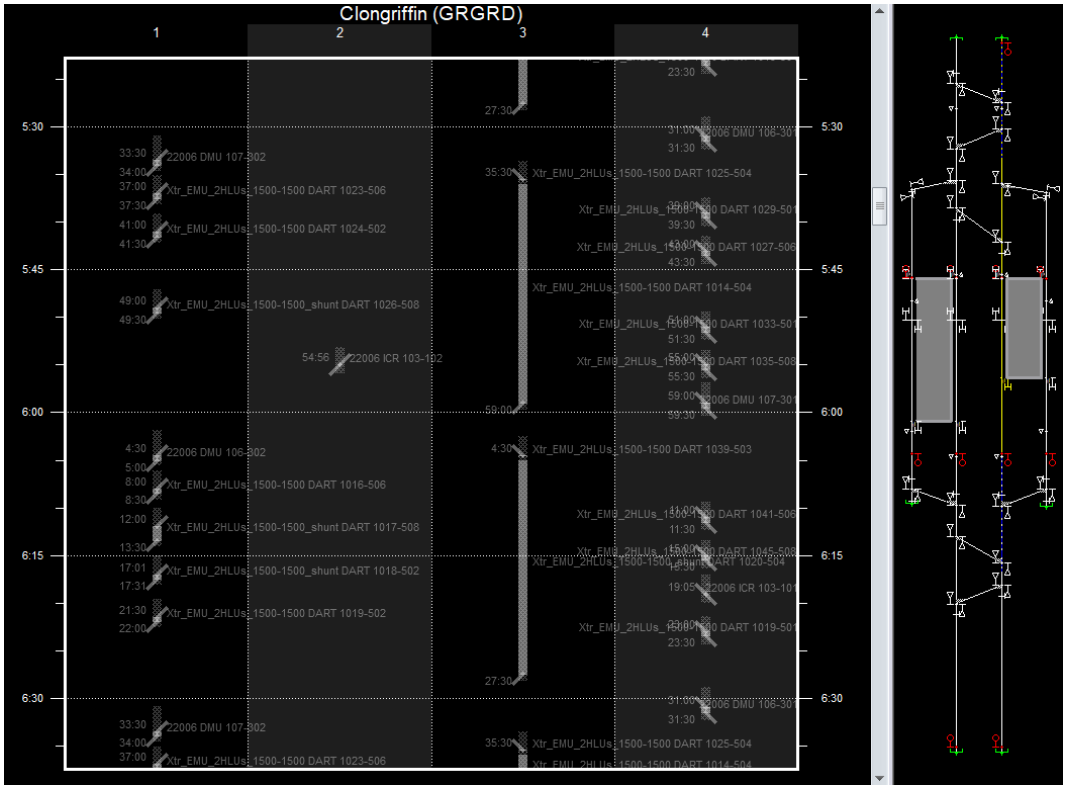


Figure 3-3. Platform diagram at Clongriffin

3.1.4 Connolly

As shown in Figure 3-4, at Connolly there are 5 services which are turning back and 15 services running through. The diagram below shows the occupation on each platform with non DART services using platforms 1 to 4 to turnback. Through services operate Northbound through platform 7 and southbound through platforms 5 &6.

For services turning back there is on average over 19 minutes of recovery time, this includes the Belfast, Dundalk and Sligo services.

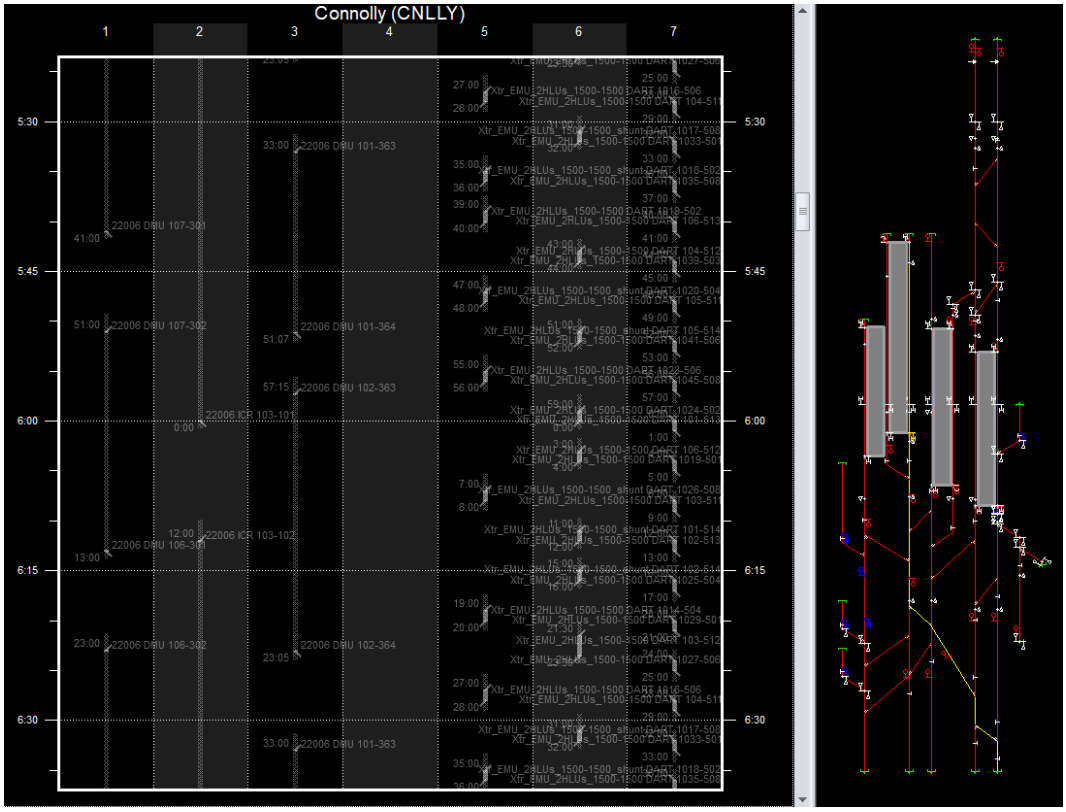


Figure 3-4. Platform diagram at Connolly

3.1.5 Howth & Howth Junction

The Howth branch operates independently of the main line with a single platform at Howth Junction and two platforms at Howth.

For services turning back at Howth there is on average over 9 minutes of recovery.

For services turning back at Howth Junction there is on average 30 seconds of recovery.

3.1.6 Bray

As shown in Figure 3-5, at Bray there are 9 services which are turning back and 3 services running through. The diagram below shows the occupation on each turnback siding platform. Through and turnback services operate Northbound through platform 2 and southbound through platform 3.

For services turning back there is on average just over 7 minutes of recovery time.

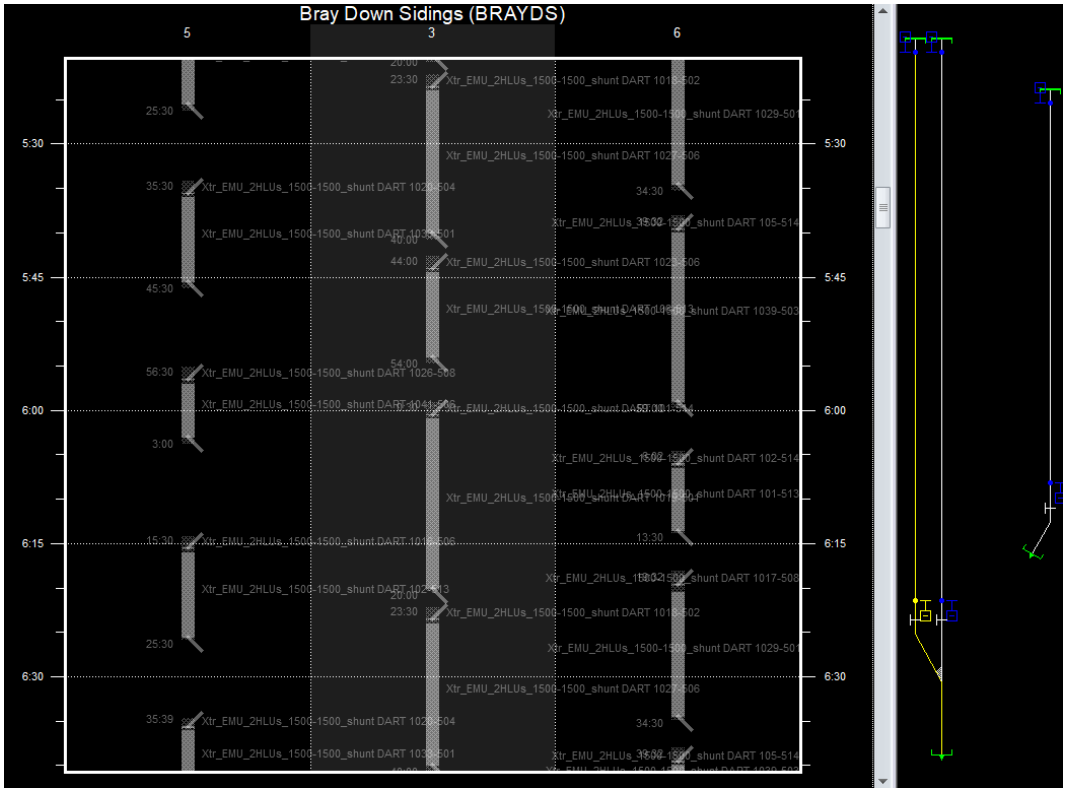


Figure 3-5. Platform diagram at Bray Down Sidings

3.1.7 Greystones

As shown in Figure 3-6, at Greystones there are 3 DART services which are turning back from the north and 1 Rosslare service turning back from the south. The diagram below shows the occupation on each platform with DART services using platform 1 to turnback. The Rosslare services turns back in platform 2.

For services turning back there is on average over 8 minutes of recovery time.

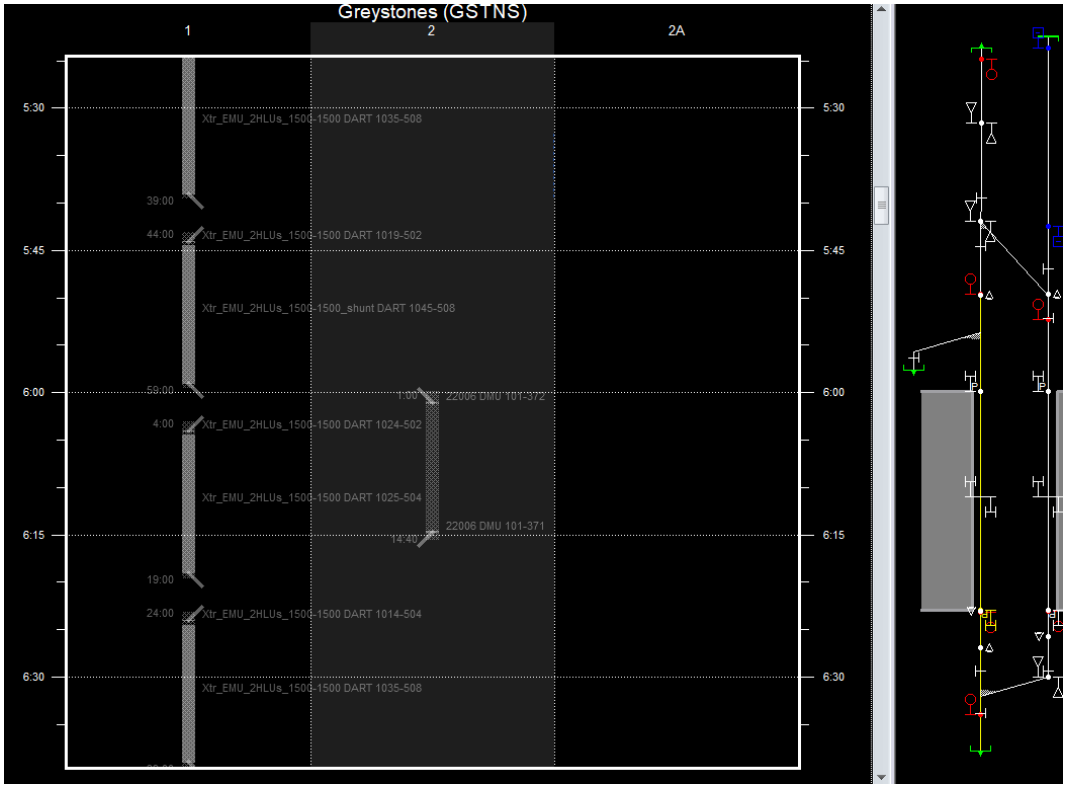


Figure 3-6. Platform diagram at Greystones

4. Results

4.1 Feasible operation

Dynamic RailSys simulation of the service specification without any delay perturbations show that the TSS1C can operate on the infrastructure provided. The maximum lateness is 42 seconds well below the Network Rail recommendation of less than 300s.

This concludes that it is feasible to operate the TSS1C with the infrastructure provided.

4.2 Normal perturbed operation (by main service groups)

This section provides lateness and punctuality results for the line of route of each of the main service groups. The left-hand axis refers to the average lateness bar graphs while the right-hand axis refers to the punctuality line graph. The three different perturbations are shown in blue (small) orange (medium) and purple (large). The x-axis describes the location at which delay is measured and shows the number of trains passing the location during the modelled peak hour.

4.2.1 DART+ Northbound

The performance results for this service group are shown in Figure 4-1.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality.

For the medium perturbation (orange) the services start from Greystones and Bray with just over 1 minute average lateness. These services continue to accumulate delay along their route even beyond the turnback of the Clongriffin and Malahide services arriving into Drogheda with over 5 minutes of average lateness.

For the large perturbation (purple) we see a similar behaviour to the medium distribution however although the average delay is the same the increased maximum lateness value highlights the impact of more secondary delays where trains delay each other more significantly.

The propagation of lateness shows how accumulated delay is tied to the structure of the timetable and network where services are following behind each other with no opportunity to overtake. It also highlights a trigger point at which the primary delays along the route and their secondary delay impact become greater than the amount of recovery time inherent in the running times. This level of delay will inform any signaller / control room interventions.

For the operation of the network with either a medium or high level of perturbation it would be recommended to intervene to the timetable operation to recover some of the lateness by cancelling or turning back services.

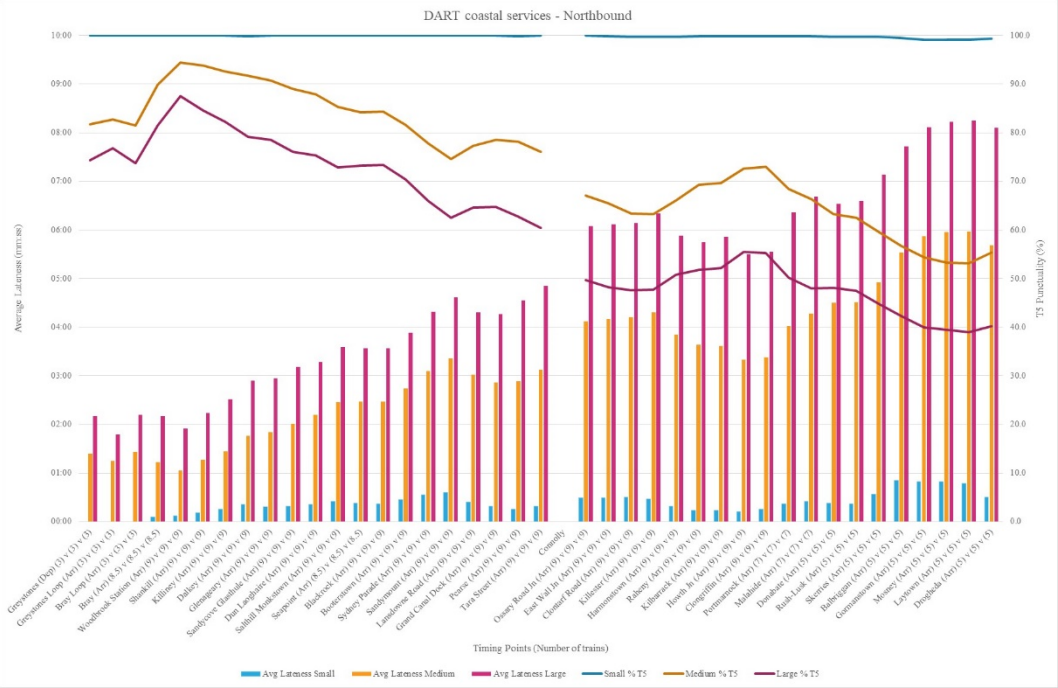


Figure 4-1. Performance results DART+ Northbound

The turnround time at Drogheda allows trains to recover from an average lateness of over 5 minutes on arrival to just over 1 minute on departure demonstrating the value of longer turnrounds at this location.

4.2.2 DART+ Southbound

The performance results for this service group are shown in Figure 4-2.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality.

For the medium perturbation (orange) the services start from Drogheda, with over 1 minute average lateness. These services continue to accumulate delay along their route as the Malahide and Clongriffin services join the route arriving into Bray with just over 4 minutes of average lateness. Access to the single line section to Greystones causes a further increase in lateness.

For the large perturbation (purple) we see a similar behaviour to the medium distribution however although the average delay is the same the increased maximum lateness value highlights the impact of more secondary delays where trains delay each other more significantly.

For the operation of the network with either a medium or high level of perturbation it would be recommended to intervene to the timetable operation to recover some of the lateness by cancelling or turning back services.

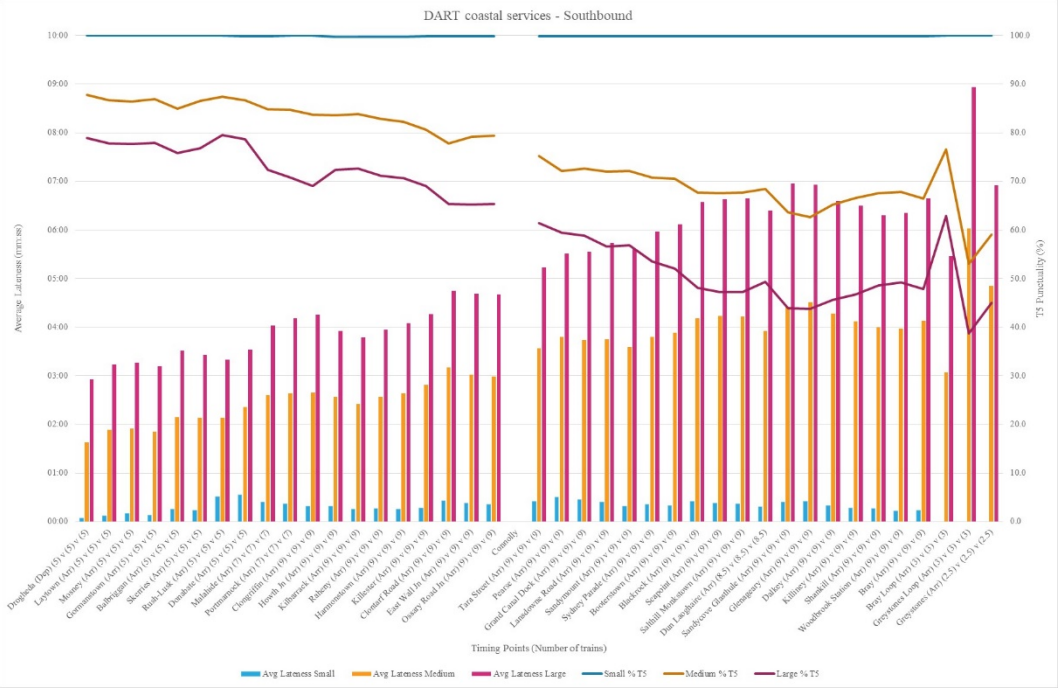


Figure 4-2. Performance results DART+ Southbound

The turnround time at Bray allows trains to recover from an average lateness of over 4 minutes on arrival to just over 1 minute on departure demonstrating the value of longer turnrounds at this location.

4.2.3 Express Northbound

The performance results for this service group are shown in Figure 4-3.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality.

For the medium perturbation (orange) the services start from Connelly, with about 30 seconds average lateness. These services are able to merge between potentially late running DART services at East Wall Junction and run in line with them until Drogheda. The services accumulate delay along their route as the Malahide and Clongriffin services leave the route arriving into Drogheda with about 2 minutes 30 seconds of average lateness.

For the large perturbation (purple) we see a similar behaviour to the medium distribution but with a greater impact of secondary delays.

These express services have more recovery time in their timings where they are not stopping at all stations helping to maintain performance.

For the operation of the network with a high level of perturbation it is expected that measure to improve the performance of the DART service from the south would improve these services too as the lateness is caused by secondary delays.

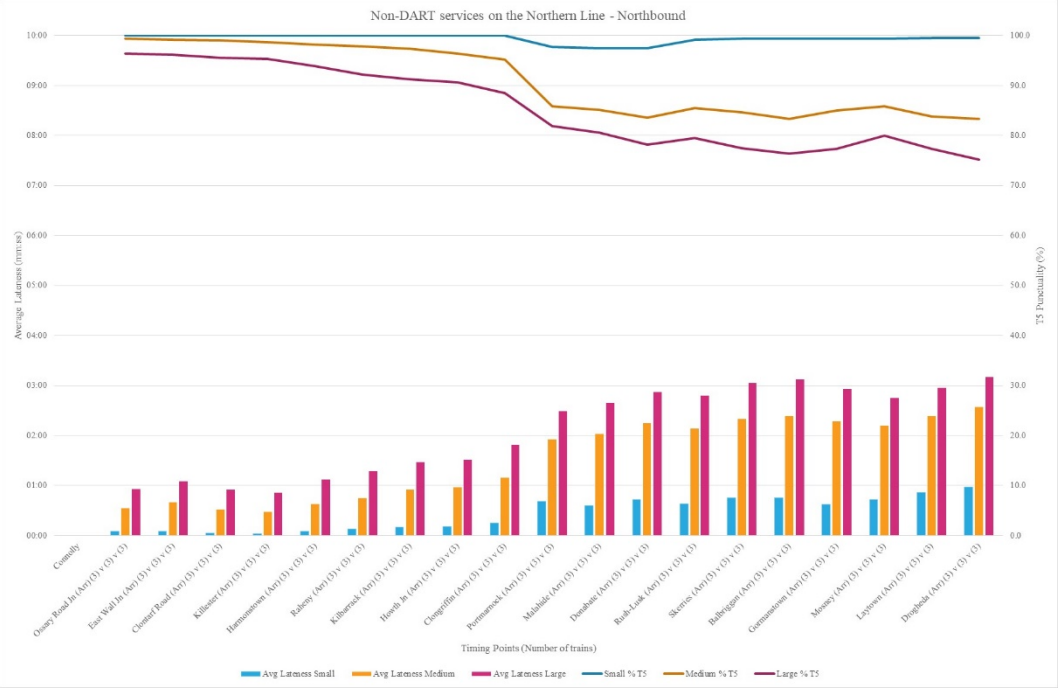


Figure 4-3. Performance results Express trains Northbound

The northbound average lateness of about 2 minutes 30s at Drogheda could impact of services timing to Dundalk and Dublin.

4.2.4 Express Southbound

The performance results for this service group are shown in Figure 4-4.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality.

For the medium perturbation (orange) the services start from Drogheda with just under 1 minute average lateness. These services are able to merge between potentially late running DART services at Drogheda and run in line with them until East Wall Junction. The services accumulate delay along their route as the Malahide and Clongriffin services join the route arriving into Connolly with less than 2 minutes of average lateness.

For the large perturbation (purple) we see a similar behaviour to the medium distribution but with a greater impact of secondary delays.

These express services have more recovery time in their timings where they are not stopping at all stations helping to maintain performance.

For the operation of the network with a high level of perturbation it is expected that measure to improve the performance of the DART service from the south would improve these fast services too as the lateness is caused by secondary delays.

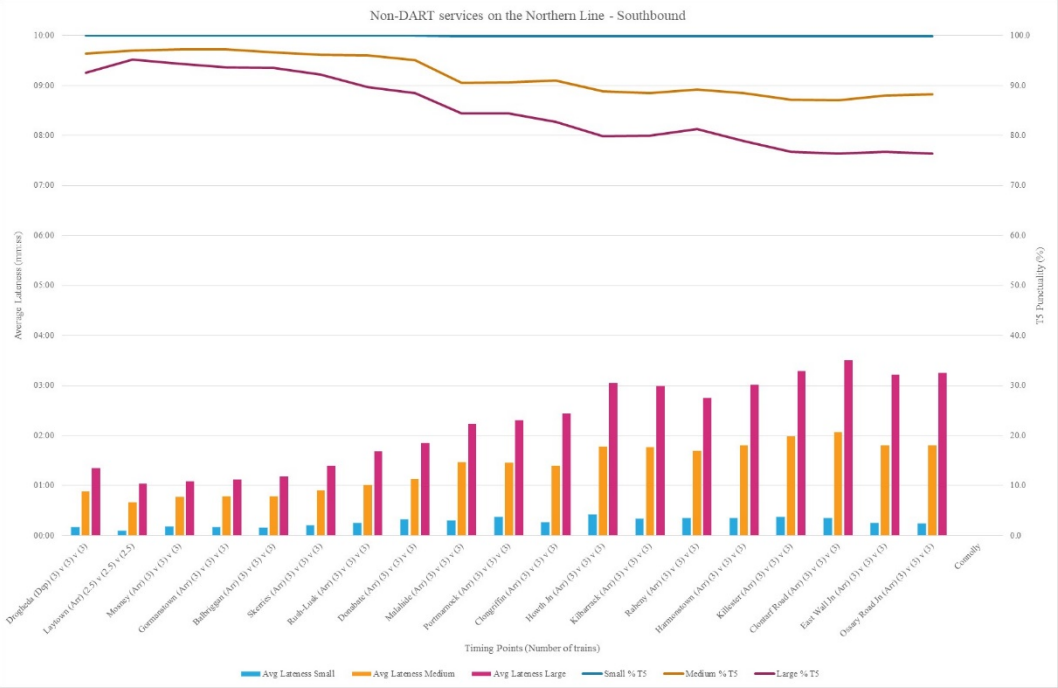


Figure 4-4. Performance results Express trains Southbound

Modelling assumes that southbound services from Dublin and Dundalk enter the modelling area broadly on time.

4.2.5 Howth Eastbound and Westbound

The performance results for this service group are shown in Figure 4-5 (Eastbound) and Figure 4-6 (Westbound).

The independent operation of the Howth branch provides isolation from accumulating delays on the main line. In all three perturbation options the level of delay build up is minimal and the large turnround recovery on the two platforms at Howth is easily sufficient to recover any lateness.

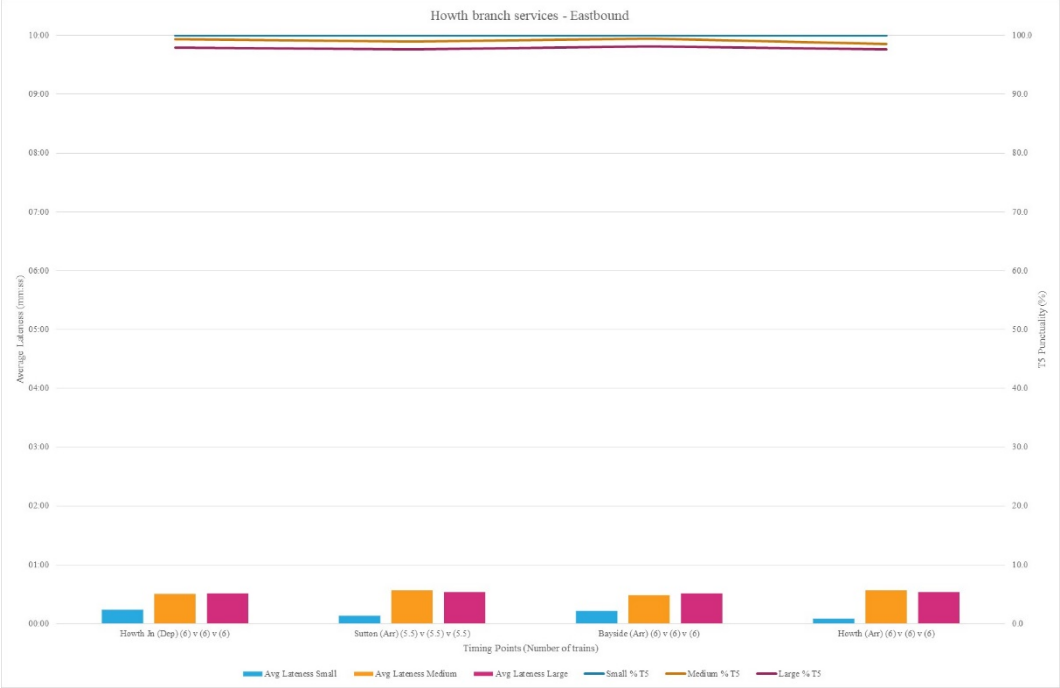


Figure 4-5. Performance results Howth branch Eastbound

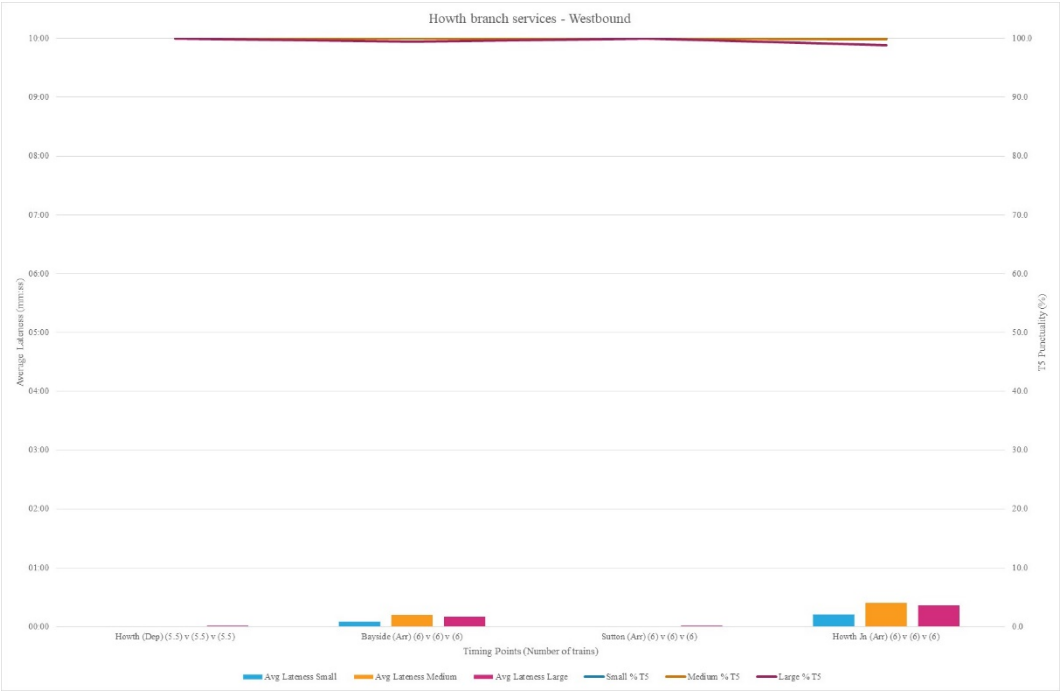


Figure 4-6. Performance results Howth branch Westbound

4.3 Normal perturbed operation (by turnround groups)

4.3.1 Trains turning round at Greystones

The performance results for this service group are shown in Figure 4-7 for terminating trains and in Figure 4-8 for trains starting at Greystones.

Three services per hour turn round at Greystones, two starting at Drogheda and one starting at Clongriffin.

For the small perturbation (blue) the services can recover lateness along the line of route and maintain a good level of punctuality. There is no knock-on effect on the single-line section between Bray and Greystones

For the medium and large perturbation, a high level of delay can be seen between Bray and Greystones. This is aggravated through the high occupancy rate of the single-line section between Bray and Greystones even

under normal operations, acting as a bottleneck under bigger delay and causing secondary delay to arriving and departing trains. Both perturbations show similar trends, with the large perturbation experiencing more delay than the medium perturbation. These services have the longest route and are therefore more impacted by the accumulation of delay.

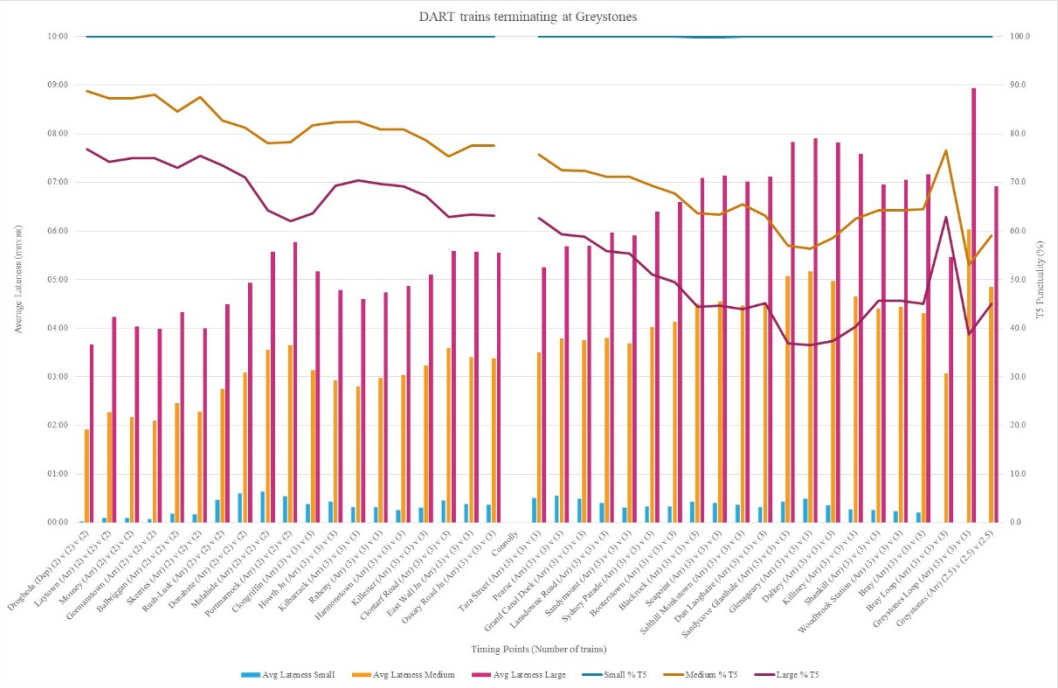


Figure 4-7. Performance results for trains terminating at Greystones

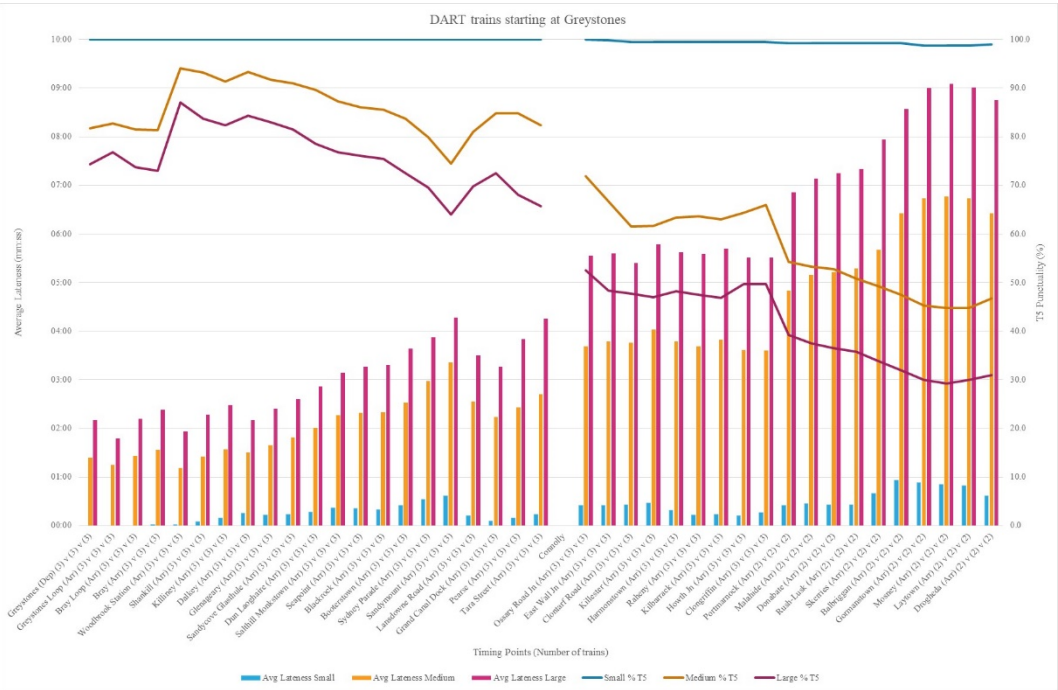


Figure 4-8. Performance results for trains starting at Greystones

4.3.2 Trains turning round at Bray

The performance results for this service group are shown in Figure 4-9 for terminating trains and in Figure 4-10 for trains starting at Bray.

All three perturbations show similar trends on delay and recovery.

For the medium perturbation, the average recovery of lateness is from just under 4 minutes arriving to 1.5 minutes departing. The large perturbation shows a difference from 6 minutes to just under 3 minutes.

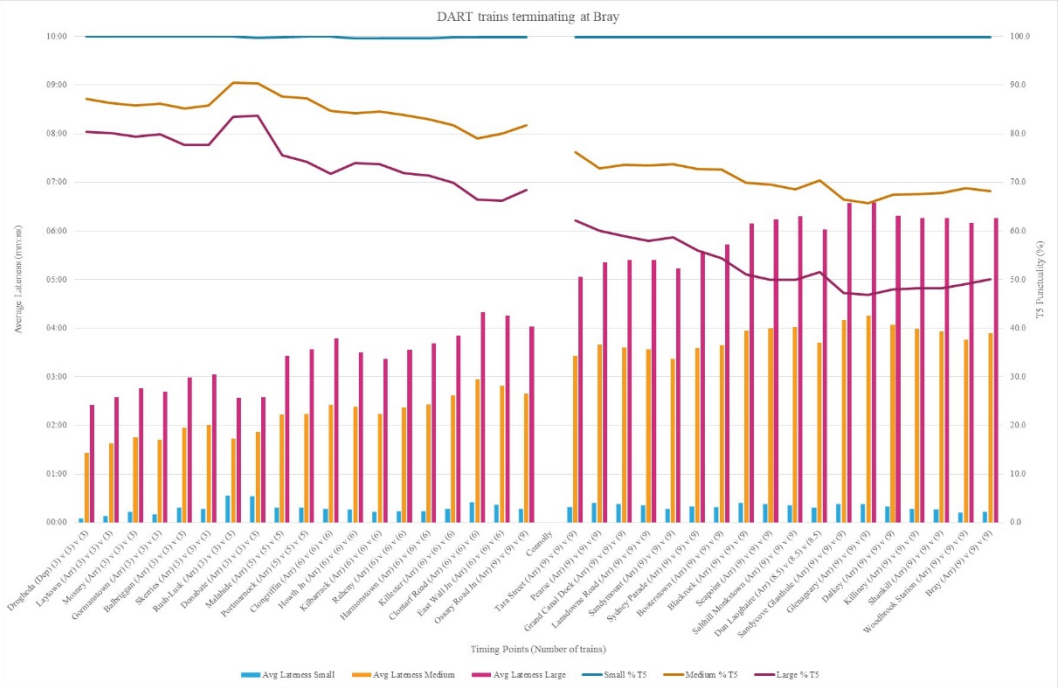


Figure 4-9. Performance results for trains terminating at Bray

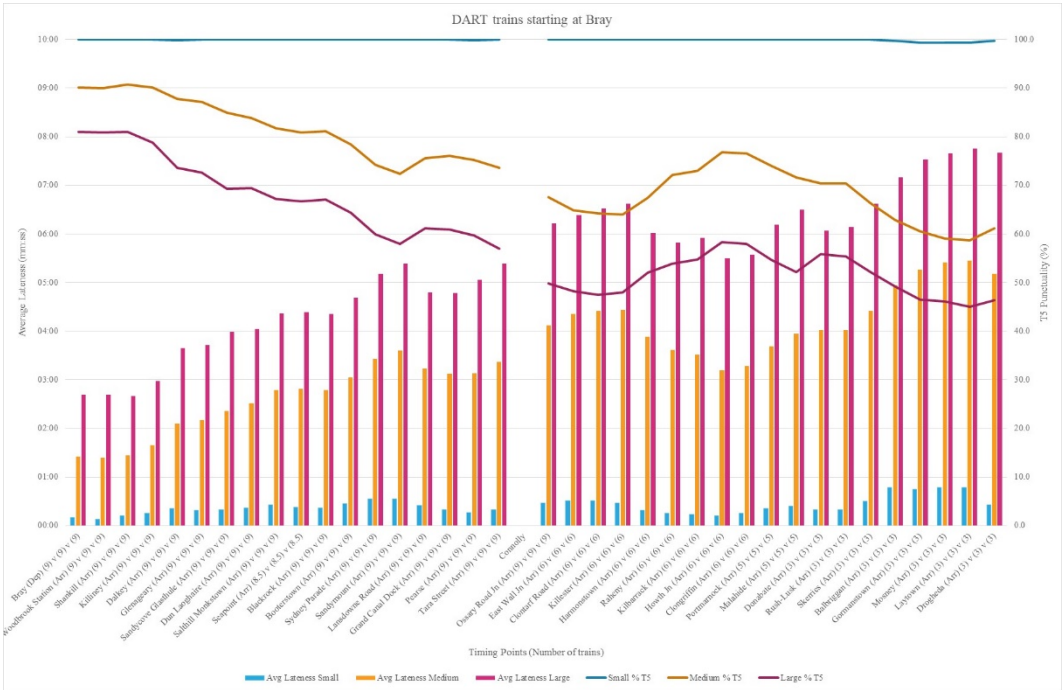


Figure 4-10. Performance results for trains starting at Bray

4.3.3 Trains turning round at Clongriffin

The performance results for this service group are shown in Figure 4-11 for terminating trains and in Figure 4-12 for trains starting at Clongriffin.

Trains terminating at Clongriffin have and average lateness of 2.5 (medium) and 4.5 (large) minutes. In this instance, the departing trains following the turnround in both instances have little delay, which can be attributed to the long turnround times at Clongriffin.

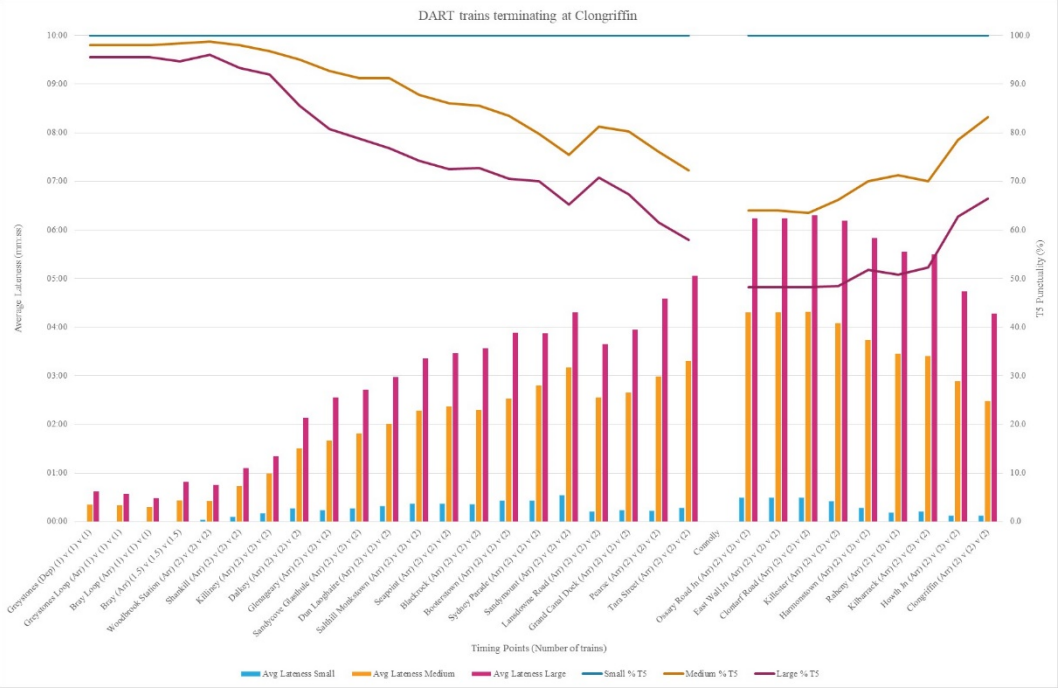


Figure 4-11. Performance results for trains terminating at Clongriffin

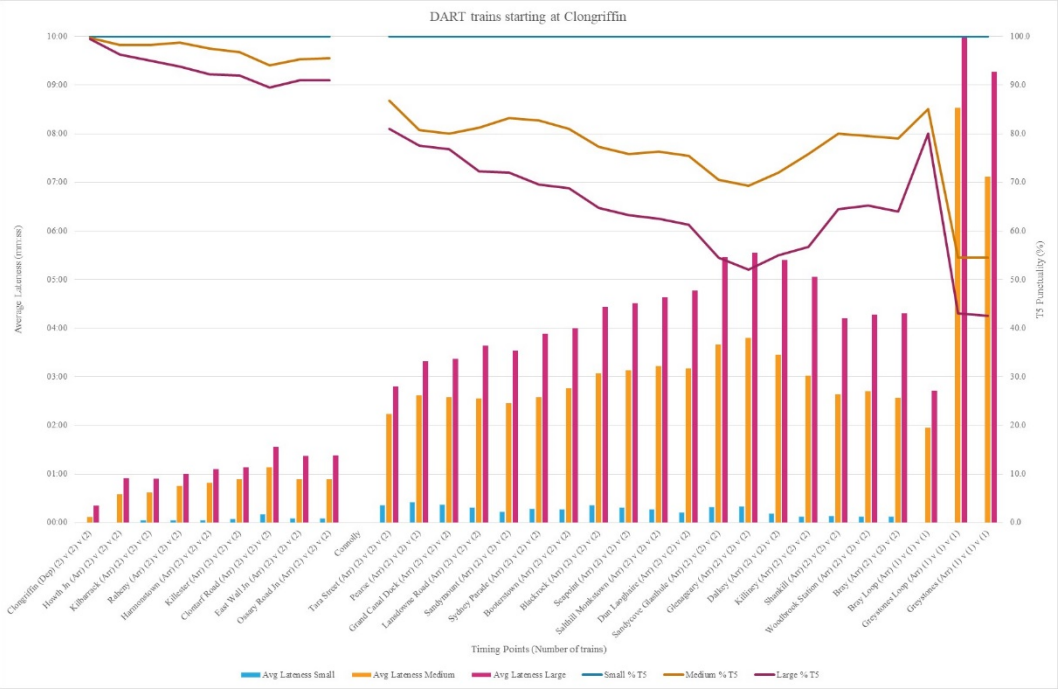


Figure 4-12. Performance results for trains starting at Clongriffin

4.3.4 Trains turning round at Malahide

The performance results for this service group are shown in Figure 4-13 for terminating trains and in Figure 4-14 for trains starting at Malahide.

All three perturbations show similar trends on delay and recovery.

For the medium perturbation, the average recovery of lateness is from just under 4 minutes arriving to just under 2 minutes departing. The large perturbation shows a difference from 6 minutes to just under 4 minutes.

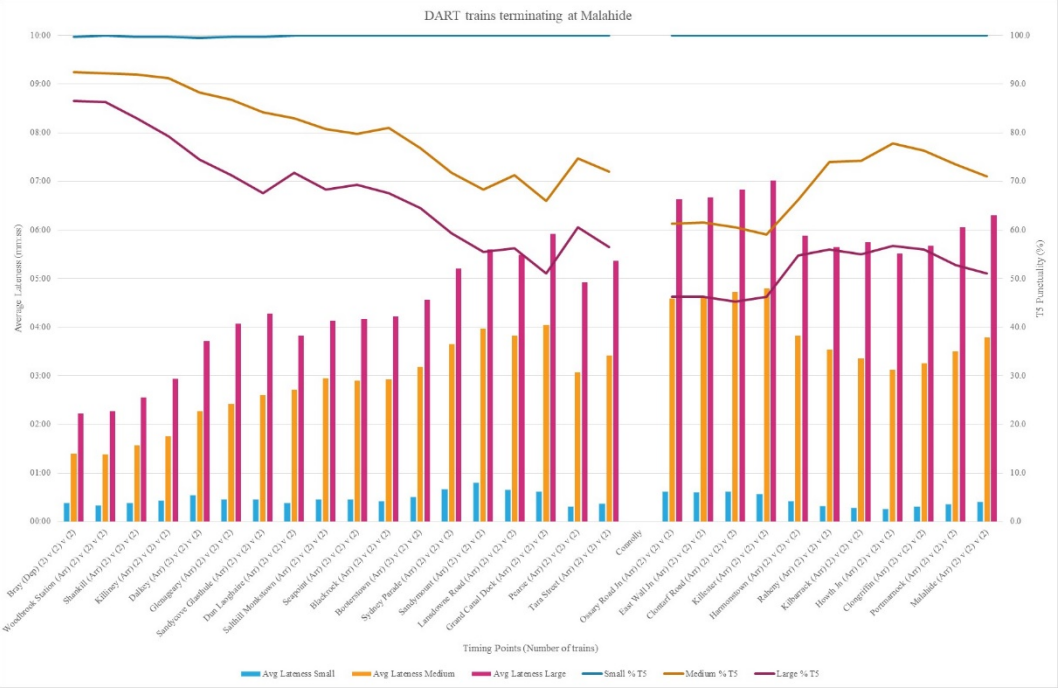


Figure 4-13. Performance results for trains terminating at Malahide

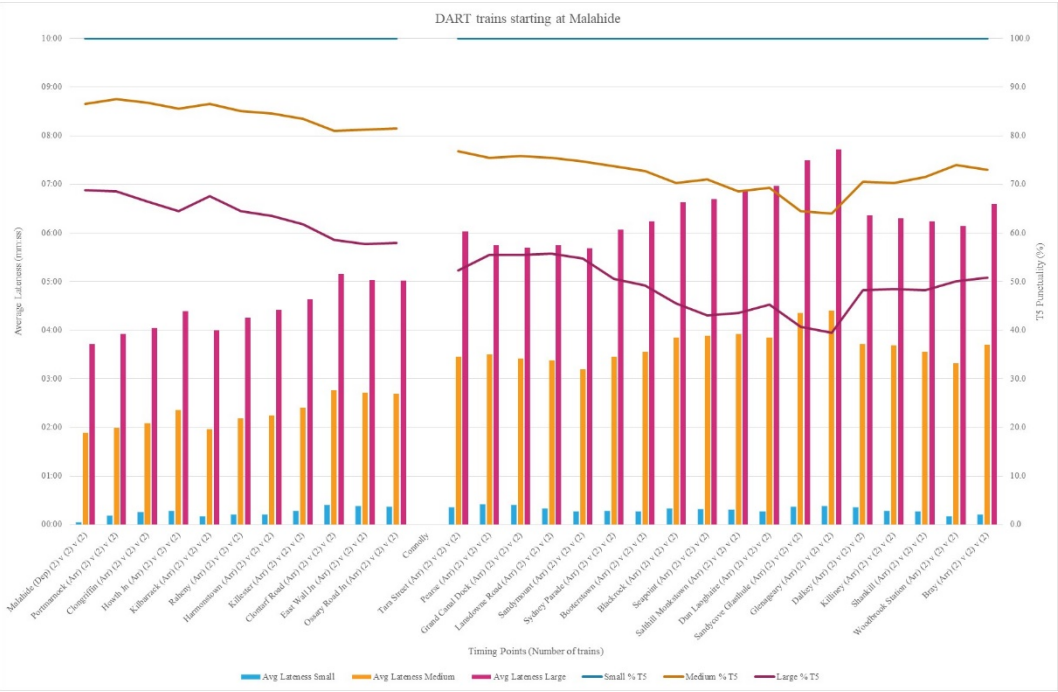


Figure 4-14. Performance results for trains starting at Malahide

4.3.5 Trains turning round at Drogheda

The performance results for this service group are shown in Figure 4-15 for terminating trains and in Figure 4-16 for trains starting at Drogheda.

All three perturbations show similar trends on delay and recovery.

For the medium perturbation, the average recovery of lateness is from just under 5.5 minutes arriving to 2.5 minutes departing. The large perturbation shows a difference from 8 minutes to just under 3 minutes.

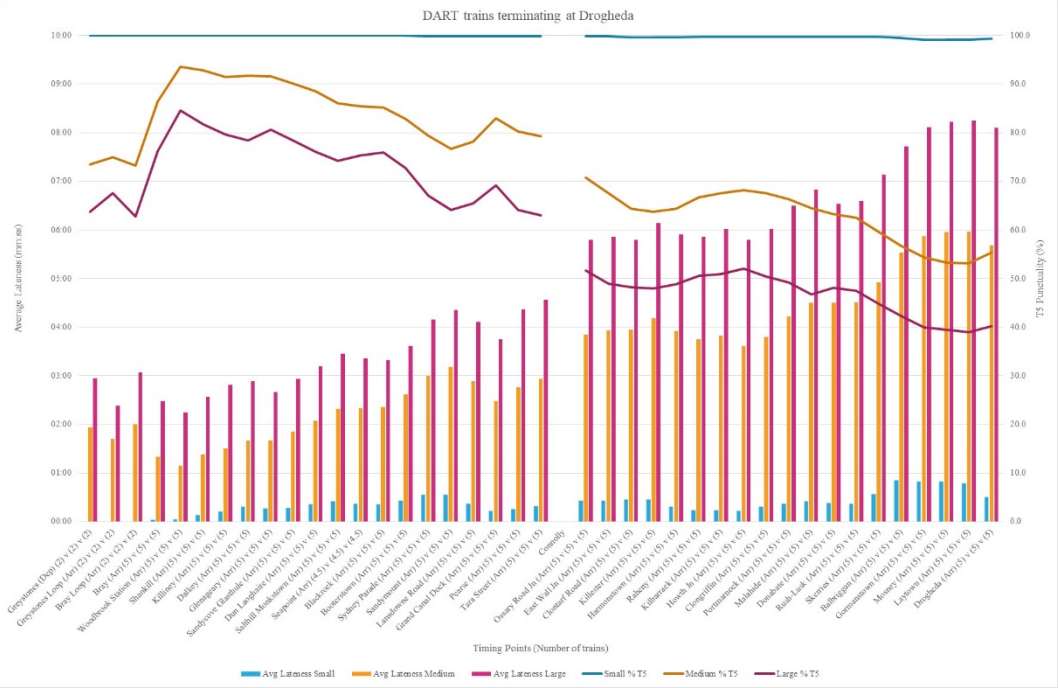


Figure 4-15. Performance results for trains terminating at Drogheda

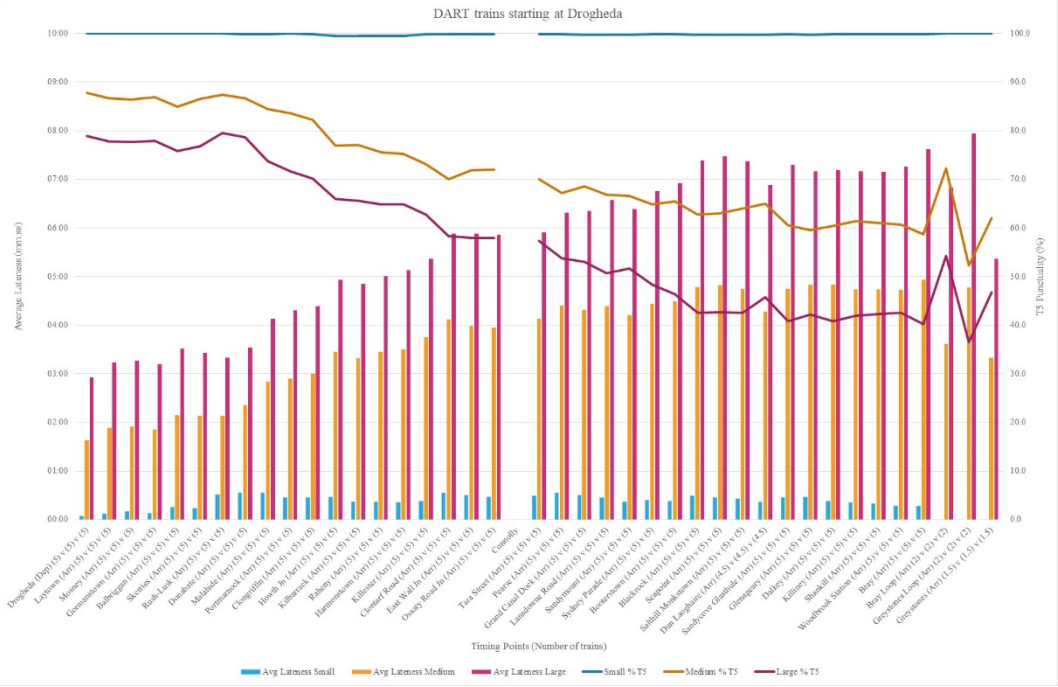


Figure 4-16. Performance results for trains starting at Drogheda

4.4 Perturbed Operation

During large perturbations or significant incidents the following options could be considered for timetable lateness recovery:

Malahide Turnback – The Malahide turnback is used by 2tph turning back. It is envisaged that a further 2tph late running northbound services could be turned back at this location to allow southbound services to be 'stepped back' and run on-time.

Clongriffin Turnback – Clongriffin platforms 2 and 3 are used by 2tph turning back. It is envisaged that a further 6tph late running northbound services could be turned back at this location to allow southbound services to be 'stepped back' and run on-time.

Connolly – Dublin Connolly platforms 1 to 4 are used by 5tph turning back from the north. It is envisaged that a further 4tph late running southbound services could be turned back at this location to allow northbound services to be 'stepped back' and run on-time.

Dun Laoghaire – Dun Laoghaire has two platforms that are not used for normal timetable operation. It is envisaged that between 4 to 8tph late running southbound services could be turned back at this location to allow northbound services to be 'stepped back' and run on-time.

Bray – At Bray station the 3 turnback sidings are used by 9tph turning back. It is envisaged that should the single line not be available an additional 1tph could be turned back at this location.

This table summarises the turnback locations.

Location	Number of turnback platforms	Number of trains planned to turnback	Average recovery time in turnback	Perturbed operation addition trains to turnback
Drogheda	3	5 tph	~10 minutes	n/a
Malahide	1	2 tph	~3 minutes	2 tph
Clongriffin	2	2 tph	~17 minutes	2 to 6 tph
Howth	2	6 tph	~ 9 minutes	2 tph
Howth Junction	1	6 tph	30 seconds	2 tph
Connolly	7	5 tph	~ 19 minutes	2 to 4 tph
Don Laoghaire	1	0 tph	n/a	2 to 4 tph
Bray	3	9 tph	~7 minutes	1 tph
Greystones	1 (+1)	3 tph	~8 minutes	n/a

There are other elements that will alter how services operate differently from today:

The repeat pattern with frequent services will allow for potentially easier interventions to the timetable during operation, using the above locations to turnback early and restart service on to an on-time path.

The alteration of the timetable and intervention to the rolling stock diagrams will be simplified with the uniform rolling stock fleet for example swapping services between different destinations more easily.

The higher level of service will require a more systematic approach to service intervention, creating a trigger location for given lateness at which point a standard contingency plan for that situation could be implemented. For example, if a southbound service to Greystones is more that X minutes late it should be turned back and Bray and used to form a return northbound Greystones service into an on time path. These plans will need development and review by the operator prior to implementation of the timetable, so signallers and control staff understand how to implement them.

5. Summary and Conclusions

The TSS1C timetable is feasible to operate on the infrastructure with no delay propagation

For the small perturbation the services can recover lateness along the line of route and maintain a good level of punctuality without signaller / control room interventions.

With the medium or large perturbation some signaller / control room interventions would be required to prevent delays from accumulating.

BEMU operation would reduce service recovery at Drogheda.

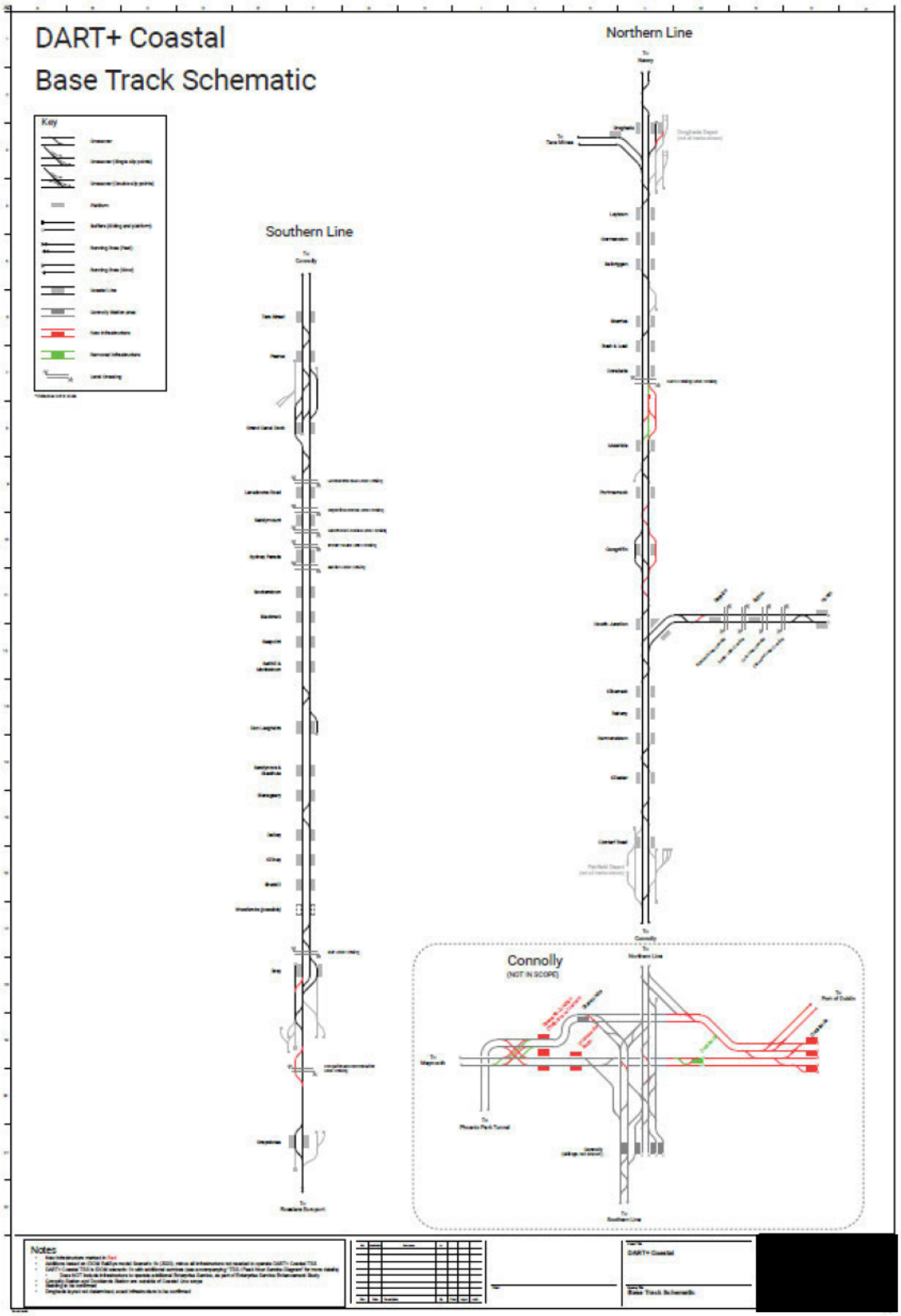
Some caveats should be considered when reviewing this analysis that has followed the approach used for the previous study. It has been undertaken for a standard pattern peak period and therefore does not consider the transition to and from peak service of start and end of service. As the service intensity reduces then the timetable would be expected to be more robust.

The timetable used for the modelling was developed as the theoretical construct which may not fully represent the final timetable implemented. Development of the timetable can consider how to plan turnround recovery at terminal station and the timings of services over flat junctions.

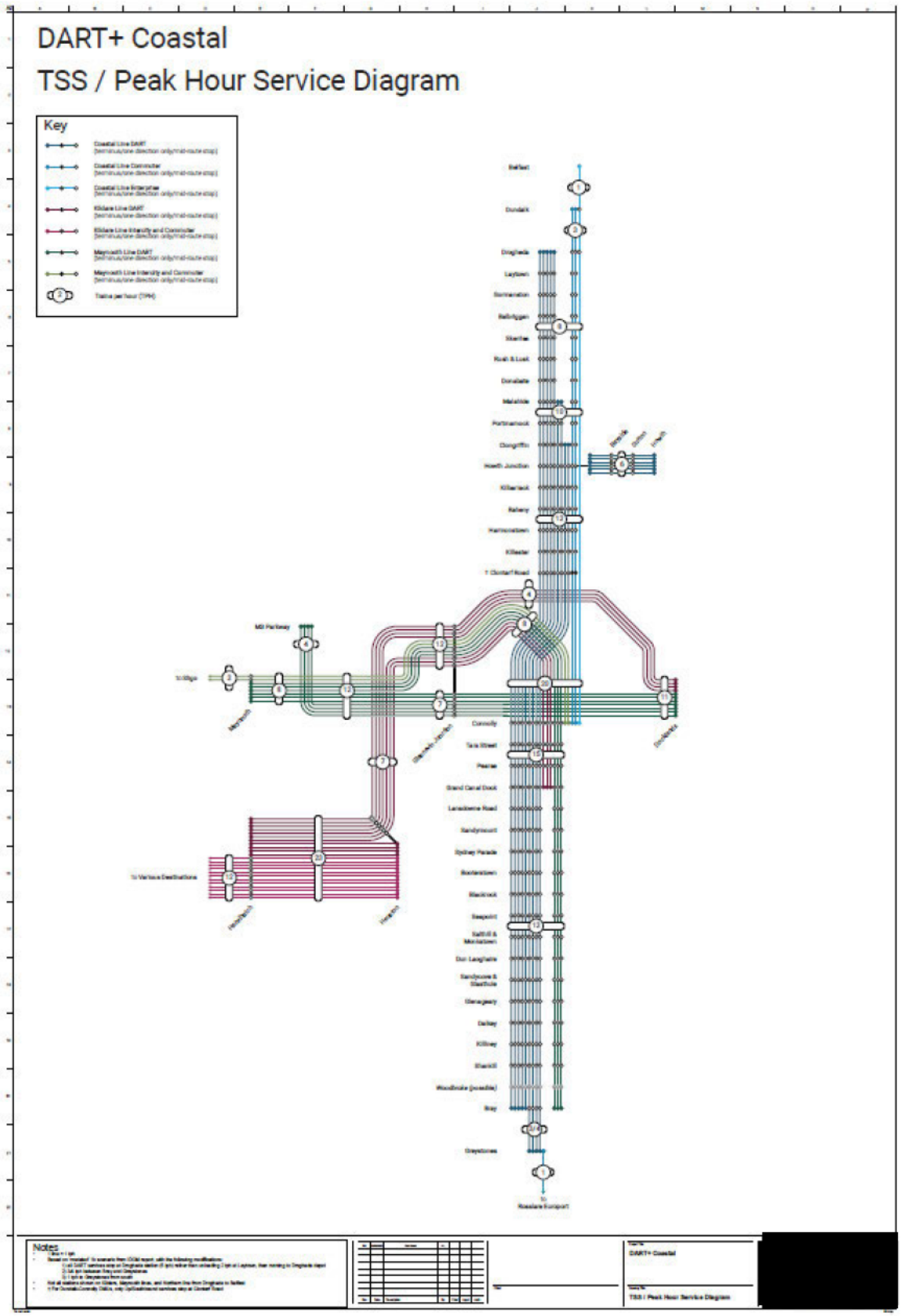
The modelling acts as a robust summary of how a future timetable with a full 20tph intensity at Connolly may behave given a nominal level of perturbation.

Appendix A

A.1 Track Layout Diagram



A.2 TSS1c Service Diagram



ARUP

Iarnród Éireann

DART+ Coastal

BEMU Project- OHLE, HV, SCADA, E&B & ESS Design Package

BEMU B2 Substation - SET Preliminary Design Report

Reference: D+WP56-ARD-P3-BE-RP-HV-000002

P08 | 18 December 2023

For DRN

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 279933-00

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Document Verification

Project title	DART+ Coastal
Document title	BEMU Project- OHLE, HV, SCADA, E&B & ESS Design Package BEMU B2 Substation - SET Preliminary Design Report
Job number	279933-00
Document ref	D+WP56-ARD-P3-BE-RP-HV-000002
File reference	D+WP56-ARD-P3-BE-RP-HV-000002

Revision	Date		
P01	29 April 2022	**Filename**	D+WP56-ARD-P3-BE-RP-HV-000002.docx
		Description	For IÉ review and comment
			Prepared by / **Checked by** / **Approved by**
		Name	[redacted]
		Signature	
P02	27 May 2022	**Filename**	D+WP56-ARD-P3-BE-RP-HV-000002.docx
		Description	Updated based on IE comment
			Prepared by / **Checked by** / **Approved by**
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		Signature	
P03	19 July 2022	**Filename**	D+WP56-ARD-P3-BE-RP-HV-000002.docx
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		Signature	

For DPN

P04	08 September 2022	**Filename**	D+WP56-ARD-P3-BE-RP-HV-000002.docx		
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P07	13 Nov 2023	**Filename**	D+WP56-ARD-P3-BE-RP-HV-000002.docx		
		Description	Updated to reflect that the troughing material may be concrete or GRP will be decided at detailed design		
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P08	18th December 2023	**Filename**	D+WP56-ARD-P3-BE-RP-HV-000002.docx		
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1. Introduction

1.1 Project Introduction

With a view to continued sustainability and seeking to reduce carbon emissions, Iarnród Éireann (IÉ) have placed an initial order for 6 five-car EMUs and 13 five-car BEMUs. The fleet order is one of six separate but complementary projects in the DART+ Programme, which is funded by NTA under the National Development Plan 2021-2030.

The new 1.5kv dc trains suitable for a 1600mm gauge will be 82m-long with capacity for 550 passengers with walk through gangways.

The BEMUs will have an approximate 80km battery range. Energy will be replenished via charging stations at selected terminus locations (namely, Drogheda station) and via regenerative braking. This will allow for emissions to be reduced ahead of the planned electrification of the full DART+ network by the replacement of some diesel services.

For BEMUs to operate successfully, charging facilities are required to recharge the batteries and therefore interventions to the existing rail infrastructure are required to allow stabling the BEMU units, provide charge points, and upgrade works to be carried out to existing depot maintenance facilities.

IÉ have identified the Northern Line as the most suitable route for potential BEMU deployment, with Drogheda Station and depot area as the preferred charging station location. The trains will run utilising the existing overhead line equipment south of Malahide and run-on battery power between Malahide and Drogheda where they will be charged.

The provision of these BEMUs will allow for the possibility of running enhanced services on the network in advance of the full electrification.

The DART+ Programme is a series of projects that will create a fully integrated metropolitan area DART network for Dublin by developing and enhancing the three existing main routes – the Maynooth Line, Kildare Line and Northern Line - through electrification and potential re-signalling. Works are also required on the Southern Line to ensure that the required capacities can be achieved.

Overall, the DART + programme consists of 7 work packages:

- Work Package 1 – DART+ Fleet – Purchase of additional trains to support new and enhanced DART Services.
- Work Package 2 & 3 – DART+ West – New DART service to Maynooth / M3 Parkway on the Maynooth / Sligo line.
- Work Package 4 – DART+ South West – New DART service to Hazelhatch on the Kildare Line.
- Work Package 5 – DART+ Coastal North – New DART services between Dublin City Centre and Drogheda on the Northern Line.
- Work Package 6 – DART+ Coastal South – Enhanced DART services to Bray / Greystones on the south-eastern line.
- Work Package 7 – DART+ Underground (long-term objective).

Arup are the Multi-Disciplinary Consultant (MDC) for the DART+ Coastal project which consists of the Northern Line (Work Package 5) and the Southern Line (Work Package 6). The scope of works for these packages are:

- Northern Line: This comprises circa 38km of electrification to Drogheda with associated bi-directional re-signalling, demolition, and re-construction of a number of bridges and depot upgrades/modifications at

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Fairview and Drogheda to cater for Battery Electric Multiple Units (BEMUs) and Electric Multiple Units (EMUs) and turnbacks.

- Southern Line: This entails work to ensure that capacities can be achieved. This includes level crossing removal, turnback facilities and stabling, and increases to line capacity of the Bray-Greystones section.

Notwithstanding the overview above, this document is only concerned with the BEMU elements of the Northern Line package which are being progressed by IÉ as a standalone project in advance of the Northern and Southern Line packages.

For the BEMU infrastructure works, Arup are responsible for delivering Phases 3 to 5a to Iarnród Éireann (Irish Rail). This consists of preliminary design and statutory process – including reference design (Phases 3 & 4) and detailed design and tender preparation (Phase 5a).

Arup are delivering all the engineering, planning application, safety assurance, PSDP and Environmental services for the project.

1.2 Purpose of the Document

The purpose of this document is to present the proposed solution for the substation compound to be located in the Marsh Road car park of Drogheda Station, in relation to SET works. Specifically, this includes both the electrical substation and the OCR associated with the BEMU charging station.

In lieu of the final electrification and other works to Drogheda Station being undertaken, the BEMU infrastructure will operate as a temporary stabling/charging facility to be implemented during the interim phase of operations. On this basis the content of this report is limited to the technical aspects of this section of the Works only.

The proposal is that the substation and associated equipment for the charging of the BEMUs will be located within a compound in the Marsh Road car park.

Power for the compound will be delivered from an existing feeder cable to an ESBN substation within the car park. From here power will be provided to the charging equipment located within containers in the compound. From the substation, cabling - in ducts and a troughing route - will be provided to power the overhead charging in the station. GRP or concrete trough may be utilised for the route on the embankment adjacent to the viaduct abutment. The selection of the trough material will be subject to an evaluation during the detailed design phase. The design of the troughing route is covered in package B3 *Charging Road – OLE and Lineside Civils*. This package covers only the Marsh Road substation compound.

1.3 Related Documents

The table below lists out the design documents that are related to this report.

Table 1: Related design documents.

Name	Code	Description
Drogheda BEMU Charging Station Single-Line Diagram	D+WP56-ARD-P3-BE-DR-HV-000003	Drawing. 1 page.
SCADA Architecture of the BEMU Charging Station at Drogheda	D+WP56-ARD-P3-BE-DR-HV-000002	Drawing. 1 page.
BEMU B2 Substation –Technical Specification of Electrical Equipment	D+WP56-ARD-P3-BE-SP-HV-000001	Document containing technical specification.
EARTHING SYSTEM ARRANGEMENT AT DROGHEDA BEMU SUBSTATION	D+WP56-ARD-P3-BE-DR-HV-000004	Drawing. 2 pages.

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Name	Code	Description
OCR FOR BEMUS CHARGING - DROGHEDA STATION - LAYOUT	D+WP56-ARP-P3-BE-DR-EL-000001	Drawing. 1 pages.
OCR FOR BEMUS CHARGING - DROGHEDA STATION - CROSS SECTIONS	D+WP56-ARP-P3-BE-DR-EL-000002	Drawing. 4 pages.
OCR FOR BEMUS CHARGING - DROGHEDA STATION – OCLZ AND CCZ	D+WP56-ARP-P3-BE-DR-EL-000003	Drawing. 4 pages.

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2. Project Details

2.1 Power Supply from ESBN

The power supply to the BEMU charging substation will be delivered from an existing feeder cable to an ESBN substation at the south end of the Depot maintenance building. The cable within the car park, which is buried and whose voltage level is 10 kV.

The existing 10 kV power supply currently serves the depot located at Drogheda from Mornington Road substation via a looped supply and passes through the Marsh Road car park. After the implementation of the BEMU charging station, the 10 kV power supply will supply both the BEMU charging facilities and the electrical installation of the depot.

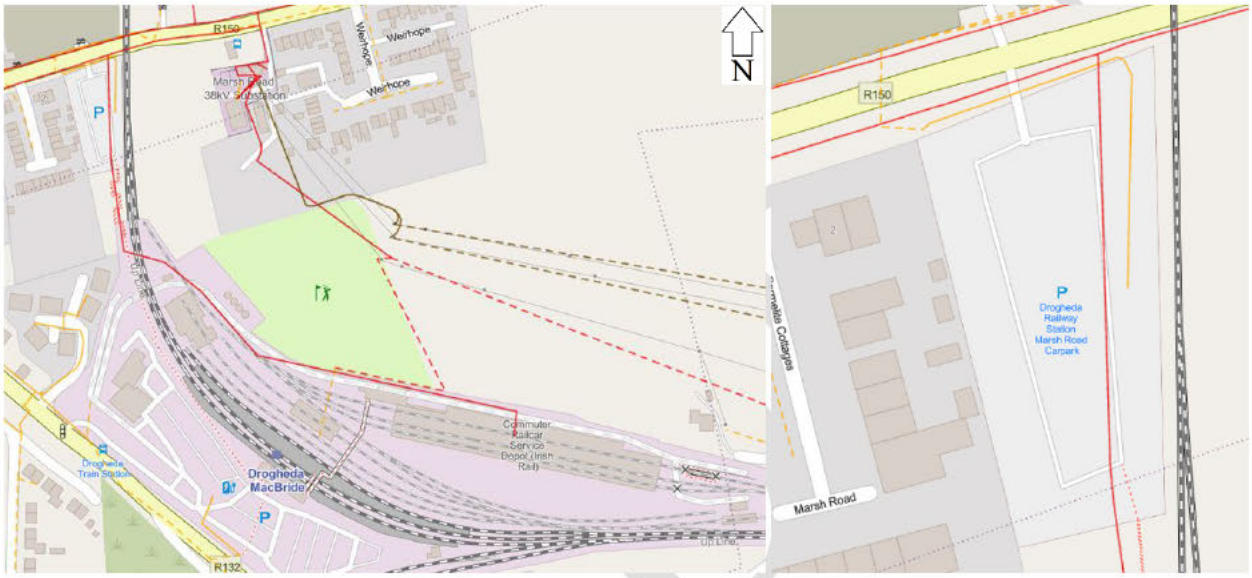
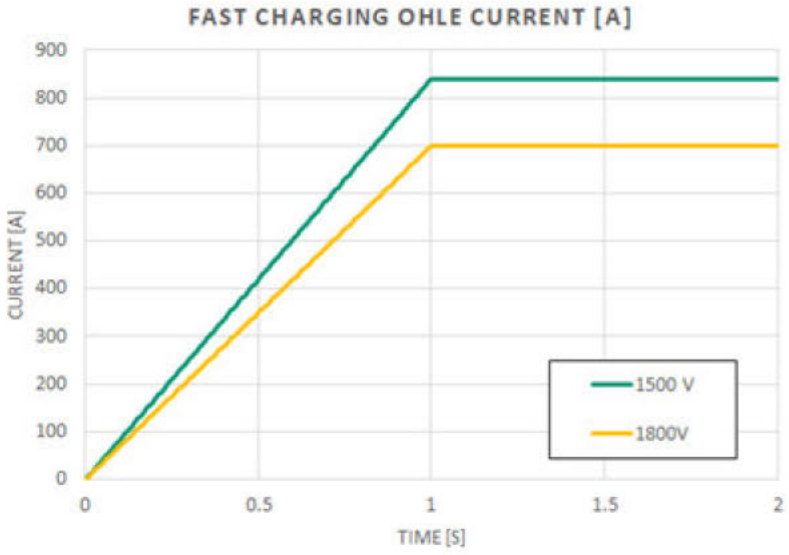


Figure 1: Layout of the existing 10 kV ESBN power supply to the depot at Drogheda (solid red lines: MV Network Objects – Underground Electricity Cables).

2.2 BEMU Electrical Parameters

According to the information provided by Alstom, the designated manufacturer of the BEMU, the on-board battery charger loading profile for a Half Length Unit (HLU) is as follows:



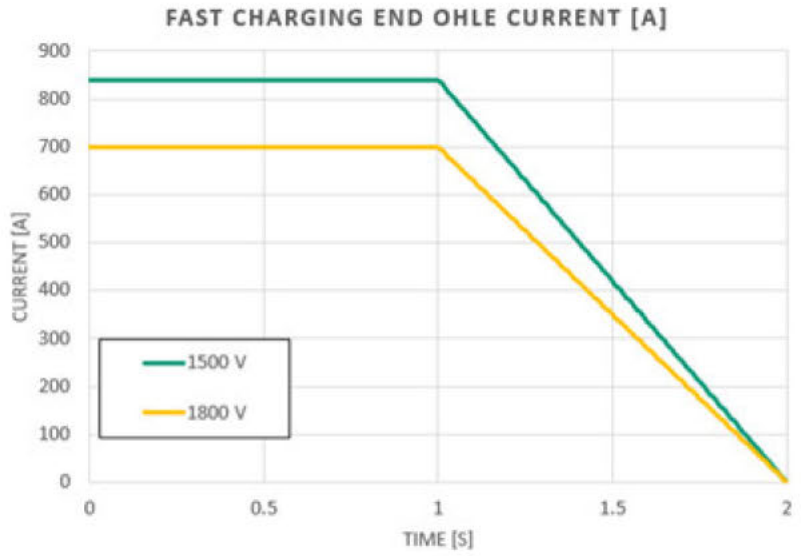


Figure 2: HLU charging profile.

Accordingly, 2xHLU consumes 1600 A during the charging process.

Some other relevant data on the HLU received from Alstom is the following:

- HLU battery capacity: 840 kWh +/- 5%
- C-rate: from approximately 1,3 (battery fully discharged) to around 0,2 (battery almost fully charged)
- Lifetime: 9 years
- BEMU batteries environmental and operational parameters: as per EN 50125, category T1:
    - Temperature range: -25°C; +40°C

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3. Design Criteria and Design Statement (Charging Station)

3.1 General

The design provided follows best industry practice. Reference should be made to Sections 3.3 and 3.4 of this report with respect to applicable Standards.

The BEMU charging station is not in line with HV FRS drawing "MAY-MDC-HVP-DART-DR-E-0002" Sheet 1 of 1 — the design does not correspond to that one specified in the HV FRS for traction substations.

3.2 Applicable Design Standards

The table below lists out the applicable standards that will be used to develop the design.

Table 2: Applicable design standards.

Source	Description	Comments
IÉ	I-ETR-4003 Electrification Standard I-ETR-4009 principles of Traction Bonding I-ETR-4004 Clearance Requirements for DC 1500V Electrified Lines I-ETR-4703 Earthing and Bonding Guidelines I-ETR-4005: Stray Current Control Measures for 1500v DC Electrified Lines	
IÉ	I-SIG-2271 Procedure for Cable Route Installation	
ESB	Construction Standards for MV Substation Buildings	Used in Building and equipment for ESB.
BS	Cables and Wiring	
IS	National Rules for Electrical Installation	
EN	Structures (Steel & Concrete) Geotechnical Railway Fixed Installations (equipment, earthing and bonding, EMC) Cables LV Installations	
IÉ	Electricity Functional Specifications System-Wide (Final) MAY-MDC-ELE-DART-SP-E-0002	The applicable standards considered in this FRS are to be used.

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Source	Description	Comments
	IDOM	
IÉ	Telecoms Functional Specifications System-Wide (Final) MAY-MDC-TEL-DART-SP-Y-0001 IDOM	The applicable standards considered in this FRS are to be used.
IÉ	I-PWY-1101 Requirements for Track and Structures Clearances	

3.3 Design Criteria

The design criteria for the preliminary design for the BEMU charging station are based on (but not necessarily corresponding to) those established in the *Electricity Functional Specifications System-Wide* MAY-MDC-ELE-DART-SP-E-0002 (Electricity/HV FRS).

Some the most relevant design criteria and technical standard are elaborated below. The same applies to the technical standards.

In those cases where there are relevant deviations in the design criteria from that established in the HV FRS, it will be indicated as such in the corresponding part in of this Section. The deviation will then be elaborated in the corresponding part in Section 3.4.

3.3.1 Ambient Temperature Range

Ambient temperature range of -**20°C** to +**40°C** is considered for sizing of the equipment in the BEMU charging station.

3.3.2 Voltage and Frequency

The voltage and frequency of the energy subsystem for the DART+ shall be 1,500 VDC aligned with ENE-TSI 4.2.3 section (1) subsection (d) ***[U26]***. The values and limits of the voltage shall comply with EN 50163:2004 clause 4 aligned with ENE-TSI 4.2.3 section (2).

3.3.3 Medium Voltage section

3.3.3.1 MV Switchgear

The BEMU charging station will require MV switchgear to connect and isolate incoming feeding from the MV network. The BEMU charging station will be equipped with the following:

- Incoming MV switchgear (ESB incoming in MV)
- Traction Transformer MV switchgear
- Auxiliary Transformer MV switchgear

Each circuit breaker will include the following:

- Cable connection box
- Withdrawable circuit breaker
- Busbar bar
- Set of measuring transformers
- Control and protection box

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Each MV switchgear be operated from the following possibilities ***[U1422]***:

- Remotely from the NTCC or CTC via the SCADA system and the local control and monitoring system
- Locally from the MV switchgear

The MV switchgears shall be provided with an integrated earthing switch in the cubicle. This integrated system shall provide at least (but not limited to) the visibility of the contacts and the reliable mechanical indication device as the two methods recognised by the IEC standard 62271-102.

3.3.3.2 Power Transformer

The BEMU charging station will be composed of a 3.3 MVA 10kV / 2x1.1kV traction transformer, dry type (10kV), with a primary winding voltage of 10kV and two secondary windings star delta, each with a voltage of 1.1kV (1.5 kV DC).

Each transformer will be suitable to be connected to a 12-pulse rectifier.

Relevant deviations in the design criteria from that established in the HV FRS (primary voltage and duty class – refer to Section 3.6.1).

3.3.3.3 Auxiliary Transformer

The BEMU charging station will be composed by one auxiliary transformer 10kV / 400V AC – 80 kVA to feed the auxiliary loads of the charging station devices.

3.3.3.4 Diesel Generator

The BEMU charging station will include one Diesel Generator 400V AC (80 kVA) to maintain the continuity supply of the auxiliary loads of the charging station devices in the event of loss of the main supply.

Ducting and ancillary equipment in the Diesel Generator Room shall comply with Irish Building regulations, BS 5588 SERIES Fire precautions in the design, construction, and use of building and National Standard Authority of Ireland (I.S. 3217: 1989 Code of practice for emergency lighting, I.S. 3218: 1989 Fire Detection and Alarm Systems).

3.3.4 Low Voltage section

The charging station Low Voltage (LV) voltage section will comprise of the following:

- For charging station, the LV section consists of one auxiliary transformer 10 kV / 400V AC, 80 kVA, supplying the Main LV 400/230V AC panel. This is a relevant deviation in the design criteria from that established in the HV FRS (primary voltage – refer to Section 3.6.5).
- The Main LV 400/230V AC panel is also backed-up by the Diesel Generator in case of a loss of power.
- Main LV 400/230V AC also feeds the two separated essential panels: Essential 400/230V AC and Essential 110V DC panels that feed the critical loads.
- The Essential 400/230V AC panel is fed by the UPS and Battery charger that is provided with a redundant feeding in AC from the Main LV 400/230V AC panel and incorporates a maintenance bypass switch.
- The Essential 110V DC panel is fed by two redundant Battery chargers, each of them with a dedicated supply from the Main LV 400/230V AC panel.

OHLE MOS will be fed from the Essential 400/230V AC or 110V DC panels at the charging station (depending on the OHLE MOS manufacturer). Should the distance between the OHLE MOS and the charging station constraint by the cabling size, an alternative supply might be studied (subject to IÉ SET

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Department) from the nearest location cabinet. LV power distribution for MOS design shall comply with I.S. 10101.

3.3.4.1 Main LV 400/230V AC Panel

The Main LV 400/230V AC Panel will be supplied by the charging station auxiliary transformer and have back-up from the diesel generator to guarantee availability of the power supply.

It will supply the 400/230V AC non-essential loads for the charging station and the two separated essential panels (Essential 400/230V AC and Essential 110V DC panels).

3.3.4.2 Essential 400/230V AC panel

The Essential 400/230V AC panel is fed by the UPS and Battery charger that is provided with a redundant feeding in AC from the Main LV 400/230V AC panel and incorporates the maintenance bypass switch. To ensure continuity of power to critical loads, if there is a loss of the main low voltage supply, the traction substation will be equipped with a UPS system with batteries, providing 16 hours of power. ***[U228]***

3.3.4.3 UPS and Battery Charger for the Essential 400/230V AC panel

The system will be installed in metallic cabinets which comprise of:

- A battery charger which maintains a floating voltage and charges the batteries under normal operation.
- A DC/AC inverter which has the function to supply the AC loads when either the battery charger fails or main AC supply fails.

The UPS shall be provided with pass function to facilitate maintenance ***[U1308]***. Batteries shall be VRPP Cd-Ni type.

3.3.4.4 Essential 110V DC panel

The Essential 110V DC panel is fed by two redundant Battery chargers, each of them with a dedicated supply from the Main LV 400/230V AC panel for the critical loads in 110V DC of the charging station.

3.3.4.5 Battery Charger for the Essential 110V DC panel

Batteries shall be VRPP Cd-Ni type.

3.3.5 Charging section

1,500 VDC equipment is insulated from ground by an insulated sheet.

3.3.5.1 Traction Rectifier

The BEMU charging station will be equipped with two 3 MW rectifiers at a nominal voltage of 1,500 VDC each.

The equipment will comprise a naturally air ventilated, freestanding, steel cubicle. Each rectifier comprises of two sections, a rectifier power section, and a control section. Doors to access to the transformer rooms shall have an interlocking to prevent staff from entering the room once the transformers are operational.

Relevant deviations in the design criteria from that established in the HV FRS (Type and Class – refer to Section 3.6.2).

3.3.5.2 Rectifier Breaker

As per HV FRS.

3.3.5.3 Negative Panel

As per HV FRS.

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3.3.5.4 Track Feeder Circuit Breaker

- High speed circuit breaker for each OCR section in accordance with HV FRS.
- Bypass switch for each OCR Circuit Breaker fed from a single redundant backup circuit breaker able to provide backup individually to any of the six OCR circuit breakers

3.3.5.5 Command and Control Rack

As per HV FRS.

3.3.6 Earthing and Bonding

As per HV FRS.

3.3.7 Stray Current Control

As per HV FRS.

3.3.8 SCADA

As per on HV FRS.

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3.4 Design Considerations

3.4.1 Technical conditions of the Power Supply from ESBN

The technical conditions at the Point of Connection to the 10 kV of ESBN are as follows:

Short-circuit level

When fed from normal forward 10 kV feeder:

- 0.293 +j1.396Ohms
- Ph-Ph 3750Amps
- 3Ph 4330Amps

When fed from standby 10 kV feeder:

- 0.402 +j1.462Ohms
- Ph-Ph 3528Amps
- 3Ph 4074Amps

Load change rate restriction

The indicative restrictions for load increase/decrease rate that we have been provided by the network operator is as follows:

Table 3: Indicative rest period between step changes at 10 kV POC.

kW step change (increase or decrease)	Indicative rest period between step changes
1000 kW	~5.5 minutes
750 kW	~160 seconds
500 kW	~40 seconds
250 kW	~5 seconds
…	…

3.4.2 Electrical Parameters of the System

- Voltage variation (±) (TBD) %
- Frequency 50 Hz
- Frequency variation (±) 1%
- Mains network ground TNS / IT
- MV Distribution voltage 10 kV
- MV ground (network isolated, direct, low or high resistance grounded) HRG
- Power factor at MV primary distribution 0.95
- Power factor at LV 0.96
- CB insulation AIR
- Power bars or busbar material Cu and Al
- Switchgear communication interface IEC 61850

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- Low voltage, 3-phase 400 V
- LV 1-phase distribution in specific detached board 230 V
- UPS (CCM, LCP, VFD & DCS) 1ph+N+PE 230V
- Switchgear control & protection voltage 110V DC
- LV switchgear control voltage 230 V-110V DC
- LV switchgear protection voltage (UPS) 110 110V DC

3.4.3 Arrangement of electrical Equipment Within the Containers of the Compound

The definitive equipment arrangement within the containers of the substation compound is to be further validated by the equipment manufacturers, upon which Phase 3 or Phase 5 documentation relative to the allocation of equipment to each container and the arrangement of the equipment within them will be produced.

3.5 Electrical Architecture of the Charging Station

3.5.1 Description of the Electrical Architecture

The electrical architecture of the BEMU charging station has been defined in line with the *BEMU Operation and Charging Concept* D+WP56-ARP-P2-BE-RP-SI-000001, and the *Charging Control Requirements Specification* D+WP56-ARP-P2-BE-RP-SI-000002.

The electrical installation aimed at providing power to the BEMU facilities can be found in *Drogheda BEMU Charging Station Single-Line Diagram* D+WP56-ARD-P3-BE-DR-HV-000003.

In summary, description of the general operating principle of the BEMU charging station is as follows:

- It is intended to charge simultaneously up to 4 HLU's battery trains; two through the charging station directly and two through the Energy Storage System (ESS). The load could be done in any of the 3 charging tracks intended to the load operation.
- Each HLU battery train consumes 800 A during the charging process – Please see Section 2.2 of this report.
- The 18.6 min is the time that it would take for the HLU to recharge, from the state of charge that it is estimated to have when arriving to the charging station, up to full charge.
- The ESS is to be sized to store enough energy to fully charge up to 6 HLU's.

In general terms, the electrical architecture of the BEMU charging station is based on transformer-rectifier unit that transforms that steps down the 10 kV power supply to the BEMU charging nominal voltage (i.e., 1,500 VDC). The power supply to the OCR on the BEMU charging roads is done through a DC switchgear, out of which there are outgoing OCR cable feeders that run all the way from the compound to the charging area.

It is to provide a short-term back up to the power supply to the BEMU charging station during peak hours of the daily operation on the Northern Line that the ESS is included in the electrical architecture of the BEMUs charging station. The ESS is connected to the DC busbar and has dedicated supply and return connections to and from the charging area.

Considering the frequency and duration of the power outages for the 10 kV power supply as informed by ESBN, no back-up power supply at 10 kV is foreseen for the BEMU charging station. However, space provision will need to be made in the MV switchboard for any future backup connection.

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3.5.2 ESS Sizing

The ESS comprises a rack of batteries for energy storage (energy storage unit), as well as a converter that draws the energy into the catenary the DC switchgear (power electronic converter unit).

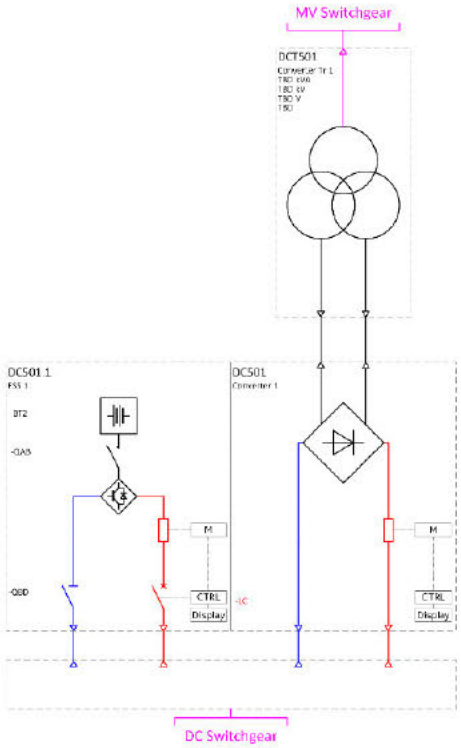


Figure 3: Configuration used for the integration of the ESS (indicative).

In line with the considerations found on *BEMU Operation and Charging Concept* D+WP56-ARP-P2-BE-RP-SI-000001, and the *Charging Control Requirements Specification* D+WP56-ARP-P2-BE-RP-SI-000002, the BEMU is assumed to reach the BEMU charging station at Drogheda with a certain state of charge, which means that not 100% of the battery capacity of the train needs to be recharged, but only a percentage of it. Consequently, the specified ESS useable energy should be derived from the fact that there should be enough capacity to charge within 1 hour (peak hour) up to 6 Half-Length Units forming three trains, one after another.

In addition, the assumptions for sizing and specification of the ESS are as follows:

- Life cycle required ≥ 5 years
- Expected charging cycles through the ESS: 3 charge-discharge cycles/day, one train comprising 2xHLU charged in every charging cycle.
- The recharge of the ESS through the transformer-rectifier follows the load change restrictions at the 10 kV Point of Connection identified in section 3.4.1.

The converter of the ESS is considered to be based on IBGT's, while the energy storage units have been considered to be made of lithium-ion.

This leads to the need use of 4-5 ESS converters in parallel for the ESS, depending on the power rating of the ESS manufacturers, when a lithium-ion chemistry NMC is used (Nickel Manganese Cobalt).

The NMC is one of the various lithium-ion chemistries available in the market. Different chemistries may entail differences in the configuration, size, and the specification of the ESS (both the energy storage unit and the power electronic converter unit), which ultimately translates into different footprint requirements and costs associated to the ESS (which can be quite significant). NMC provides the highest energy density consistent with a reduced and realistic substation footprint and number of functional elements.

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Interaction between the ESS and the TCR

The converter of the ESS is a fully bidirectional DC/DC converter, with a topology that gives flexibility enabling charge and discharge whenever needed (Figure 1). The signals from Thyristor Controlled Rectifier (TCR) – please see Section 3.6.2 of this report – and ESS shall fully utilize the power rating of the transformer-rectifier unit and recharge the ESS batteries as soon as the train operation makes it possible.

The ESS is assumed to be used as a complement for the charge of the BEMU's, when it is done through the TCR, whose power flow is limited by the restrictions for load increase/decrease rate at the Point of Connection to the 10 kV ESB network (please see Section 3.6.2 of this report), so that there is no need to impose restrictions on the BEMU on-board charging control.

Furthermore, the ESS is assumed to have the feature to be recharged not only when it is idle, but also even while it is charging a BEMU. In this regard, three possible cases can be defined from an ESS fully charged condition:

- **Case 1:** In any given hour, 3off 2xHLU trains charged through both TCR and ESS (both systems working simultaneously to overcome the restriction of the load increase rate at the Point of Connection), with resting periods between one train and the next one. Meanwhile, the ESS is being recharged from the TCR during the initial instant of the charging cycle of one 2xHLU train (using the surplus of usable power from the TCR that may result from the load increase rate restrictions at the 10 kV Point of Connection).
- **Case 2:** In any given hour, 3off 2xHLU trains charged through both TCR and ESS (both systems working simultaneously to overcome the restriction of the load increase rate at the Point of Connection), one after the other. Meanwhile, the ESS not being recharged from the TCR (not using the surplus of usable power in the TCR at any point).
- **Case 3:** 3off 2xHLU charged only through the ESS, one after the other, without having the ESS being recharged from the TCR.

Every case above entails different requirements for the ESS battery capacity: Case 3 > Case 2 > Case1.

The feature to have the ESS recharged while a BEMU is also being charged could only be the case during the Normal Operation of the charging station, and not during the Emergency Operation (as defined below):

- **Normal operation:** When the TCR and the ESS are in operation, it is intended to have up to 2off 2xHLU being charged simultaneously; one through the TCR and one through the ESS. – In this scenario, the feature to recharge of the ESS while a BEMU is being charged (Case 1) could be provided in case there is any surplus power available.
- **Emergency operation:** When the power supply though the TCR is not possible (e.g., due to the outage of the power supply from the power grid), the ESS would be operating as a standalone (**Case 3**). In that case, the feature is obviously not possible to be provided, and the provision of enough energy storage capacity for the charging of 3off 2xHLU is to be guaranteed. – It is this scenario that ultimately determines the size of the ESS (worst case approach).

3.6 Technical Description of the Elements of the Charging Station

3.6.1 Power Transformer

The power transformer will be made of a cast resin used for indoor installation with one primary and two secondary windings. The windings will be manufactured in such a way that the process will ensure protection against undesirable gases.

The core will be made of grain oriented low-loss electro-laminations insulated on both sides. Limbs and yokes will be shaped and assembled with a minimum number of core bolts. The Lamination will be joined, compressed, and braced to minimize stray loss and noise. The laminated core will be carefully assembled and rigidly clamped to ensure that it is not damaged during shipment and operation.

The core will be protected against corrosion by a two-component varnish.

The insulating materials used are flame-resistant and self-extinguishing.

The transformer is free of partial discharges up to at least 2 times the rated voltage, and it can withstand short-circuit currents and voltage surges.

The rectifiers are designed to receive a six-phase secondary AC system with a phase shift of 30° to produce the connected diode bridge with a 12 pulse DC output.

Taking the nominal charging rate as a starting point, the converter will be duty class I (in line with the BEMU charging profile – see Section 2.2 of this report).

With duty class I, the rectifier is suitable for a continuous duty, which would be suitable for the constant current charging profile of the BEMU as informed by Alstom. A duty class I rectifier would not necessarily suit a different application that does require overloading capabilities of the rectifier, such as traction power supply.

Considering the above, with a rectifier designed for a duty class I, it may not be reused for conventional traction power purposes at some other location on the DART+ Project.

3.6.2 Rectifier (TCR)

The rectifier will be a controlled Thyristor Controlled Rectifier (TCR) whose load demand from the 10 kV ESBN power supply can be smoothly regulated. The controlled rectifier is able to create the output characteristic according to a pattern saved into memory or according to the instantaneous external reference value. This requirement for the rectifier will ensure compliance with the restrictions for load increase/decrease rate at the Point of Connection to the 10 kV ESB network.

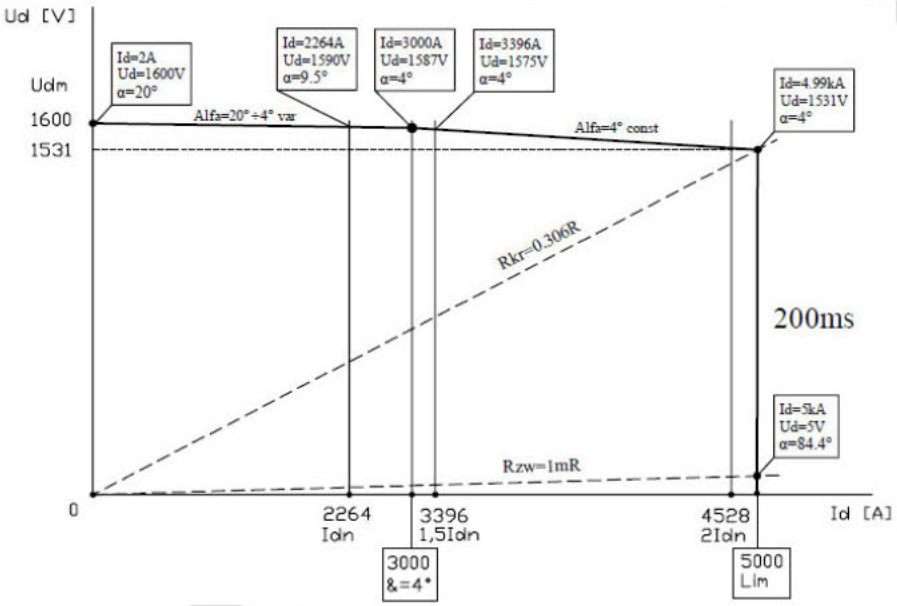


Figure 4: Rectifier output characteristics (indicative).

The rectifier will be naturally cooled, and consist of two three-phase bridges, forming the 12-pulse rectifier.

Each rectifier is fitted into a sheet-steel case with an open top and bottom, front doors, back and side covers. It is fixed using non-tracking isolating supports. The structure will be capable of withstanding the load without deformation. The structure will be provided with the elements necessary for its transportation.

The isolating material between the rectifier and the floor and between the DC switchgear will have a minimum of 100 MOhms.

Vents will be provided in the lower half of the front doors.

The changing of a diode must be possible to be carried out by one individual only within a reasonable period of time.

The loss in blocking activity of a diode (internal short-circuit) causes a two-phase transformer to short-circuit which appears in the rectifier arm in the form of a reserve current. This internal short-circuit is interrupted by the back-up diode fuse. The faulty diode is then isolated selectively. Blowing of the diode fuse is indicated in the micro switch fitted on the fuse and permits further evaluation. With one diode out of service, the rectifier is able to carry a 100% load (rated power without overload).

Protection of the rectifier against external short-circuits is provided by the Medium Voltage circuit breaker for the transformer in conjunction with a thermal / overcurrent time relay. This concept and a corresponding design of the components will allow the rectifier to carry a DC side busbar fault until the line-side circuit breaker opens.

Each rectifier unit will be duty class I (in line with the BEMU charging profile – see Section 2.2of this report).

3.6.3 DC Switchgear

The DC switchgear has been designed to have a dedicated busbar section and a set of supply and return cables to and from charging area for the both the transformer-rectifier unit and the ESS. This will allow for flexibility on the power supply to the charging area, being possible to operate with either charging power supply independently, whenever needed (e.g., during scheduled outages of either the power supplies – transformer-rectifier or the ESS).

It also will allow to have the ESS charge from the transformer-rectifier unit.

The DC switchgear has a metal casing and is factory-assembled and tested. The switchgear will be suitable for indoor installation. It is free standing and complies with IEC 349. The equipment of the DC switchgear is installed in standard sheet metal casing with the following main features:

- Withdrawable high-speed circuit breaker
- Encloser Construction.
- Allows for monitoring and remote operations.
- Clear arrangement of operating devices and indications.
- Low maintenance and long-life span.

Every incoming DC power switch for the main DC panels will withstand all loading that the rectifier units can supply. The positive-side switch will be equipped with a motorized drive for electrical control. The Negative Isolating Switch (NIS) will be manual with a lever and equipped with a blocking coil used for interlocking and safety operations.

The Isolating switch cell will be made using 1 motorized isolator switch, including voltage transducer, ammeter, and voltmeter. Another isolating switch cell will be installed for the negative isolator which will permit electrical isolation of the negative rectifier from the negative track. An under voltage (U>59) relay will be included in the NIS case. In this casing, the stray current measurement will be made. The return current will be measured and the current which returns to the stop though the earthing mesh (stray current) will also be measured. These two parameters will be transmitted to the NIS cell PLC, connecting the digital output of the ammeters which measures the aforementioned currents to the PLC.

As previously mentioned on the negative return circuit, there will be two different conductors; one for current return, and another for stray currents. The first will be an isolated conductor and the second one will be a bonding conductor.

Traction power at 1,500 VDC will be supplied to the catenary system at each traction substation through High-Speed DC Circuit-Breakers (HSCB).

The mechanical control system of the HSCB will have a stored energy mechanism in order to ensure a closing and opening speed control, independent of an operator. The control system must always finish any operation that has been started and must be capable of completing the open-close-open operation using only the stored energy.

FOR DRN

The circuit breaker unit will be a withdrawable type that can be rolled in and out of its cubicle without the use of an external cart. The circuit breaker carrier wheels will be made of high strength fiberglass or another material with similar fire-resistant properties. The mechanical control system will have an energy storage mechanism (to be actioned manually) that ensures the possibility to have an opening-closing-opening operation, for those cases when there is an outage of the LV power supply. The control system must always finish any operation that has been started and must be capable of completing the open-close-open operation using only the stored energy.

The DC switchgear will have a bus coupler switch, manually and electrically controlled, which is to remain normally closed to allow the interconnection between the TCR and the ESS. It will be housed in a metal-enclosed prefabricated case along with the control and measuring instruments.

According to the provision of the HV FRS, the negative busbar of the BEMU charging station will be connected to the running rails by the return cables (VLD to be connected separately between negative busbar and earth).

3.6.4 Energy Storage System (ESS)

The characteristics of the ESS are as indicated in Section 3.5.2 of this report.

The ESS will be compliant with standard IEC 62924. It will also be suitable for to be installed indoors (within a container).

The ESS controller will enable adjustment of the thresholds of the ESS output characteristics.

3.6.5 LV Transformer and Auxiliary Services

The transformer will be installed to supply low voltage power to the Main LV board and associated auxiliary services loads. The three-phase power transformer will be of a cast-resin dry-type, of continuous service and indoor, with elevation and transportation elements, bushing, earth electrodes, adjustable wheels and temperature control equipment with tripping and alarm relays.

To distribute the weight more evenly, they will be installed in metallic enclosures.

The auxiliary services transformer feed supply power to the main LV Panel which feed the lighting system, fire protection services, etc. In addition, the distribution will feed the Battery Charger and an uninterrupted power supply (UPS) for the essential loads.

The rectifier/battery charger equipment will be fed from the main LV panel at 400/230 V.

In addition, a UPS will be installed for essential users and incorporate a small distribution switchboard with output switches, including the power supply to different services and auxiliary equipment.

The transport and installation will be carried out with transport elements and adequate tools such as elevation devices.

During its placement, efforts will be made to ensure that no damage is caused.

The earthing bus will be connected along the length of the cabinet and to all enclosures for the metallic elements to which there is direct access. The principal earth wire will be connected at either end of the bus, with the appropriate connecting elements.

3.6.6 Diesel Generator Set

The power backup to Main LV panel in case of failure of the 10 kV power supply line to the transformer will be done by means of a diesel generator.

FOR DRN

3.6.7 Interlocking and Protection Equipment

3.6.7.1 Personnel Safety

The interlockings which protect personnel and avoid incorrect operation of the equipment are attained by means of locks which are installed on the doors, on the manual controls of the equipment, etc., and by means of wall keys that can be freed only if the correct steps for the operation of the equipment have been followed.

The access to each cell will be protected in such a way that they cannot be accessed until the DC and AC high voltage input has been cut off. For example, in order to be able to open the rectifier cell or enter the transformer cabinet, the high-voltage must be disconnected and the circuit-breaker of the DC or Low-voltage AC must be disconnected too.

Disconnection due to interlockings is produced when one of the mechanisms against incorrect operation is activated, such as access to live cells and the rest of the "safety" protection functions of the installation itself and the personnel. Switchgear cubicle access doors will be equipped with integral type locks, preferably incorporated in the handles in the case of indoor equipment.

3.6.7.2 Operation Safety

Operations that will endanger the devices in the installation will not be able to be carried out.

The operations which can be carried out from the Control Room or Panel will be synchronized with the operation from the remote control.

The isolator busbar section will not be able to close by itself if one or more high-speed circuit-breakers are in the closed position. The corresponding group of connectors must also be open.

The rectifier output DC switch will be interlocked with the transformer group's power supply high-voltage switch.

The external feed outlet switches will be interlocked with their respective high-speed circuit-breakers.

The by-pass isolator will only be able to act when the feed switches are disconnected, and the by-pass busbar is no longer working. A voltage detector must be installed in each by-pass busbar.

3.6.7.3 Equipment Safety

The positive-side switch and the negative-side switch will be equipped with auxiliary contacts used to indicate position, motor control, etc. The interlocking between the positive DC power switch and the 10 kV AC switchgear will be provided, so that the AC power switch can be closed only after the DC power switch has been closed and the DC power switch can be opened only after the 10 kV AC switch has been opened.

For protection against contact with bars that are energised, when a carriage has been removed for maintenance, a metal fence will be fitted around the cell carriage area.

3.7 ESB Substation

The ESB substation will be constructed as detailed in the construction standards provided (Figure 3).

As detailed in the ESB standard a freestanding substation will have:

- Strip foundation at 1450 deep (subject to ground conditions).
- Cavity wall with 215 mm concrete block or solid concrete inner leaf, 100 mm cavity and 100 mm outer leaf.
- Concrete floor slab with 900 mm deep ducts.
- Floor steel mesh electrically isolated from any other steel in the building.
- Floor steel mesh welded together with two earthing and two test points.
- Cast in situ re-enforced concrete roof with approved weather proofing membrane.

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- Steel door from an ESB approved supplier.
- Copper earth mat, from an ESB approved supplier, outside the door at 200 mm deep.
- A level area externally.
- Drainage: Any rainwater falling on the roof of the ESB sub-station or the containers will be captured by guttering. From here it will flow via down pipes to the surface water drainage system below ground. The rainwater falling on the surface of the compound will migrate through the porous surface to the perforated drainage pipes below ground. The drainage system passes through a fuel interceptor prior to connection to the local authority sewer.



Figure 5: Typical freestanding ESB MV substation.

Considering the relative location between the ESB MV substation and the set of containers of the BEMU charging station, and that it is required by ESB that the customer's main circuit breaker should be located so that the feeder cables can run directly from the ESB substation duct, through the boundary wall at the base of the duct, and directly up into the main circuit breaker terminals, the IÉ Circuit Breaker position is corresponds to A, in Figure 6.

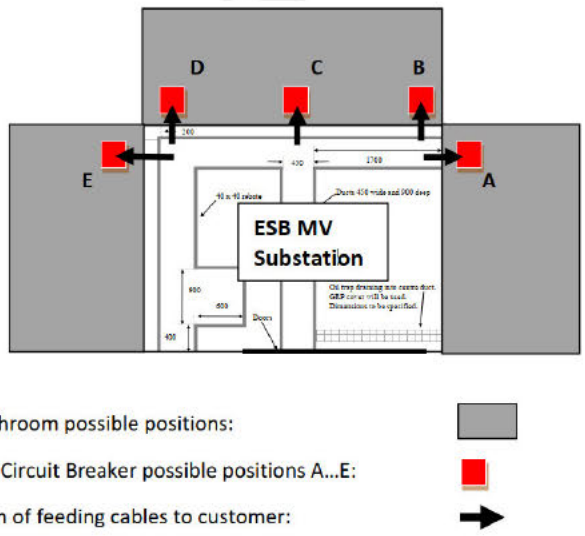


Figure 6: Typical alternatives for the location of customers' switchrooms in relation to the ESB MV substation

In addition, in relation to the Earthing design of the ESB MV substation, three main elements that have to be installed during the substation construction are to be considered, according to *ESB's Construction Standards for MV Substation Buildings*:

- Earthed steel reinforcing mesh in the substation floor (section 4.5 of ESB's standard).

- Copper earth wires laid as required adjacent to the substation by ESB Networks (section 4.7. of ESB's standard).
- A copper earth mat under the footpath at the substation door (section 4.8. of ESB's standard).

For DRN

3.8 Earthing and Bonding Preliminary Design – Integrated Earthing Grid

During Phase 3, the Earthing and Bonding design is focused on defining the Integrated Earthing Grid for the compound.

The preliminary design of the Integrated Earthing Grid of the compound is described in this section and is accompanied by the respective E&B drawings.

Provided that the definitive equipment arrangement within the containers of the substation compound is to be further validated by the equipment manufacturers, this preliminary design will have to be verified in subsequent design phases of the Project (namely, Phase 5).

3.8.1 Scope of the Design of the Integrated Earthing Grid

Either a fault current or lightning that strikes a structure can cause damages to the structure, its occupants, and their property, including equipment failure, particularly internal networks. The damages and failures may also extend into the environment of the structure and may involve the local environment.

Fault current or lightning can cause three basic types of damage:

- D1: injury to living beings due to touch and step voltages.
- D2: physical damage (fire, explosion, mechanical destruction, chemical emanations) due to the lightning current, including dangerous sparking.
- D3: failure of internal networks due to LEMP (Lightning Electromagnetic Pulse).

To reduce this damage, protection measures must be taken in the framework of buildings and structures.

This section specifies general principles and basic rules for earthing and lightning protection. They are applicable on every building and area of the substation.

3.8.2 Design Activities

3.8.2.1 Design Activities Conducted in Phase 3

- Preliminary calculation of the earthing electrode section according to the standard IEEE 80-2000.
- Preliminary specifications of each component implanted for the lightning and earthing protection according to EN 50164.

3.8.2.2 Design Activities to be Conducted in Phase 5

- Detailed calculation of the earthing electrode section according to the standard IEEE 80-2000.
- Implementation of drawing of integrated plant earthing grid.
- Implementation of drawing of bonding with all ring earthing electrodes of each building or area.
- Implementation of drawing of bonding with all metallic equipment on site.
- Implementation of drawing of bonding with trenches and galleries on site.
- Detailed specifications of each component implanted for the lightning and earthing protection according to EN 50164.

3.8.2.3 Tests to be Conducted for Phase 5

An earthing testing at the location of the compound is to be conducted at the Marsh Road charging station.

The ongoing geotechnical investigations on the area will have covered this requirement.

For DRN



Figure 7: Spotting plan for the ongoing GI on the Drogheda area (tentative).

3.8.3 Description of the Preliminary Design of the Integrated Earthing Grid

3.8.3.1 General Description

The Integrated Earthing Grid will consist of an arrangement of copper conductors whose cross-section is to be defined during Phase 5.

3.8.3.2 Interconnections of Grid Conductors

Conductors forming the Integrated Earthing Grid will be interconnected at every crossing by means of an exothermic welding. This type of connections provides more robust uniform joint and is less susceptible to wear in corrosive environments.

The exothermic welding connection process is a method of making electrical connections of copper-to-copper or copper-to-steel, in which no outer source of heat or power is required.

In this process, conductors are prepared, placed in a purpose-designed graphite mould, and exothermically welded to produce a permanent electrical connection.



For Drawing

Figure 8: Example of mould for exothermic welding.



Figure 9: Example of result of exothermic welding.

3.8.3.3 Depth of Burying of the Integrated Earthing grid

The Integrated Earthing Grid is to be buried one meter deep.

The cases of crossing with the other buried elements are treated in the subsequent sections.

3.8.3.4 Protection of the Integrated Earthing Grid

All conductors are protected by a warning grid, according to the figure below:

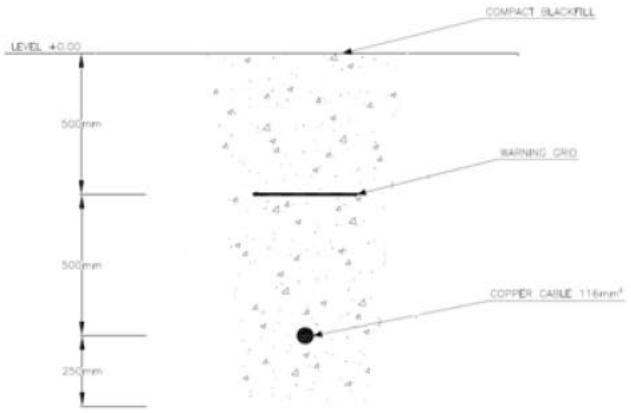


Figure 10: Indicative arrangement of the warning grid.

3.8.3.5 Interconnections of the Integrated Earthing Grid with Trenches.

Trenches may have a depth of 0.5 – 1.4 m from ground level, approximately, which may interfere with the Integrated Earthing Grid.

If that happens, the Integrated Earthing Grid is to be placed under the trench.

At every crossing between a conductor of the Integrated Earthing Grid and a trench, an equipotential connection is to be provided.

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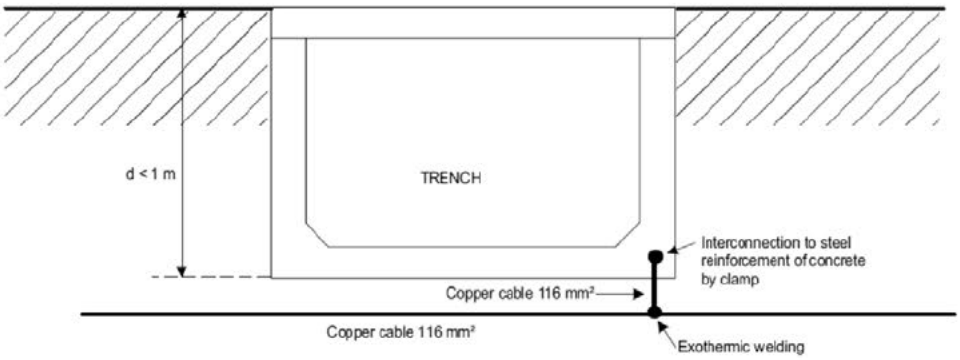


Figure 11: Interconnection between IEG and trench. Trench with d < 1m.

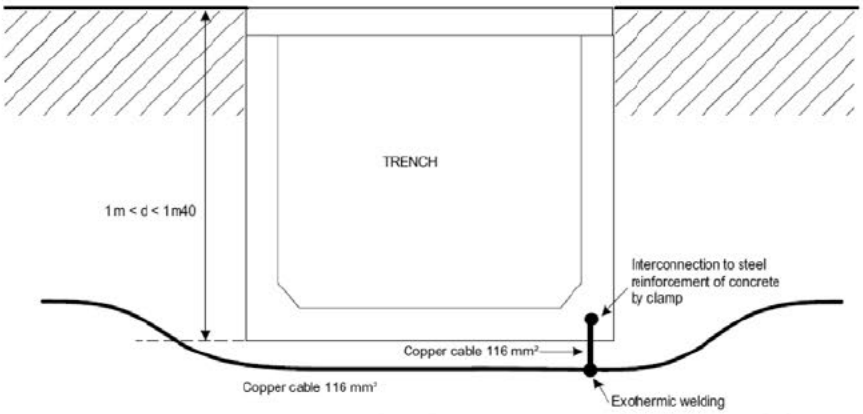


Figure 12: Interconnection between IEG and trench. Trench with 1 m < d < 1.4 m.

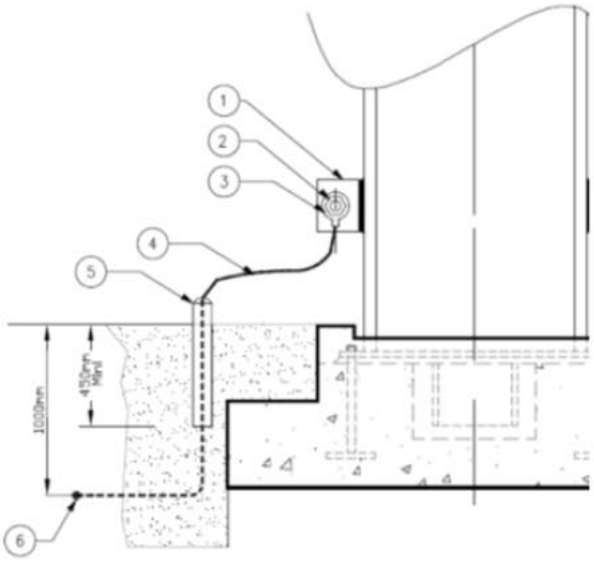
3.8.3.6 Interconnections of the Integrated Earthing Grid with and Rebars

To provide equipotential interconnections between concrete steel reinforcement and the Integrated Earthing Grid, a copper cable will be used. The connection of this cable to the rebars will be made by clamping.

3.8.3.7 Interconnections with Metallic Equipment

Metallic columns or outdoor lighting masts

Interconnections will be done by using exothermic welding.



(1) – Plate 50x30x5 mm (minimum)

(2) – Screw

(3) - Lug

(4) – Copper cable

(5) – Mechanical protective sleeve

(6) – Integrated Plant Earthing grid

Figure 13: Interconnection between IEG and metal columns.

Metallic Fences

Fence will be interconnected to Integrated Earthing grid every 20 m by, by using copper cables and clamping.

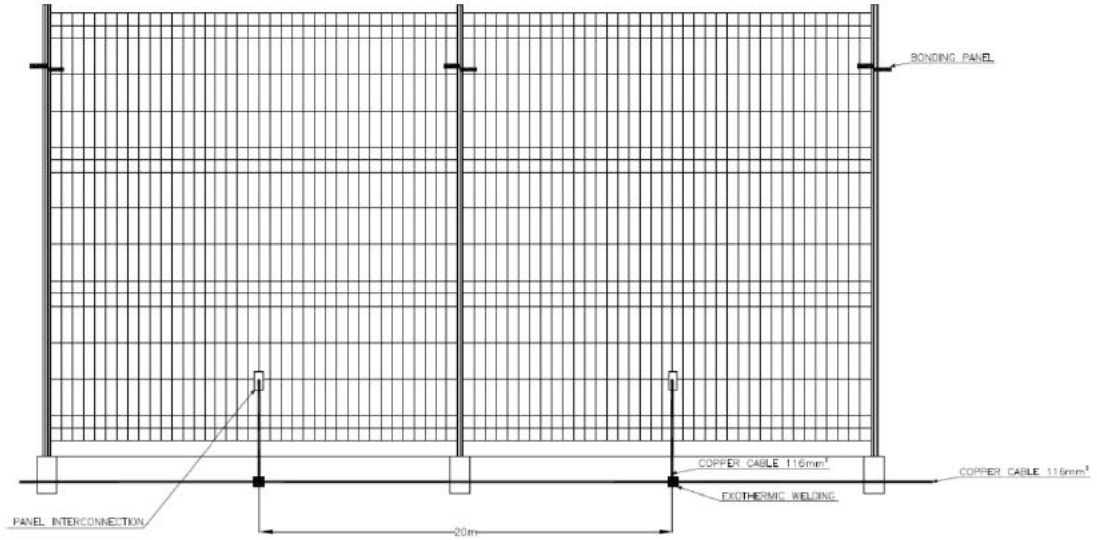


Figure 14: Interconnection between IEG and metallic fence.

3.9 SCADA Preliminary Design

In the drawing *SCADA Architecture of the BEMU Charging Station at Drogheda* D+WP56-ARD-P3-BE-DR-HV-000002, a solution is shown for the integrating of the SCADA of the BEMU charging station to the existing SCADA of the currently electrified section of the Coastal Line.

The SCADA architecture is in line with the BEMU Interface Control Document D+WP56-ARD-P3-BE-RP-HV-000001 and the Charging Control Requirements Specification D+WP56-ARP-P2-BE-RP-SI-000002.

The main intended functionalities of the SCADA system at the BEMU charging station are:

- To do remote control and monitoring of the 10 kV ESB incoming power supply to the charging station.
- To provide indications and alarms related to the charging and auxiliary equipment of the BEMU charging station, including but not limited to Power Transformer, TRC the Auxiliary Transformer, Diesel Generator, UPS, MV Switchgear, Circuit Breakers, LV System, VLD, battery charger status.
- To monitor and control the OHLE switches.
- To monitor the stray current control system.

Integration of SCADA systems

It is intended that all indications and alarms from the elements controlled by the SCADA of the BEMU charging station are reported centrally at the NTCC and CTC. The proposal for this integration of the (as set out in *SCADA Architecture of the BEMU Charging Station at Drogheda* D+WP56-ARD-P3-BE-DR-HV-000002) has been done under the following assumptions:

- The start of the operation of the BEMU programme is prior to the implementation of the MPLS SCADA & Signalling Networks (which will allow the deployment of updated telecommunication infrastructure along the Coastal Line up to Drogheda).

- There is an existing optic fibre between Malahide and Drogheda that is currently unused (dark fibre) and that can be used for the purpose of the integration of the SCADA systems.

In relation to the modifications to be done to the SCADA at the NTCC and CTC at Connolly for the integration of the SCADA of the BEMU charging station at Drogheda, a simple configuration would be needed.

Emergency shutdown system

At this stage the Independent Emergency Shutdown System (IESS) will not be required at the BEMU site in Drogheda. The IESS will be implemented once the line to Drogheda is electrified.

Emergency shut down of the power supply to the OCR will be provided locally via Emergency Power Off (EPO) buttons located at the BEMU Charging Substation. It is also possible to provide additional EPOs at the charging platforms.

If remote intervention is required from the ECO, the SCADA system of the BEMU charging substation will be able to provide that functionality.

3.10 Electromagnetic Compatibility

3.10.1 Definitions and Sources

EMC refers to "the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to other equipment in that environment" according to the Directive 2014/30/EU on the harmonization of the laws of the Member States relating to EMC.

Whenever there are electrified railways, it is necessary to determine the existence of interference effects. Electromagnetic compatibility (EMC) helps ensure the ability of one system (e.g., trackside equipment) to operate in the presence of effects caused by a nearby system (e.g., electrified railways). Such effects include voltages and currents in the trackside equipment caused by unintended coupling to voltages and currents existing on the traction power supply system of the railway. For electromagnetic compatibility issues to arise, three distinct entities are required: the emitter of interference, the receptor of interference, and the coupling path between them.

The coupling path for possibly interfering voltages and currents entering the trackside equipment from the nearby electrified railway can involve three distinct physical mechanisms: electric field coupling, magnetic field coupling and conduction. However, it is the magnetic coupling that is most concerning in the case of ac traction power supply systems for railways.

There are methods and procedures that can be applied to the railway to deal with and mitigate interference concerns wherever they occur.

3.10.1.1 Magnetic-Field Induction

Magnetic-field induction is of concern whenever there are trackside equipment or conductive infrastructure that are parallel to electrified railway lines for long distances. It is often the dominant induction mechanism when the impedance between the parallel conductive infrastructure is relatively small (i.e., the parallel conductive infrastructure is well grounded), so that effect of electric-field induction is reduced. Inductive coupling may be of concern during normal electrified railway line operation. During faults, however, the current may increase dramatically and hence dramatically increase the coupled currents and voltages.

Magnetic field coupling is driven by electrified railway current and can generally produce low open circuit voltages in the order of tens of Volts but at the same time currents of up to tens of Amperes. Magnetic field coupling could be of concern during both normal operation and fault condition of the electrified railway, and it is the dominant induction path in low impedance track signal circuits. Mis-operation of signals, equipment damage and personnel safety are of special concern in relation to this phenomenon.

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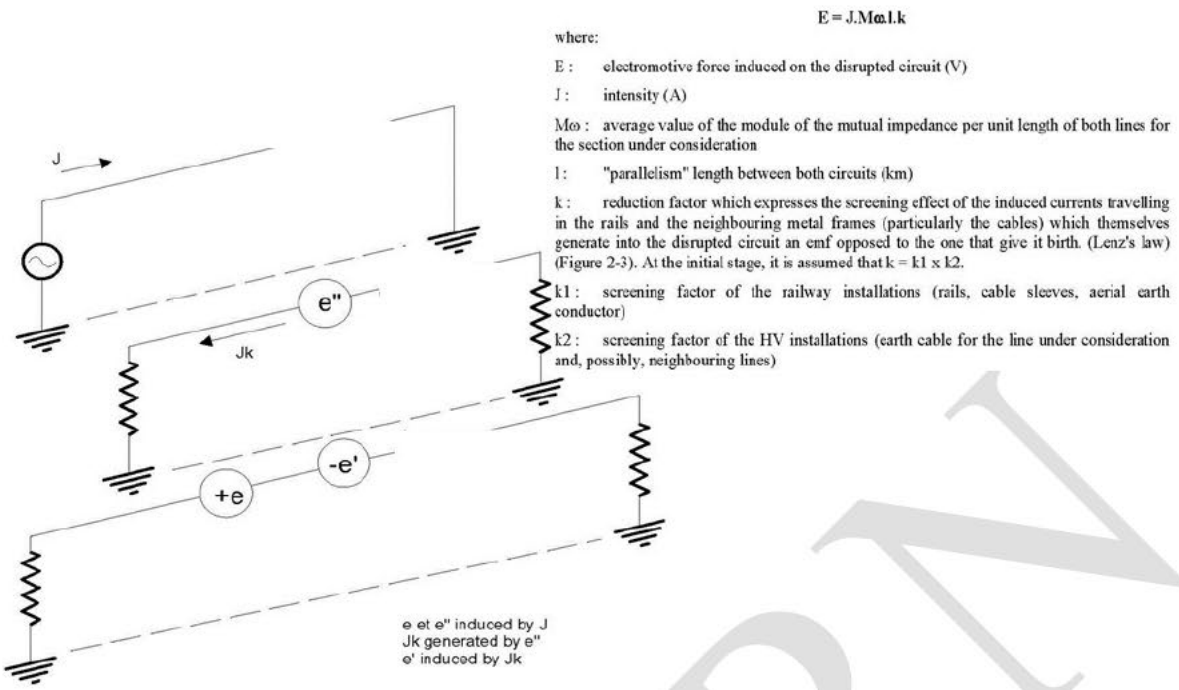


Figure 15. Magnetic induction EMC phenomenon.

The maximum distance allowable for any victim circuit running parallel to the electrified railway will be ultimately determined by the magnitude and the frequency of the current on the inducing circuit (e.g., electrified railway) and the lateral distance between the victim circuit and the inducing circuit.

The maximum distances for cables laid alongside the railway system are between the tens and the hundreds of meters, depending on the operation conditions of the electrified railway.

It should be noted that no fault conditions on the electrified railway were considered for analysis of this EMC phenomenon. This would require information which is not provided in the input data and would require a more elaborated modelling and simulation process. The magnitude of the short-circuit current of the electrified railway as well as the settings of the protection devices of the traction power supply system for the railway line will play a role in determining the specific requirements in terms of induced voltage during short-circuit condition.

As a general fact, the magnetic field coupling could be of concern during both normal operation and fault condition of the electrified railway, and it is the dominant induction path in low impedance track signal circuits. Moreover, signalling equipment, regardless of the specific technology used, is intended to feature the immunity levels against ac interference (including magnetic field) defined in EN 50121-4.

The voltage magnetically induced on a conductive element running parallel to the joint corridor (e.g., trackside conductors) depends mainly on the following parameters 1). Distance between the inducing circuit (i.e., electrified railway) and the victim circuit (i.e., trackside conductors) —(d), 2). Magnitude of the current on the inducing circuit —(I); and 3) length of parallel exposure of the victim circuit to the inducing circuit —(L). In addition, this relation is modulated by screening factors applicable to both the inducing circuit and the induced circuit (k factors) and may be summarized as follows:

- $e = 2\pi f I L k M$

Where,

- e induced electromotive force e on a victim [mV]
- f frequency of the inducing current [Hz]
- I inducing current [kA]
- L length of exposition between the source and victim systems [km]

- k screening factor ($0 \leq k \leq 1$; $k = ki*kc$)
- ki screening factor of the inducing circuits
- kc screening factor of the induced circuit
- M coefficient of mutual inductance between the inducing circuit and the induced circuit, which in turn depends on the separation between inducing and induced circuits d [μH/km]

As it may be seen, the separation between the electrified railway and trackside conductor that allows to have induced voltages on the trackside conductor below the allowed limits becomes a trade-off with the rest of elements of the relation shown above (i.e., magnitude of the current on the inducing circuit; and length of parallel exposure of the victim circuit to the inducing circuit, etc.).

3.10.2 Risks Associated to EMC

Impacts of high-voltage power transmission lines on railway systems can be categorized as follows:

- Abnormal equipment operation
- Equipment damage
- Personnel safety

3.10.2.1 Abnormal Operation of Railway Equipment

Railway equipment is designed to fail in such a way that safety is maintained. If the track signals detect a problem, they slow or stop the trains. If the highway-crossing gate system detects an inappropriate input, it lowers the gates. The idea is that it is better to stop the trains than to risk a collision. These safe failures are sometimes called right-side failures. The opposite would be wrong-side failures, which are considered not acceptable under any circumstance.

The most common abnormal operations resulting from AC interference are false activation of highway-grade-crossing train detection equipment (gates down with no train). Another common problem is dropout of the locomotive cab signalling system that displays wayside signals inside the cab. Because these cab systems utilize inductive coupling from the track, operate at audio frequencies near power frequencies, and use very low power levels, they are more susceptible to ac interference than other systems.

Abnormal operation for railway signalling systems is defined as a significant departure from the normal operational behaviour of the signalling system, which results from one of the following causes:

- A wrong-side failure mode
- A right-side failure mode

Abnormal operation might be more associated to signalling equipment based on the use of track circuits. In any case, the abnormal operation of the of the railway equipment (or even the damage of the equipment) will arise whenever the railway signalling equipment is exposed to electromagnetic emissions (from the electrified railway specifically) that exceed the immunity level against ac interference defined in EN 50121-4, which the railway signalling equipment is assumed to comply with. These electromagnetic immunity requirements have been selected to ensure that apparatus will operate as intended even under the electromagnetic disturbances most likely to be experienced in a railway.

3.10.2.1.1 Wrong-Side Abnormal Operation

Abnormal operation resulting from wrong-side failures is extremely rare. In the case of severe railway signal equipment damage resulting from a catastrophic event, multiple vital component failures may be created in the signalling equipment simultaneously. This most often results from lightning, surges, or electrified railway faults that cause excessive voltage to be applied to the inputs or outputs of the signal equipment.

Although there are several layers of protective devices installed in railway signal equipment, the external surge protection devices used are primarily designed to provide protection from nearby lightning strikes and may not be able to withstand the longer durations and larger energies associated with electrified railway faults.

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In the event that multiple failures are created within the signalling equipment in a simultaneous or near-simultaneous fashion, a wrong-side failure may occur. In many ways, this is no different than what would be expected to happen in the event of a fire, flood, or other environmental catastrophe that creates conditions that are outside of the equipment's intended operating environment.

Most likely, the equipment will fail-safe, due to inherent redundancies and the use of the normally-energized principle in the design of the equipment. But almost anything is possible after multiple simultaneous failures. This is because the equipment is only required to be single-fault tolerant.

Wrong-side failure means that a deviation from normal signal system operation has occurred, the signal system has not detected it, and this has resulted in a potentially unsafe condition or mode of operation. As the purpose of most railway signalling equipment is to provide an indication of what movements may safely be made, both by trains and the motoring/pedestrian public, the end result of this failure is usually some form of a false clear signal aspect, which gives the wrong indication to the train operator or public.

A wrong-side failure usually takes the forms of a signal system that displays a more permissive aspect than was safe or proper. For example, a green signal aspect was displayed, when the signal's aspect should have been either yellow or red.

3.10.2.1.2 Right-Side Abnormal Operation

A right-side failure means that some significant deviation from normal signal system operation has occurred, but there has been no reduction in safety. Right-side failure modes are by far the most common cause of abnormal signal equipment operation.

When modern signalling equipment enters a right-side failure mode, this means that the system has either detected an actual failure or is otherwise unable to confirm its own proper functioning. The occurrence of a right-side failure means that the system has both detected the presence of a problem and has taken appropriate action to ensure the continued safety of both train movements and the public. This action usually takes the form of placing the system in its most restrictive state, i.e., the wayside signals for the trains turn red, or the warning devices (gates, lights, bells, etc.) at a grade crossing are put into operation. The signal equipment will remain in this condition until the failure goes away, or possibly longer, due to the use of delay timers which prevent rapid back-and-forth transitions between the normal and failure modes of operation in the case of intermittent failures.

In order to be vital, railway signal equipment must enter a right-side failure mode whenever the proper functioning of any vital part of the signal system cannot be verified. This means that the equipment is intentionally designed to produce red wayside signals and false crossing warning system activations in response to the presence a problem.

AC interference is sometimes the cause of abnormal operation of railway signal equipment, but there are many other more common causes. The presence of ac interference should never be assumed to be the primary suspect until there is either direct evidence of the presence of excessive levels of ac interference voltage present between the rails of an abnormally operating track circuit, or all other potential causes of the observed symptoms have been eliminated.

An example of the abnormal operation of railway signal equipment, where ac interference is implicated, is having the warning devices activated at a grade crossing when there is no train approaching. As the most susceptible receptors of ac interference, the motion sensors and crossing predictors installed at grade crossings are usually the first indication of an ac interference problem.

Under conditions of moderate to severe interference, the presence of ac interference energy (usually 50 Hz and its harmonics) can fool the motion sensor or crossing predictor into believing that a vital failure has occurred. This happens when the noise level rises high enough to distort the measured characteristics of the electrical signals transmitted and received by the motion sensor or crossing predictor.

3.10.2.2 Damage to Railway Equipment

When damage is caused by the electrified railway operation, it is usually due to surges from faults or switching operations. Steady-state ac interference does not often cause damage because railway signal equipment is designed to withstand ac voltage levels well above those considered hazardous to personnel (50

V rms steady-state). Since steady-state interference levels are usually maintained below this level for safety, steady-state interference rarely causes damage.

Track surge protective devices (SPDs or arresters) used on railway equipment[1] are designed to withstand lightning. SPDs used on track circuits are designed to fail open (not shorted). They fail when the energy flowing through them exceeds their i^2t capacity (i — current in amperes, t — time in seconds). While the current through an arrester will be an order of magnitude higher for lightning than for an electrified railway fault, the duration of the current can be three to five orders of magnitude greater for the electrified railway fault. Thus, the energy coupled by a electrified railway fault can be much greater than from a lightning strike. The result is that the arrester is often destroyed, leaving the rest of the undamaged equipment vulnerable to lightning.

Although a small amount of ac interference energy, related to the power-line frequency, is always present on railway rails due to induction, it is usually inconsequential, and has no visible effect on the operation of the railway signalling equipment. The previous statement is done under the assumption that the railway signalling equipment features the immunity levels against ac interference defined in EN 50121-4. These electromagnetic immunity requirements have been selected to ensure that apparatus will operate as intended even under the electromagnetic disturbances most likely to be experienced in a railway.

Somewhere above this normal level of ac interference lies a range of energies which can cause operational problems for the various types of signalling equipment in use, but will not cause any permanent damage. The exact voltage and/or current thresholds at which this occurs will vary widely, depending primarily on the type of equipment installed. However, these thresholds are also strongly dependent on other factors, including the operating frequency used by the equipment, the operating mode or modes selected, and the particular electrical characteristics of the track and associated components installed at each location.

In general, as the level of interference rises, so does the rate of operational problems with the signalling equipment; in some cases, this trend may only be visible using statistics. As problems from ac interference are often random or pseudo-random in nature, the specific times at which a signal system experiences trouble (assuming a constant interference level) will often be random or pseudo-random as well. But the frequency and duty cycle of visible symptoms will generally correspond to the level of interference – once the level of interference has risen above the threshold required to induce the first operational problem.

3.10.2.2.1 Trackside Equipment (S&T)

For Signalling & Telecommunications apparatus installed inside the railway environment, the following requirements apply:

- Immunity requirements as per EN 50121-4 standard

The immunity levels given in EN 50121-4 standard apply for

- vital equipment such as interlocking or command and control,
- apparatus inside the 3 m zone,
- ports of apparatus inside the 10 m zone with connection inside the 3 m zone,
- ports of apparatus inside the 10 m zone with cable length > 30 m.

3.10.2.2.2 Power Supply Apparatus

For power supply apparatus are all electrical and electronic apparatus and systems intended for use in railway fixed installations associated with power supply, the following requirements apply:

- Immunity requirements as per EN 50121-5 standard

Emission and immunity limits are given for items of apparatus which are situated:

[1] Railway signalling equipment might be protected by means of the installation of a surge panel (with SPDs of arresters) which receives the track leads connecting the rails. SPDs are intended to protect the down stream equipment from surges by diverting the energy to ground.

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a) within the boundary of a substation which delivers electric power to a railway;
b) beside the track for the purpose of controlling or regulating the railway power supply, including power factor correction;
c) along the track for the purpose of supplying electrical power to the railway other than by means of the conductors used for contact current collection, and associated return conductors. Included are high voltage feeder systems within the boundary of the railway which supply substations at which the voltage is reduced to the railway system voltage;
d) beside the track for controlling or regulating electric power supplies to ancillary railway uses. This category includes power supplies to marshalling yards, maintenance depots and stations;
e) various other non-traction power supplies from railway sources which are shared with railway traction.

The immunity levels given in EN 50121-5 standard apply for

- vital equipment such as interlocking or command and control,
- apparatus inside the 3 m zone,
- ports of apparatus inside the 10 m zone with connection inside the 3 m zone,
- ports of apparatus inside the 10 m zone with cable length > 30 m.

3.10.2.2.3 Magnetic Field Limits

All equipment surrounding an electrified railway are subject to a steady magnetic field intensity that is proportional to the flowing current intensity, to the distance, to the conductors geometry, etc.; the EN 50121 standard normalized the amplitude of the magnetic field level for the test of equipment immunity to particularly high levels, that for trackside environment (EN 50121-4) and substation environment (EN 50121-5) was fixed at 100 and 300 A/m for ac systems. In the generic immunity standards these values are lower and equal to 10 and 30 A/m for the residential and industrial environments.

The magnetic field caused by currents of an electrified railway is considered steady in the sense it is subject normally only to slow variations, due to changes in the load demand. On the contrary, transients may be produced by short circuits and consequent protections triggering and the phenomenon may affect equipment located both trackside and at substation; however, this phenomenon is considered relevant only for the EN 50121-4 environment and therefore was included into the standard, by means of a dedicated test for transient magnetic field, again at a 300 A/m intensity, based on the basic standard EN 61000-4-9.

Table 3.4. Magnetic Fields Immunity Levels for Trackside Equipment

Reference	Summary of Scope	Maximum Magnetic Field (Immunity)
EN 50121-4	Magnetic fields in signaling and telecommunication equipment with 50Hz (test according to EN 61000-4-8).	100 A/m (rms)
	Magnetic fields in signaling and telecommunication equipment with pulse (test according to EN 61000-4-9).	300 A/m
EN 50121-5	Magnetic fields in fixed power supply installations and apparatus with 50Hz. (test according to EN 61000-4-8)	100 A/m (rms)

3.10.2.3 Personnel Safety

AC interference sometimes can be large enough to have an effect on a person on the ground touching the railway system. If the voltage levels are high enough, a shock hazard might exist.

For high impedance receptor circuits excited by electric induction, the short-circuit current to ground is a good measure of the hazard. But for low impedance receptor circuits excited by magnetic induction or conduction, the current is limited by the own receptor and any other element that may make part of the circulation patch of the current (including earth). So, a direct measurement of the current is impractical. The common practice is to select a value of open-circuit voltage, as the maximum acceptable limit for the situation being evaluated.

Magnetic coupling results in an induced voltage that is distributed along the exposed length of a conductor. Signal conductors that are well isolated from earth, such as many pole-line conductors (i.e., communication installations in which conductors are mounted on top of poles/masts), may have impedance high enough to prohibit hazardous magnetically induced current from flowing through a person contacting the conductor. If an abnormal condition develops on a normally high-impedance circuit, such as low impedance to ground at a remote location, the circuit is no longer high impedance. The isolated signal-line condition is in contrast to telephone or communications conductors that are earthed at some remote location (central office). Rails may have a sufficiently low impedance to earth such that the current through a person contacting the rail is controlled primarily by the impedance of the person and the voltage of the rail. The hazard associated with this type of circuit should be evaluated based on the voltage induced onto the circuit.

A minimum criterion for steady-state voltage induced on railway facilities by magnetic field induction would be to limit the voltage to a maximum of 60 V ac rms point-to-point (within reach) under worst case conditions.

It is important to note that the effect of the induced voltage is only not evidenced on the rails but also on the OHL conductors. That is why the general requirement is that the earthing and bonding of current carrying equipment, enclosures and associated structures (including the OHL conductors that make part of the traction return current circuit, e.g. OPC, BEC, RC), rails, and other trackside equipment be designed such that touch voltages do not exceed the values indicated in EN 50122-1: 2011, Section 9.2.2.

Moreover, it should be born in mind that the grounding network and the traction return current circuit are closely interconnected to constitute a single composite network that facilitates equal-potentiality for all normally-non-current-carrying-conductive equipment and structures and ensures flow of all fault current towards the earth. However, the rails are assumed to be the part most probable to be in contact with during operation or fault condition of the railway system.

In addition, it should also be born in mind that apart from the former relevant issues relating to personal safety (related to common-mode), there also exists the concern for abnormal operation of railway systems if the differential mode in the rails is greater the equipment immunity.

Another aspect of personnel safety is exposure to electric and magnetic fields.

3.10.2.3.1 A.C. Voltage Limits for the Safety of Persons

The (effective) touch voltage (U_{te}) is defined as the voltage between conductive parts when touched simultaneously by a person or an animal.

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Table 3.5. Maximum permissible effective touch voltages Ute, max in AC traction systems as a function of time duration (EN 50122-1)

t s	$U_{te,\ max}$ **long-term** V	$U_{te,\ max}$ **short-term** V
> 300	60	-
300	65	-
1	75	-
0,9	80	-
0,8	85	-
0,7	90	-
< 0,7	-	155
0,6	-	180
0,5	-	220
0,4	-	295
0,3	-	480
0,2	-	645
0,1	-	785
0,05	-	835
0,02	-	865
Key t time duration $U_{te,\ max}$ permissible effective touch voltage		

3.10.2.3.2 Limits for EMF's: Electric Field (V/m), Magnetic Field (A/m and µT) for Safety of Persons

The following standards are analysed regarding electromagnetic effects on living beings at the frequency of 50 Hz. The aim is to ensure that the exposure levels to the fields (E, H, B) are not harmful to both the workers and the general public.

Table 3.6. Standards Related to Limits of Exposure to EM Fields.

Reference	Title
Directive 2013/35/CE	Minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)
IEEE Std. C95.6:2002	Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz
ITU-T series K.52	Guidance on complying with limits for human exposure to electromagnetic fields
ICNIRP recommendation. Low frequency rev. 2010	Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz)

A summary of the electromagnetic field maximum exposure levels for the general public (not workers) at the frequency of 50 Hz is shown below.

Table 3.7. Limits of Exposure to EM Fields for General Public.

	IEEE std. C95.6:2002	ITU-T K.52 (ICNIRP 1998)	ICNIRP rev.2010
E (V/m)	5.000	5.000	5.000
H	719	80	160

	IEEE std. C95.6:2002	ITU-T K.52 (ICNIRP 1998)	ICNIRP rev.2010
(A/m)			
B (μT)	904	100	200

A summary of the electromagnetic fields maximum exposure levels for trained persons (workers) at the frequency of 50 Hz is shown below.

Table 3.8. Limits of Exposure to EM Fields for Trained Personnel

	Directive 2013/35/CE	IEEE std. C95.6:2002	ITU-T K.52 (ICNIRP 1998)	ICNIRP
E (V/m)	10.000	20.000	10.000	10.000
H (A/m)	800	2.160	400	800
B (μT)	1.000	2.710	500	1.000

3.11 Other design aspects

3.11.1 Access control

An access control mechanism (namely, a digital key – fob) common to each container in the substation compound is proposed to be set in place. That way, the same fob could be used to access all the containers in the compound. This approach is proposed under the understanding that it will only be maintenance technicians that will need to have access to the containers.

For accessing the substation compound, a lock and key is proposed instead. This, considering that vegetation control and other staff may need to have access to the compound but not the containers.

3.11.2 Emergency Power Off buttons

On the platforms 2/3 and on depot road 4, emergency power off buttons which are suitably housed in weather proof enclosures shall provide the ability of IÉ staff to shut off power to the OCR, by key resettable push buttons which are linked to the substation and which will, when operated, cause the DC circuit breakers to be opened as mentioned in section 3.9.

3.11.3 Emergency Telephones

Telephones on the ends of platforms 2/3 will enable drivers to contact directly the ECO in the event of operational difficulties. These telephones shall be linked to the IÉ Telecoms network via Drogheda TER.

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4. Design Criteria and Design Statement (OCR)

4.1 General

The BEMUs charging will take place on the Up Main line (platform 2), the Siding line (platform 3) and the DMU Service 4 line. The charging will be done by supplying energy to the trains' pantographs through an Overhead Conductor Rail system (OCR).

The BEMU will operate as a temporary stabling/charging facility to be implemented during the interim phase of operations. Hence the charging infrastructure has an expected operational lifespan of approximately 5-10 years. Following electrification of the Northern Line and subsequent decommissioning of the charging infrastructure, there is the expectation that the various components may be reused elsewhere.

The purpose of this chapter is to describe the proposed solution for the OCR system to be located in the charging roads in Drogheda Station and Depot.

4.2 Input Design Parameters

4.2.1 Rolling stock

The BEMU charging will be done by using both pantographs to supply the train, with a OHLE contact on the carbon strips of the pantographs. The OHLE will be an Overhead conductor rail system (OCR) in order to provide adequate capacity for required electrical current and suitable contact as per the static contact forces exerted by the pantographs on the contact wire, according to the information provided by Alstom (around 130N vs 85N exerted by pantograph during the running).

The OCR system has been designed in order to consider the following different BEMUs configurations, according to indicated in RFI's D+WP56-ARP-P3-BE-RI-KX-000169 and D+WP56-ARP-P3-BE-RI-KX-000170:

- One Half Length Unit (HLU)
- Two coupled HLU
- Two uncoupled HLU at 5 m between them (considering 2 coupled HLU stop with +/-5 m of tolerance and then second HLU is moved back 5 m)
- One Full Length Unit (FLU)

In these RFI's, the location of the pantographs for each BEMU are indicated. The HLU BEMU have two pantographs located on this same Vehicle (IC2), which is the middle Vehicle. The FLU BEMU have pantographs located on third Vehicle counting from each Unit end (IC2 and IC2').

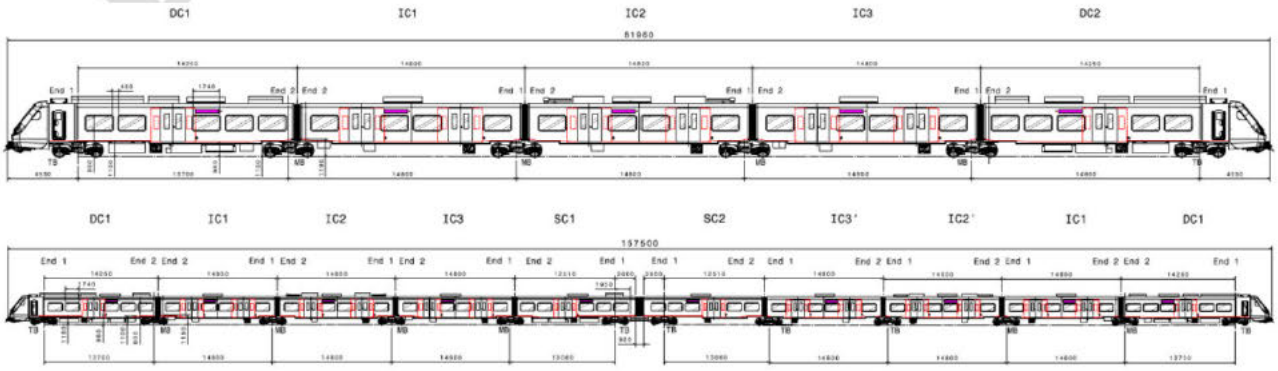


Figure 16: HLU and FLU BEMU configurations

According to what has been informed by IÉ, no FLU will be used in the operation of the BEMU program; only HLU will be used. However, in order to make possible to operate with FLU, if doing so is ever needed, the OCR design has been done taking into consideration the dimensions of both 2xHLU and FLU trainsets.

4.2.2 Drogheda Station

The charging roads are the Up Main line (Platform 2), the Siding line (Platform 3) and the DMU Service 4 line.

The island platforms 2&3 located between Up Main line and the siding line are set to a fall towards the centre, where there is a linear drain which conveys surface water into the drainage system. On the platforms are located typical station items such as lighting columns, CCTV columns, benches, poster boards and planters.

The DMU Service 4 line is constructed on slab track, with the concrete slab extending to the midpoint between this line and siding line.

Additionally, the existing footbridges OBB81 and OBB81C are located in the area of the station affected by the charging system and they have to be considered in the design - in particular the OBB81, which has a clearance of 4464 mm above the rails (clearance of OBB81C is 5800 mm from rails).

4.3 OCR System

4.3.1 OCR proposed arrangement

The proposed OCR system is formed by two independent sections of conductor rail (with clamped Cu-ETP 120 mm^2 contact wire) in each track in order to avoid placing the system below the existing footbridges OBB81 and OBB81C, in particular below the first one, which has a clearance of 4464 mm above the rails.



Figure 17: Typical OCR arrangement with CW clamped in the conductor rail

Considering the position of pantographs for all the required configurations, the length and the location of the two OCR sections along each track have been defined in order to cover the position of the pantographs considering all the BEMUs configurations indicated above maintaining enough horizontal distance between the conductor rails to the footbridge.

In any case, existing footbridge mesh of footbridge OBB81C is to be replaced with an IP2x compliant mesh with bottom 1.2 m solid parapet in according with IÉ requirements, as indicated in drawing D+WP56-ARD-P3-BE-DR-EL-000002.

The OCR design considers a tolerance in stop position of +/- 5 m and a distance between uncoupled HLUs of 5 m, according to indicated in RFI's D+WP56-ARP-P3-BE-RI-KX-000169 and D+WP56-ARP-P3-BE-RI-KX-000170. It was considered a 1.9 m distance from panto head to the end of the coach where it is placed, based on the distance of 70.974 m between nearest pantographs in two coupled HLUs arrangement shown in RFI D+WP56-ARP-P3-BE-RI-KX-000135.

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The current design has been made assuming that the OCR will be replaced and there will no longer be charging BEMUs when OHLE is installed in Malahide-Drogheda section as part of the DART+ Coastal electrification works.

The defined OCR sections set the stop positions of the different BEMU configurations, as shown in the layout drawing D+WP56-ARD-P3-BE-DR-EL-000001.

The HLUs different arrangements defined above will stop in the "Proposed stop position for HLUs / 2xHLUs / 2xHLUs not coupled" indication shown in the drawing at the north end of the station. The uncoupled second HLU will stop at 5m to the south from the coupled position, so the pantographs for the uncoupled HLU will stand 5m to the south from the coupled ones.

The drawing also shown the "Proposed stop position for FLUs" indication just in case the FLUs were ever used in BEMUs operation. This is located at 6.42 m from the proposed stop position for HLUs, so the first set of pantographs is displaced that distance to the south from the HLUs pantographs position and the second set of pantographs of FLU match with the second set of pantographs of the 2xHLUs arrangement. In this way, the second OCR section can be away from the overbridges covering all the train arrangements proposed.

Currently, the OCR design assumes that the trains will arrive from the Malahide direction. However, in principle, trains approaching from the north side could also use charging facilities in Up Main track stopping at the "End position for 2HLU/FLU" indication shown on the drawing.

The contact of the OCR is on the carbon strip of the pantographs and it is with the train at standstill, so the conductor rail will be placed at the track centre in the supports. The contact wire height will be 4.7 m from running rails, according to nominal value indicated in Electricity Functional Specifications System-Wide for DART+ Programme, document MAY-MDC-ELE-DART-SP-E-0002.

In this way, the live parts of the OCR and pantographs will be placed out of the platform area and fulfilling with the minimum clearance from standing surface required by the EN 50122-1 to protect from direct contacts, as shown in the typical cross sections drawing D+WP56-ARD-P3-BE-DR-EL-000002.

4.3.2 OCR supporting structures

The OCR will be supported by means of structures located approximately every 10 m as shown in the layout drawing D+WP56-ARD-P3-BE-DR-EL-000001. OCR structures will be designed for working life of 60 years according to standard CCE-TMS-410.

For Up Main track, the conductor rail sections will be supported from masts located in the centre of platforms 2 and 3, by mean of a beam and a drop tube in each location. At these locations, existing drainage should be diverted. However, this is preferred as opposed to placing masts closer to the platform 2 edge from aesthetically point of view and in order to reduce the obstruction to the normal pedestrian travel routes.

For the siding track at platform 3 and DMU service 4 track, the masts will be located between these two tracks, with a beam and drop tube for each track. Masts will be placed maintaining the minimum clearance from nearest running rail of the siding track at platform 3, according to I-PWY-1101 standard, considering that walkway is not needed as far as the existing slab can be used as walkway and the masts are located at this location to avoid clashing with this DMU servicing slab.

First structure in each OCR section will have a portal beam between masts for Up Main track and siding track, in order to install the feeding cables from cable route along the siding track up to the overhead conductor rails located in Up Main track.

The OCR structures are shown in the typical cross sections drawing D+WP56-ARD-P3-BE-DR-EL-000002. Masts are proposed to be HEB steel structures according to Electricity FRS for DART+ programme. Anti climb spikes have been considered in the masts.

The OCR structures and foundations have been designed according to relevant standards (EN 50119: Railway applications- Fixed Installation – Electric traction overhead contact lines, the OHLE Structure Design Report for DART+ Programme, document MAY-MDC-STR-ROUT-RP-S-0001, Electricity Functional Specifications System-Wide for DART+ Programme, document MAY-MDC-ELE-DART-SP-E-

0002, CCE-TMS-410). Design loads and foundations design are included in the BEMU B3 Charging Road – OLE & Lineside Civils Preliminary Design Report, document D+WP56-ARP-P3-BE-RP-CX-000201.

The design developed has only considered the OCR loads. The Preliminary Design of the electrification will assess if the masts can be reused for final electrification considering the required OHLE layout and the required OHLE loads.

4.4 OCR Feeding Arrangement

Power for the charging roads is delivered from the new sub-station located in the Marsh Road car park as described above.

It is considered that there should be one outgoing feeder from Traction Power Substation and one outgoing feeder from ESS to each OCR section of the three charging roads. Preliminarily, 3x300 mm2 Cu insulated cables are considered for each outgoing feeder, so 6 insulated copper cables of 300 mm2 will connect to the two OCR sections on each road.

The current return is done by insulated cables for each OCR section from rails to Traction Power Substation and ESS, considering that IRJ have been installed in the rails according to OCR sections.

In order to isolate the OCR sections from the incoming feed for maintenance works, pole mounted lineside switches are proposed to be installed in the OCR masts located between siding track at platform 3 and DMU service 4 track. In order to place them out of the platforms.

The Electricity FRS for DART+ programme states that DART+ Programme OHLE lineside switches shall be motorised. However, in this case, the installation of manually operated isolating switches are proposed in order to simplify the system and considering that the disconnectors currently installed in the existing electrification are also manually operated.

The lineside switches will be fitted with position indication at the switch level. Indication of the switch position shall be provided to SCADA for logging and indication to ECO. They are normally closed and they will be locked in the "open" position when an isolation is being taken.

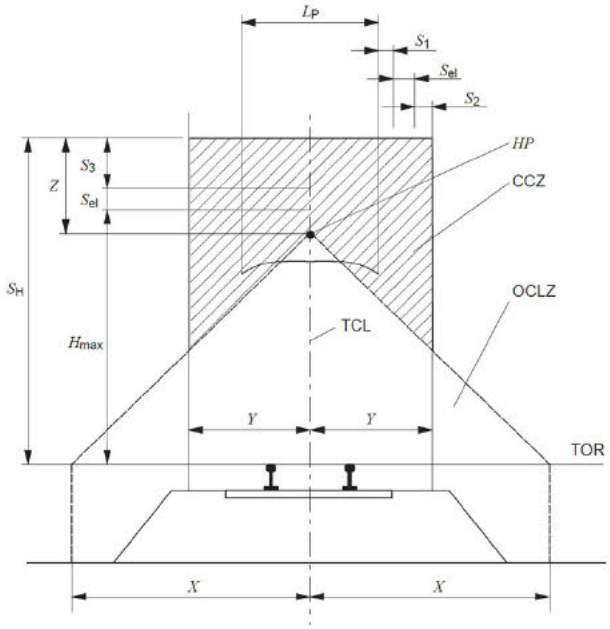
Therefore, one two-pole switch will be installed for each OCR section (2 per charging road) between each OCR section and the outgoing feeder cables from Traction Power Substation and from ESS (6 insulated cables of 300 mm2).

It is proposed to install the switches for OCR sections of UP Main track and siding track in the northern mast of the portals structures, so insulated and mechanically protected cables can be installed from the switch to the Up Main track OCR sections supported on the portal beam above platforms. The switches for the OCR sections in the DMU service 4 track will be installed in the adjacent OCR structure.

4.5 Earthing and Bonding

The earthing and bonding will be designed according to EN 50122-1 and the Electricity FRS for DART+ programme. As per these FRS, the reinforced concrete foundations of the OCR structures act like earthing electrodes, lowering the resistance to earth.

All conductive parts inside CCZ/OCLZ zones shall be earthed by connection to earth wire / traction earth with a wire of sufficient section to withstand short circuit currents. These zones are defined for protective provisions and are the zones whose limits are in general not exceeded by a broken overhead contact line or an energised de-wired or broken current collector and its fragments. Figure below defines the zone inside which such contact is considered to be probable, according to EN50122-1. For the DART+ Programme the value for the parameter X is given as 4m, Y is given as 2m and Z as 2 m according to the Electricity FRS for DART+.



Key

TOR	top of rail
HP	highest point of the overhead contact line
OCLZ	overhead contact line zone
CCZ	current collector zone
TCL	track centre line
X	maximum unidirectional (half) horizontal OCLZ, top of rail level
Y	maximum unidirectional (half) horizontal CCZ
Z	distance between *HP* and S_H
S_1	width of lateral movement of the current collector
S_2	lateral safety distance for the broken or dewired current collector
S_3	vertical safety distance for the broken or dewired current collector
S_{el}	electrical clearance in accordance with EN 50119
S_H	maximum height of current collector zone
L_p	current collector width
H_{max}	maximum height of the fully uplifted current collector

Figure 18. Overhead Contact Line Zone and Current Collector Zone

All the apparatus with conductive surfaces mounted on earthed metallic structures shall be earthed (via the PE wire) once. Therefore, if the cable feeding the apparatus includes the PE wire, such wire shall be unconnected to avoid the loop. All the earthing wires or cables (PE) of an apparatus installed inside OCLZ/CCZ zones shall be dimensioned to support the eventual short circuit current. Only Class II equipment might remain unearthed.

On the other hand the exposed conductive parts of traction and non-traction power supply which are located within the contact line zone or the current collector zone and which are not insulated from earth shall not be bonded directly to the return circuit due to the effects of stray current corrosion (according EN 50122-2). In these circumstances a voltage-limiting device (minimum functionality VLD-F) shall be used to make an open connection from the exposed conductive parts to the return circuit to create a short-circuit path and in consequence to cause the interruption of the current in a short time to keep the voltage within the limits given in Table 6 or in 9.3.2.3 of EN 50122-2.

Therefore, the OCR masts will be bonded to rails via pole mounted VLD according to EN 50122-1.

4.6 Standards to Be Used in the Design

Table 9: Design Standards

Source	Description	Comments
European Commission Regulation	EU/1299/2014	Technical Specification for Interoperability for the 'Infrastructure' subsystem
Irish Rail	I-PWY-1141	Engineering Requirements for Passenger Platforms and Barrow Paths
Irish Rail	I-PWY-1101	Requirements for Track and Structures Clearances
Irish Rail	CCE-STR-PSD-005 Version 1.0	Technical Approval for Civil Engineering Structures
Irish Rail	CCE-TMS-390	Preparation of Drawings (Approval and Certification Process)

Source	Description	Comments
Irish Rail	CCE-TMS-410	Civil Engineering Structures Design Standard
Irish Rail	I-ETR-4004	Clearance Requirements for DC 1500V Electrified Lines
Irish Rail	I-ETR-4009	Principles of traction bonding
Irish Rail	I-ETR-4003	Electrification Standard
Irish Rail	I-ETR-4703	Earthing and Bonding Guidelines
Irish Rail	I-ETR-4005	Stray Current Control Measures for 1500v DC Electrified Lines
Eurocode	IS EN 1990 & NA	Basis of structural design
Eurocode	IS EN 1992-1-1	Design of concrete structures
Eurocode 7	I.S. EN 1997-1:2005	Geotechnical design
Eurocode	IS EN 206-1	Concrete: specification, performance, production and conformity
EN standard	EN 50119	Railway applications — Fixed installations — Electric traction overhead contact lines
EN standard	EN 50121-1	Railway applications — Fixed installations — Electrical safety, earthing and the return circuit Part 1: Protective provisions against electric shock
Electricity FRS	MAY-MDC-ELE-DART-SP-E-0002	Electricity Functional Specifications System-Wide for DART+ Programme
OHLE Structure Design Report	MAY-MDC-STR-ROUT-RP-S-0001	Basis of design for the OHLE Structures
ESBN standard	DOC-280518-DFK	Company standard Construction Standards for MV Substation Buildings

For DRN

Appendix A

Design Decision Log

For DRN

Item Ref	Discipline	Chainage	Deliverable Package	Design Decision/ Assumption	Originator (Name)	Originator (Co.)	Owner	Date Raised	Description of Decision / Assumption	Incorporated as "Value Engineering" (yes)	Justification	Acceptable to MS? (Y/N)
	Electrification	31 3/4	BEMUs	Design Decision			[redacted]	21/02/2022	The BEMU charging will be done by using both pantographs to supply the train, with a OHLE contact on the carbon strips of the pantographs.		TF-00154 Alstom Question Responses For the fast charging, the decision is to use both pantographs to supply the train, with a OHLE contact on the carbon strips. The carbon strip shall be copper impregnated, with a percentage compliant with TSI (around 30 - 35%).	-
	Electrification	31 3/4	BEMUs	Design Decision				21/02/2022	Charging will be done through OCR		TF-00154 Alstom Question Responses Only during the fast charging, static contact force exerted by the pantograph on the contact wire will be higher than during the running (around 130N vs 85N). This solution works only if the catenary is rigid.	-
	Electrification	31 3/4	BEMUs	Design Decision				11/11/2021	The OCR design allows for charging HLU as well as 2x HLUs.		RFI's D+WP56-ARP-P3-BE-RI-KX-000169 and D+WP56-ARP-P3-BE-RI-KX-000170	-
	Electrification	31 3/4	BEMUs	Design Decision				11/03/2022	The OCR design allows for charging FLUs. Original design has not been modified as per IE email about not considering the FLU as changes to work complete was not required		RFI's D+WP56-ARP-P3-BE-RI-KX-000169 and D+WP56-ARP-P3-BE-RI-KX-000170 Email from Patrick Conway to Chris Cox in 11/03/22	-
	Electrification	31 3/4	BEMUs	Design Decision				11/11/2021	The design allows for charging 2 uncoupled HLU at 5 m between them (considering 2 coupled HLU stop with +/-5 m of tolerance and then second HLU is moved back 5 m)		RFI's D+WP56-ARP-P3-BE-RI-KX-000169 and D+WP56-ARP-P3-BE-RI-KX-000170	-
	Electrification	31 3/4	BEMUs	Design Decision				11/11/2021	Tolerance in stop position: +/- 5 m		RFI's D+WP56-ARP-P3-BE-RI-KX-000169 and D+WP56-ARP-P3-BE-RI-KX-000170	
	Electrification	31 3/4	BEMUs	Design Decision				20/07/2021	1.9 m distance from panto head to the end of the coach		Based on the distance of 70.974 m between nearest pantographs in two coupled HLUs arrangement shown in RFI D+WP56-ARP-P3-BE-RI-KX-000135	

For

	Electrification	31 3/4	BEMUs	Assumption			[redacted]	08/10/2021	OCR will be replaced and there will no longer be charging BEMUs when OHLE is installed in Malahide-Drogheda section as part of the DART+ Coastal electrification works.		As far as electrification is installed from Malahide to Drogheda, the charging facilities in Drogheda will not be required	
	HV	Marsh Road car park	BEMUs	Assumption		ESB		10/12/2021	The power supply to the BEMU charging station will be at 10 kV instead of 38 kV.		ESB has informed that the connection of the BEMU to their network can only be done in the short term at a voltage level of 10 kV.	
	HV	Marsh Road car park	BEMUs	Design Decision		Ardanuy/Arup		30/11/2021	Incorporation of an Energy Storage System (ESS) to back up the expected short-term operation of the BEMU charging station (as described in the *BEMU Operation and Charging Concept* document).		ESB has informed that the connection of the BEMU to their network can only be done in the short-term at a voltage level of 10 kV.	
	HV	Marsh Road car park	BEMUs	Design Decision		Ardanuy		19/04/2022	Power transformer — Deviation in the design criteria from that established in the HV FRS: Primary voltage (38 kV --> 10 kV).		Following the change in the voltage level of the power supply to the BEMU charging station.	
	HV	Marsh Road car park	BEMUs	Design Decision		Ardanuy		19/04/2022	Auxiliary transformer — Deviation in the design criteria from that established in the HV FRS: Primary voltage (38 kV --> 10 kV).		Following the change in the voltage level of the power supply to the BEMU charging station.	
	HV	Marsh Road car park	BEMUs	Design Decision		Ardanuy		29/04/2022	Rectifier — Deviation in the design criteria from that established in the HV FRS: Type (uncontrolled --> controlled).		With a controlled Thyristor Controlled Rectifier (TCR), the power drawn from the 10 kV ESBN power supply can be smoothly regulated. This requirement for the rectifier will ensure compliance with the restrictions for load increase/decrease rate at the Point of Connection to the 10 kV ESB network.	
	HV	Marsh Road car park	BEMUs	Design Decision		Ardanuy		29/04/2022	Rectifier — Deviation in the design criteria from that established in the HV FRS: Duty class (VI --> I).		With duty class I, the rectifier is suitable for a continuous duty, which would be suitable for the constant-current charging profile of the BEMU as informed by Alstom.	
	HV	Marsh Road car park	BEMUs	Design Decision		Ardanuy		29/04/2022	Power transformer — Deviation in the design criteria from that established in the HV FRS: Duty class (VI --> I).		As a fallout of the duty class defnied for the rectifier.	

For Approval

	HV	Marsh Road car park	BEMUs	Design Decision		Ardanuy/Arup	[redacted]	29/04/2022	ESS — Assumptions for sizing and specification of the ESS are as follows: - Life cycle required ≥ 5 years - Expected charging cycles through the ESS: 3 charge-discharge cycles/day, one train comprising 2xHLU charged in every charging cycle. - The recharge of the ESS through the transformer-rectifier follows the load change restrictions at the 10 kV Point of Connection informed by ESB..		Life cycle: based on the expected timeline of the DART+ Project. Specifically, the timeline for the BEMU program and the New Electrification Program on the Northern Line (Malahide - Drogheda). Expected charging cycles through the ESS: In line with the assumptions in the BEMU Operation and Charging Concept document. Charging of the ESS: As a fallout of the restrictions for load increase/decrease rate at the Point of Connection to the 10 kV ESB network.	

For D

Appendix B

Comment Sheet

DART+ Coastal BEMU - SET ELE HV TEL Package
Technical Review Record

Report: DART+ Coastal BEMU Project - SET ELE HV TEL Package (docs listed in 'Sheet 1')
Received: 27/05/2022

No.	Comment By	Document	Doc Section Ref	IE Comment	Consultant Response	IÉ Comment (P02)	Consultant Response to IÉ Review		Issue Status (Closed)
1	[redacted]	SP-HV-000001 B2 Tech Spec Electrical Equipment	2.6	Do the characteristics define the curent and dischcarge rate to be achieved by the ESS (such as a C Rating)?	The charge/discharge requirements for the ESS are to be derived by the manufacturer of the ESS from the charge/discharge requirements of the BEMU (which are indicated in this report and related documents in terms of charging current and time, c-rate, and expected daily operation of the BEMU charging station).				Yes
2	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	1.1	"The new 1600mm-gauge 1.5kv dc trains will be 82m-long with capacity for 550 passengers with walk through gangways.", revise sentence, as you might refer to rail guage.	It has been rephrased for clarity: "The new 1.5kv dc trains suitable for a 1600mm gauge will be.."				Yes
3	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	1.1	As pe[redacted]comment above, if describing the train characteristics, the 1600mm-gauge should refer to the track gauge. In the sentence it could be misconstrued that the gauge of the train itself is 1600mm?	Same as above.	No further comment.			Yes
4	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	4.3.1	"... maintaining enough horizontal distance between the conductor rail to the footbridge." What is the horizontal clearance to OBB81C and how has this been verified (i.e. why is the mesh being replaced if we are maintaining enough horizontal clearance - is there a potential opportunity here?)	According to survey of Drogheda station, the horizontal distance between the end of the rail conductor and the deck edge shown in the topography is 2.24 m. However, looking at pictures of the overbridge, the current parapets are closer to the conductor rails. The horizontal distance between the end of the rail conductor and the roof edge, which is the closest line shown in the topography, is 1.24 m. Minimum horizontal clearance from standing surface to live parts for 1.5kV dc is 1.45 m according to figure 3 of standard EN 50122-1. Therefore, existing footbridge mesh of footbridge OBB81C is proposed to be replaced in order to increase the safety measures. It should be replaced in any case with the full electrification.	Response needs clarification. Is the 'Minimum horizontal clearance from standing surface to live parts for 1.5kV dc is 1.45 m according to figure 3 of standard EN 50122-1' achieved, or is there only 1.24m? If the required distance is not achieved, what will be done? If addition section/s as per DDR-P02 comment 1 can be provided, this will likely clarify.	we will provide a longitudinal section around the area of the footbridge in order to define the distance between the OCR and the nearest footbridge element.	No further comment.	Yes

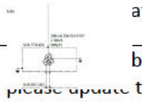
5	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	4.3.1	Where existing footbridge mesh is to be replaced, note that bottom 1.2 m is to be solid with IP2X mesh above this level as advised by STSE.	Noted. Text to be reworded in the drawing and in the report	Drawing D+WP56-ARD-P3-BE-DR-EL-000002 Sheet 2 of 4 not updated to reflect solid 1.2m parapet in either text or drawing.	Drawing to be updated	No further comment.	Yes
6	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	1.1	Other than Drogheda, what terminus station has charging? "Energy will be replenished via charging stations at selected terminus locations"	The only BEMU charging station foreseen so far is Drogheda. A clarification has been added to the text in the report in this sense.	Noted			Yes
7	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	3.3.3.2	"primary voltage and lass" typo?	Fixed. It meant "duty class".	Noted			Yes
8	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	3.5.1	"It is intended to charge simultaneously up to 4 HLU's battery trains; one through the charging station directly and one through the Energy Storage System (ESS)", should it state 2 by HLU through the charging station dorectly and 2 by HLU through the ESS?	That is correct. Fixed.	Noted			Yes
9	N/A		N/A	N/A	N/A				Yes
10	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	3.5.1	"However, space provision will need to be made in the MV switchboard for any future backup connection." Was a location not also selected and space to be made in cable ducts?	By the time a gen-set was being considered, the tentative location for it was by the existing fuel tank at Drogheda. However, considering that the gen-set was dropped from the design of the BEMU charging station, no precise location for it was in the end defined or specified. The cable ducts running from the charging area/depot to Marsh Road car park have been sized considering a space reserve for the connection of a gen-set to the substation.	Noted			Yes
11	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	4.3	"The current design has been made assuming that the OCR will be replaced and there will no longer be charging BEMUs when OHLE is installed in Malahide-Drogheda section as part of the DART+ Coastal electrification works" This will create a challenge for maintaining BEMU operations while commisioning and a new OHLE system on platforms 2&3? Before this is agreed to, do we need to know how BEMU operation will be maintained while Mainline electrifcation is be commisioned?	The assumption made is that BEMUs will not be required once the electrification between Malahide to Drogheda is finished and EMUs will replace the BEMUs. The period while new electrification is installed and commisioned and the BEMUs charging facilities are dismantle need to be assessed in the electrification design. In principle the process should be done in stages, track by track around the operating BEMU service.	Its still not clear how this will be achieved.	OCR structures will be optimised for the design of the BEMU charging. OHLE design will be designed to ensure that the wiring is efficiently laid out and such that the decommissioning of the OCR and erection of the contact wire is eased. This may mean that the OCR structures are made entirely redundant.	Comment closed for the purpose of this doc only. IÉ PM team should ensure this is picked up in detailed design for BEMU and EMU project minimise wasted effort	Yes

12		...RP-HV-000002 B2 SET Prelim Design Rpt	4.3	"The design developed has only considered the OCR loads. The Preliminary Design of the electrification will assess if the masts can be reused for final electrification and, in that case, foundations and masts will be designed to withstand the OHLE loads." Will a dresign be done at that point if they cannot or is it too late in the BEMU phase deisgn process? Seems strange to to design for both cases. Will the old foundations be dug up or more foundatiosn be dug on the platform?	The preliminary design of the new electrification in Drogheda station is not developed yet as there are some elements still to be defined (modification of footbridge OBB81, track alignment, loads, etc.), so if the OCR structures can be reused they will but it is not assessed yet. The paragraph has been reworded		We maintain that it is not possible to make allowance for the future OHLE arrangements	Comment closed for the purpose of this doc only. IÉ PM team should ensure this is picked up in detailed design for BEMU and EMU project minimise wasted effort	Yes
13	N/A	...RP-HV-000002 B2 SET Prelim Design Rpt	N/A	N/A	N/A				Yes
14	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	repot title	as this in the ner future will be going via I-SET-9100, rename the pack to "Dart+ Coastal- BEMU Project- OHLE, HV, SCADA, E&B & IESS Design Package"	The suggested pack name has been incorporated in the title of the report.	The overall submission should be renamed to be aligned with the deliverables tracker and the intended purpose of the deliverable	Packaging of deliverables has been done in accordance with the direction of the project team in order to expedite the review process.		Yes
15	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	general	add a section as appendices in the report for "Design Decision Log" which is a log of all decision been made in the making of the design	Appendix 1 — *Design Decision Log* was added.				Yes
16	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	general	add a table in the report listing all the drawings for this submission, their relevant numbers, number of pages, etc	Section 1.3 *Related Documents* was added, under which the rest of the preliminary design documents for the BEMU charging station are listed out.				Yes
17	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	general	how will the user requirements for electrification and HV team will be captured? will a section in the report added called the user requirements specification?	The Charging Control Requirements Specification document already contains the user requirements for the BEMU charging station.	this comment closed for now. However, my understanding there is seperate parallel discussion to discuss this matter.			Yes

For

18	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	general	as this submission will be the basis of prelim design for HV and OHLE, include the report and the results for Dart+ Existing+ BEMU as apprendices to this submission. As the power study required to valid prelim design.	The design of the BEMU B2 substation is based on documentation that has already established that the BEMU charging time (18.6 min), charging profile (as informed by Alstom), and the expected operation of the BEMU charging station (in terms of number and simultaneity of BEMUs to be charged). Under this understanding, the basis of design for the BEMU B2 substation is irrespective of results of the simulations referred to (Dart+Existing+BEMU). Simulations for BEMU operation are pending approval, so at the moment there is no simulation report of the kind mentioned that may be attached to the B2 preliminary design report and in any case independent of the substation design.	if the BEMU similation are to be done by othersplease clearly state in the report that the similations or power study for BEMU integeration within the electrified lines are outside the scope of this submission	The simulation of the BEMU is outside of the scope of this document and the BEMU substation project. The requirements for the substation operation are only defined by the 400A pantograph current and the charging time.	comment closed for the purpose of this doc only	Yes
19	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	1.2	"This report is to be read in conjunction with the BEMU B2 Substation - SET Preliminary Design ReportD+WP56-ARD-P3-BE-RP-HV-000002, w", as this submission will be the prelimary design for hv and OHLE, it would make sense to merge the two submission under ""Dart+ Coastal- BEMU Project- OHLE, HV, SCADA, E&B & IESS Design Package", please advise?	The document structure proposed for the preliminary design of the BEMU charging station comprises the main design report (now renamed as "Dart+ Coastal- BEMU Project- OHLE, HV, SCADA, E&B & IESS Design Package"), which is accompanied by a series of complementary design documents (the list of complementary documents of the BEMU B2 substation is now found on section 1.3 of the main report). One of such documents is the Technical Specification. It is usual practice to have the TE (which goes into more detail of the specifications of the equipment to be installed) as a separate document from the main design report (where the more general aspects of the equipment to be installed can be found), so that the main design report can be a concise document that spans over the different design aspects and links the different complementary design documentation. We would advise to keep the main design report and the TE as separate documents.	comemnt closed for prelim design purposes only			Yes

For

20	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	Table 2.2	The LV side of the transformer proposed here while in FRS, my understing, please see below:  would that be an issue? could the output of the transmormers be similar? or from your experience ats not possible?	It has been changed to the value shown in the FRS. The manufacturers may have different intermediated voltages between the power transformer and the rectifier. That is irrelevant to the design, because what matters in the end is the output voltage of the rectifier (in this case, the 1500 Vdc).	Noted, comment closed for prelim design stage			Yes
21	[redacted]	...DR-HV-000003 Charging Station SLD	general	 been provided by myself on the SLD, please update the SLD as per the comments/discussion provided on this diagram	The SLD has been updated according to the comments.	comment closed for prelim design stage.			Yes
22	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	general	although the sectioning diagram for the BEMU is quiet small. Hoever, its required as it the schematic in a clear format	The sectioning diagram for the BEMUs is included in the Drogheda BEMU Charging Station Single-Line Diagram drawing (D+WP56-ARD-P3-BE-DR-HV-000003), so it was not considered to develop and independent drawing only for the OCR sectioning	comment closed for prelim design stage.			Yes
23	N/A		N/A	N/A	N/A				Yes
24	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	general	my understanding, ESB will impose a gradual step up demand on their network at drogheda charging station, what mitigation been factored in within the design to allow for such demand restriction?	The use of a Thyristor Controlled Rectifier (TCR) - as opposed to a non-controlled rectifier based on diodes - whose load demand from the 10 kV ESBN power supply can be smoothly regulated. As stated in the report, this type of controlled rectifier will ensure compliance with the restrictions for load increase/decrease rate at the Point of Connection to the 10 kV ESB network.	comment closed for prelim design stage			Yes
25	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	general	I noticed for example the Diesel generator have different nomial volatge than the one provided in the FRS, other component also, I understand the input volateg from ESB will change the specification for TTR and ATR. however, the compoenents on the LV side or the secondery part of the TTR and ATR, could those be in line with FRS? mainly for ease of hold of maintenance parts and consistency for future projects/maintenance procedure.	The voltage output of the auxiliary diesel generator is 400 V, which is the nominal voltage for the LV power distribution as per the FRS. In general, when it comes to the auxiliary services installation (LV power supply) for the substation, the only parameter that changes with respect to the FRS is the primary voltage of the 80 kVA auxiliary transformer. Every else downstream such transformer, including the 80 kVA diesel transformer, the main LV 400/230 Vac panel, the essential 400/230Vac panel, the essential 100 Vdc panel, the UPS and the	comment closed for prelim design stage			Yes

					battery chargers remain unchanged with respect to the FRS.				
26	[redacted]	...DR-HV-000004 Earthing System	general	I could only see a drawing regarding the general earthing arrangment i.e. exterior for the substation. How about the E&B due to OHLE i.e. OCLZ and CCZ? Should you not provide a drawing to cover that purpose?	The OCLZ and CCZ are described in Section 4.5 of the report. In any case, drawing showing the OCLZ and CCZ areas in the OCR cross sections is to be developed	awaitng updated drawings.	Updated drawing for the OCLZ and the CCZ areas are being produced separately.	comment closed for the purpose of this doc only	Yes
27	[redacted]	...SP-HV-000001 B2 Tech Spec Electrical Equipment	general	please advise on where the EMC will be covered?	The most relevant EMC issues around the BEMU charging station, which are the interferences with the signalling system, have been addressed in the document D+WP56-ARD-P3-BE-RP-SL-000001 Signalling considerations for enabling Drogheda as charging point for BEMUs.	EMC should also be discussed briefly in this submisson	A section on EMC compatibility will be added to the report particularly in relation for conducted and radiated interference and also with regard to the generation of harmonics in the DC circuit and into the supply.	comment closed for P0 version only	Yes
28	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	figure 1	not clear, please provide a better quality figure	An image has been updated for one with a better quality.				Yes
29	N/A		N/A	N/A	N/A				Yes
30	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	3.2	update the table as per the latest standards issued example 4004 is missiong.	This standard has been included in standard table shown in Section 4.6.				Yes
31	[redacted]	...DR-HV-000002 SCADA Architecture	3.4.1	Is this relvant? 	It is important, because the short-circuit level at the point of connection depends on the configuration of the distribution network that is supplying the substation. Any parameter of the electrical design of the substation that is dependent on the short-circuit level at the point of connection (e.g., earthing grid, electrical protection coordination) will require to consider either the max. or min. short-circuit level. So, provided that ESB has informed such information already, it would be good to leave it there for reference for this and future design phases.				Yes

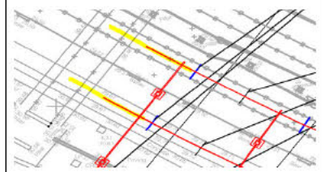
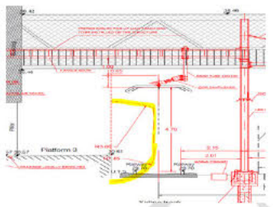
For

32	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	general	Although the OHLE Layout plan and crossections are quiet minimal, provide as appendices for this submission	The OCR drawings have been added to the list of documents shown in Section 1.3 of the report	noted, comment closed for prelim design stage only.			Yes
33		...DR-HV-000002 SCADA Architecture	General	Depot Road 4 is not shown. Will the same SCADA Architecture be used?	The scheme is indicative of the SCADA architecture, but it indeed applies to all the charging roads, including Deport Road 4.				Yes
34		...RP-HV-000002 B2 SET Prelim Design Rpt	4.2 4.3	Are FLUs still being considered in the OCR design? Please refer to email from Patrick Conway to Chris Cox and Rob Snell on 11 March 2022 and comments on the BEMU Requirements Register.	FLUs were considered originally in the OCR design as per RFI's D+WP56-ARP-P3-BE-RI-KX-000169 and D+WP56-ARP-P3-BE-RI-KX-000170. Later on, we were informed no FLU will be used in the operation of the BEMU program. However, in order to make possible to operate with FLU, if doing so is ever needed, the original OCR design has been maintained. This is explained in Section 4.2.1 of the report. Additionally paragraph 4.3.1 has been reworded.				Yes
35		...RP-HV-000002 B2 SET Prelim Design Rpt	General	Why do the the page numbers start from 0 or 1 at the start of each chapter/section?	It has been fixed so as to have a continuous numbering across the document.				Yes
36		...RP-HV-000002 B2 SET Prelim Design Rpt	3.3.1	Is cooling equipment required for extreme circumstances, i.e. high air temperature combined with the heat generated by the equipment inside a steel container? This comment also applies to various sections of BEMU B2 Substation - SET Preliminary Design Report (D+WP56-ARD-P3-BE-RP-HV-000002).	The cooling requirements of the equipment is specified in the Technical Specifications. It is up to the manufacturer of the equipment to validate these requirements and up the manufacturer of the containers (assuming it is a different manufacturer) to define the requirements of the very containers that will allow to meet those of the equipment installed inside them.				Yes
37		...SP-HV-000001 B2 Tech Spec Electrical Equipment	2.3.1 Table 3	How can a "Max. permissable temperature" be "At least 40°C"? Should it not be just 40°C?	It has been amended to rather indicate the ambient temperature that needs to be considered for the design of the TCR: -20°C to +40°C.				Yes
38		...SP-HV-000001 B2 Tech Spec Electrical Equipment	2.6 Table 6	Discharge voltage threshold - is 1400Vdc sufficient for 1500Vdc OCR charging?	The values of 1400 Vdc and 1600 Vdc in the table are the thresholds corresponding to an ESS with nominal voltage of 1500 Vdc. These thresholds can be adjusted and that will be set by the ESS manufacturer of the ESS so that there is an optimum charge/discharge control of the batteries of the ESS.				Yes

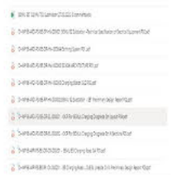
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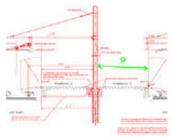
DART+ Coastal BEMU - SET ELE HV TEL Package
Technical Review Record

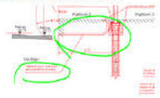
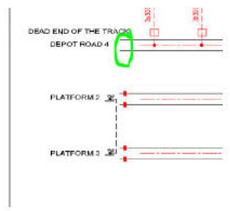
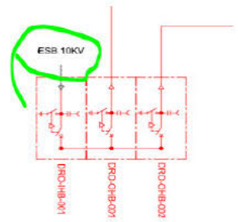
Report: DART+ Coastal BEMU Project - SET ELE HV TEL Package (docs listed in 'Sheet 1')
Received: 02/08/2022

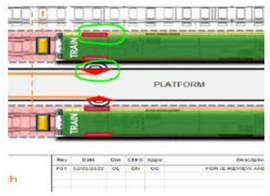
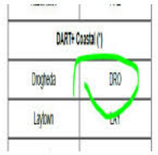
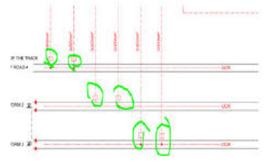
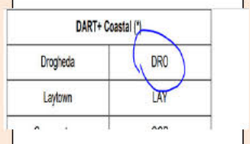
No.	Comment By	Document	Doc Section Ref	IE Comment	Consultant Response	IÉ Comment (DDR2)	Consultant Response to IÉ Review	IÉ Comment (IDC)	Consultant Response to IÉ Review	Issue Status (Closed)
1	[redacted]	...DR-EL-000002 OCR For BEMUs Charging Drogheda Stn X Sections	General	Would it be possible to show a longsection or two that would detail the location of the solid conductor rail and any live OHLE equipment, in relation to the footbridge to confirm the required clearances between the infrastructure are achieved? Show electrical clearance envelope according to figure 3 of standard EN 50122-1 on the footbridge. Section/s to be taken along highlighted line/s.  	A longitudinal section around the area of the footbridge is provided in order to define the distance between the OCR and the nearest footbridge element.	No further comment.				Yes
2	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	Table 1	Add CCE-TMS-410 Civil Engineering Structures Design Standard	Standard is shown in Table 4 of the document.	Now Table 9: No further comment				Yes
3	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	3.7	Para 1: Check reference to Figure 8	Reference has been fixed.	Ther are 3 No. Figure 3's in the report	Numbering of figures across the document has been fixed.			Yes
4	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	3.7	Drainage?	Additional text outlining the approach for drainage added.	No further comment				Yes
5	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	Project Abbreviation	update the table to include only the releated abbreviation for this report.	Abbreviation table has been reviewed.					Yes

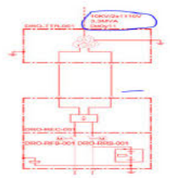
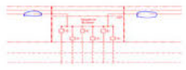
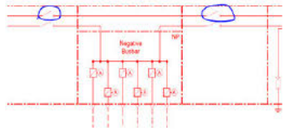
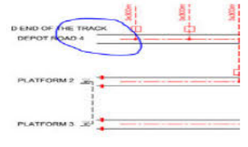
6	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	1.1.	" including reference design (Phases 3 & 4) and detailed design and tender preparation (Phase 5a). ", avoid the use of reference design and use prelimary design instead.	Change has been implemented in the document.					Yes
7	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	1.2.	"The design of the sub-station is covered in package “B2 Sub-Station”.", reference the correct document number, name as per the latest submission	Reference has been updated.					Yes
8	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	General, 2.1.	could you provide photo also for platform 2?	The photo of platform 2 is included.					Yes
9	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	2.2.1.1.	provide a crosssection or schematic for the buried muiltiduct, this would need to show what cables you are planning to put in this multiduct system i.e. for example 1.5k.v cables, negative return, LV, telecom, etc, and how deep the troughing route.	Additional text will be included to specify criteria for cable segregation. However, the precise cable arrangements will be left to the contractor to avoid unnecessarily constraining the design.					Yes
10	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	2.2.1.1.	"The steepest section of this slope is approximately 1 in 2. It is possible for the troughs to be secured to the ground with stakes if movement was of concern. In addition, the troughing can be laid on the surface if required. ", would this not create safety risk by placing 1500dc cable not buried in the ground? i suggest you run the proposal with CCE &SET	The slope on the abutment is understood to be at risk and as agreed, surface or partially buried cable routes will be sufficient to ensure mechanical protection of the cables. The provision of ground level identification markers will be added to ensure sufficient notice of presence of cables without attracting undesired attention.	please create hazard in the project hazard risks regarding the 1500vdc and the mitigation proposed to avoid danger	No hazard exists as the risks are fully mitigated by a lockable trough and it is located in a fenced area.	comment closed based on MDC assessment.		Yes
11	[redacted]	...DR-HV-000002 SCADA Architecture		has the max distance for cat 6 cables been exceeded between substation and RFID readers, or is scada cabinet much closer to platforms than substation? Not sure where SER is but same question	Additional information has been added to clarify how the connection between the RFID and the SCADA is to be implemented.	noted				Yes
12	[redacted]	...DR-HV-000002 SCADA Architecture		"RFDI", RFID typo? 2 places.	Corrected.	noted				Yes
13	[redacted]	...DR-HV-000002 SCADA Architecture		should drawing reference NTCC rather than CTC?	Drawing has been updated to reference NTCC and CTC.	noted				Yes
14	[redacted]	...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report	3.3.3.	Please refer to the "Dart+ West-OHLE Structure Design Report for further information on the wind speed, etc. Update the document	Document will be updated upon early receipt of design information on wind speed. It is understood	The information was shared with the CRE months ago, please refer to the relevant CRE for further info.	The document was updated according to information included in Dart+ West- OHLE			Yes

	[redacted]			to reflect the shared design report.	that this superseds the information contained in the Electrification FRS.		Structure Design Report.			
15	[redacted]	...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report	2.2.2	"via pole mounted VLD according to EN 50122-1.", should you not also specify a type as per FRS?	A voltage-limiting device VLD-F shall be used to make an open connection from the exposed conductive parts to the return circuit to create a short-circuit path and in consequence to cause the interruption of the current in a short time to keep the voltage within the limits given in Table 6 or in 9.3.2.3 of EN 50122-2.					Yes
16	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	SHEET 01 0F 02	is this possible to have 1500v dc cable with the negative returns, etc using GRP eleveated route? would seperation between cabes achieved? also would this not going to cause safety/maintenance issues? please provide example and previous project experience on any similar design/environments for IDC discussion.	Elevated cable routes are a recognised approach where buried cables are not preferred where distrubing ground is to be avoided. The cables will have the necessary mechanical protection.	please add to the project hazard record with mitigation implementaion to avoid risk/danger.				Yes
17	[redacted]	...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report	Appendix A	Appendix A table, please see screenshoot below:  Is not aligned within what submitted within this package, please see below:  Please align.	The drawings listed in the table are those identified are relevant to the B3 design report, however the report was reviewed separately and the project opted to include in this package for context and completeness					Yes

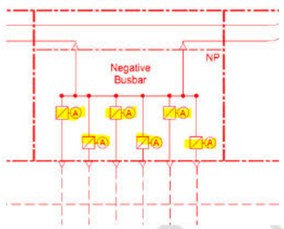
18	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	SHEET 01 0F 02	should this not be a UTX? advise? 	The cable route is under the viaduct arch and not an UTX.					Yes
19	[redacted]	...DR-EL-000002 OCR For BEMUs Charging Drogheda Stn X Sections	sheet 01 0f 04	provide distance between structure and platform edge 	Dimension have been added.					Yes
20	[redacted]	...DR-EL-000002 OCR For BEMUs Charging Drogheda Stn X Sections	General	No representation for EW and FW, why? Also, please provide PRELIM crossection showing the TFSC connection to the OHLE.	Additional details have been added.	please advise on the feeder cable connection for siding track and Up Main OCR. also, i noticed no cable route for feeder cable on the Up Main OCR, is this correct? as the one on the siding track it seems only for bonding sturcture to track, please advise	The feeder cables (insulated cables) are routed between the siding track and the service slab track. For Up Main OCR, the feeder cables are installed from that cable route up to the OCR supported on the proposed portals. OCR switches are proposed to be located in the mast of the portal located at siding track side. From the switch to the OCR, the insulated cables are supported along the portal beam.			Yes
21	[redacted]	...DR-EL-000002 OCR For BEMUs Charging Drogheda Stn X Sections	D+WP56-ARD-P3-BE-DR-EL-000002 SHEET 4 OF 4	The feeder wire resporesentation is not clear, please provide a clearer representation, also if i understood correctly, would this not infridge CCE standards of not having live elements over passenger platforms?	The feeder cable is insulated and mechanically protected on the beam. There are no live elements over the platform. The precise cable arrangement on the structure is to be decided by the contractor observing the defined constraints.					Yes

22	[redacted]	...DR-EL-000002 OCR For BEMUs Charging Drogheda Stn X Sections		please advise on the purpose of this connection? 	The duct is provided for the bonding cables to the track.				Yes
23	[redacted]	...DR-EL-000001 OCR For BEMUs Charging Drogheda Stn Layout	Sheet 1 of 1	should IRJ not clearly shown in this drawing? mainly t mark the boundary of the charging tracks, etc.	IRJs are covered in the signalling scope and part of that preliminary design report.				Yes
24	[redacted]	...DR-HV-000003 Charging Station SLD	1 of 1	should there not be IRJ here? 	An IRJ at the end of depot road 4 has been added, regardless of the results of the site survey that is pending.				Yes
25	[redacted]	...DR-HV-000003 Charging Station SLD	1 of 1	should this not be red also? 	Corrected.				Yes
26	[redacted]	...DR-HV-000002 SCADA Architecture		replace IESD with IESS, apply comment accross the submission. Also, my understanding the IESS requirement as per FRS are not to be provided for BEMU substation and if any emergency shut down are to be provided, then the functionalities would be as per existing, please advise.	The term has been amended in the document. In line with the understanding that the IESS requirements are not extensive to the BEMU charging station, the existing functionalities of the IESD as described in the HV FRS will be incorporated into the SCADA of the BEMU charging station. The updated SCADA architecture diagram has been updated to reflect such changes.	please refer to the recent RFI responses regarding IESS functionliaties.	Considering the answer to D+WP56-ARP-P3-NL-RI-KX-000298, the BEMU B2 Substation - SET Preliminary Design Report has been updated (specifically, Section 3.9 SCADA Preliminary Design). The SCADA Architecture already show that IESS elements (i.e., EPO) are to be installed at the charging substation.			Yes

27	[redacted]	...DR-HV-000002 SCADA Architecture		please advise which element would be located on train and which will be located on track/platform for the items highlighted in green? 	The reader is located trackside and the tags are to be mounted on the BEMU underframe or the solebar. The precise location will be dependent on the BEMU designer. (Does this need to be clarified in the ICDD?)	it would be ideal to add a note in the IDC version regarding the location of these devices.				Yes
28		General Comment		is stary current monitoring device are to be provided for the BEMU charging locations?	Stray current control to be provided as per HV FRS, as stated in the B2 Preliminary Report.	Noted, could this be shown in SLD IDC version?	The basic elements of the measuring station for stray current control are included in the SLD.	comment closed for preliminary design stage. comment to be discussed further at D&B		Yes
29		...DR-HV-000003 Charging Station SLD		according to table 25, FRS electricity, please see below:  The abbrevisation for "DRO" are for Drogheda substaion and not BEMU, ease use different abbreviation for BEMU Sub	The SLD has been updated according to with the suggested coding.	the abbreviation used are the same as the ones allocated to Drogheda substation, please advise as every substation needs to have different naming				Yes
30		General Comment		ADD a note within the report to state the BEMU substation design is not in line with FRS drawing "MAY-MDC-HVP-DART-DR-E-0002 Sheet 1 of 1	Note has been added.					Yes
31		...DR-HV-000003 Charging Station SLD		are these MOS switches? please provide names for these switches 	Label will be added.	noted. However, in the FRS TABLE 25, DRO shall be used for Drogheda substation and not BEMU substation, please advise on alternative name	An alternative code for the BEMU charging station at Drogheda has been used ni the SLD: DRO_BEMU.	comment closed for preliminary design stage. 		Yes

32	[redacted]	General Comment		Has a confirmation from SET been given whether the provided Switches are Mototised or not moorised with SIL indication for BEMU?	The intention is for manually operated switches. Indication of the switch position shall be provided to SCADA for logging and indication to ECO.				Yes
33		General Comment		add IE OHLE and HV standards, the tables are not up to date example IE-ETR-4004	Relevant standards are added in Sections 3.2 and 4.6 of the document for the substation and OHLE, respectively.				Yes
34			N/A	N/A	N/A				NA
35		...DR-HV-000003 Charging Station SLD		As like transformer, please include the details of rectiier unit. 	Details of the rectifier have been added to the SLD.	Okay noted			Yes
36		...DR-HV-000003 Charging Station SLD		Please clarify the beneifit of providing two isolators on positive line on its way to ESS where its both end provided with a circuit breaker 	That is provided so that the negative cubicle can be used independently by either the transformer-rectifier or the ESS. However, the SLD has been reviewed as part of a rationalisation of the design.	Comments noted and closed at this stage.			Yes
37		...DR-HV-000003 Charging Station SLD		Does it really require marked isolators on negative line ? 	Same as above.	Comments noted and closed at this stage.			Yes
38		...DR-HV-000003 Charging Station SLD		IRJ missing on Road 4 	An IRJ was added to the end of depot road 4 .	Okay noted			Yes

39	[redacted]	...DR-HV-000003 Charging Station SLD		Are these lineside switches are always closed? 	Lineside manually operated switches are normally closed and only opened during isolations.	Okay noted.				Yes
40	[redacted]	...DR-HV-000003 Charging Station SLD		Doesn't it require a VLD (o) at substation level?	It is required to minimize safety risks at the substation compound. The correponding note has been added to the document.	Okay noted				Yes
41	[redacted]			Communication channel fro electrification is available till Malahide . There is no communication channel / fibre provide between Malahide & Drogheda. How the SCADA communication achieved in this section?	According to some discussions with IÉ, there seems that a dark cables does may exist between Malahide and Drogheda, which is the understanding and assumption the SCADA architecture was based on.	Okay noted				Yes
42	[redacted]			No details of IESD operation strategy	In line with the answer to comment no. 26 above.	Okay noted				Yes
43	[redacted]			The document stating about the rating of TCR as 3.6MW and transformer capacity as 3.3MVA please clarify	Power rating of the rectifier transformer to account for the harmonics produced by the rectifier downstream.	If so, the capacity of rectfier transfomer should be higher that the rectfier unit. Here the tranforemer rating is 3.3 MVA and rectfieier unit is 3.6MW. Is the rating of the rectifer 3.6MW correct?	The power rating of the controlled rectifier is 3.0 MW. The rating has been corrected in the technical specification document.	Okay Noted		Yes
44	[redacted]			DC switch gear rated voltage mentioned as 1800V. Our system voltage is 1500V	The decision to charge the BEMUs at 1500 Vdc instead of 1800 Vdc was informed to us. The design has been amended accordingly.	Comments noted and closed .				Yes
45	[redacted]			Please include the type of rectifier bridge connection i.e; series or parallel	The connection of the bridges is in parallel. The SLD will be amended to indicate so.	Okay noted				Yes

46	[redacted]			The traction transformer rectifier group class is mentioned as Class-1, but traction purpose it is generaly used as class VI.	With duty class I, the rectifier is suitable for a continuous duty, which would be suitable for the constant current charging profile of the BEMU as informed by Alstom. A duty class I rectifier would not necessarily suit a different application that does require overloading capabilities of the rectifier, such as traction power supply.	Okay noted				Yes
47	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt		Typo SET Preliminary Design Report" title says : "Iranrod Eireann"  	Report text updated.	Okay noted				Yes
48	[redacted]	...DR-HV-000003 Charging Station SLD		Does it really require current measuremnet on all the negative return cable?  	It is a usual practice to measurement the traction return current flowing through each return cable coming in the negative cubicle. That way it is possible to verify that the traction return current is consistent with the traction power output of the substation, as well as detect and locate failures on the return circuit.	Okay noted.				Yes
49	[redacted]			Does the controlled rectifier control for output or input	The controlled rectifier is able to create the output characteristic according to a pattern saved into memory or according to the instantaneous external reference value.	Okay noted.				Yes
50	[redacted]			Clarify that the connection between the CTC/NTCC is via the SCADA network	A note has been added to the report and the SCADA architecture drawing has been updated accordingly.					Yes

51	[redacted]			RFID function - is this to be viewed as a vital function?	The switching of the OCR is not considered a vital function.	OK			Yes
52				Difference between FLU and two HLUs coupled	The pantograph position relative to the vehicle ends is different for the FLU compared to the HLU, hence this is considered in the geometry of the OCR.	Okay noted			Yes
53				Piling difficulties for centre of platform might require a set of mini piles due to the reach using mini tracked rigs.	The possibility of using an alternative piling method will be noted in the B3 document 3.2.2.				Yes
54				MOS indications of blade position	The SCADA will detect and provide indication of the isolation switch blade position. Additional has been added to the report and drawing labelled.	Okay noted.			Yes
55				Container acces and security strategy for compound	Additional text will be added defining the access control strategy to be implemented.	Okay noted.			Yes
56				ECO camera monitoring of charging roads and compound possibly required - further clarfication expected on the platform monitor.	IE to provide further direction, however the assumption is that the actual charging process would have an overseeing monitor capability.	As we are introducing new equipment into the network, there may be an operational advantage for the ECO to be able to observe the charring facility for the trains especially if a fault occurs. With regard to Substation compounds a CCTV camera is required.			Yes
57				Bonding between return rails	Additional bonding has been included between the running rails as part of a rationalisation of the design.	Okay noted.			Yes
58				Auxilary transformer substituted by a LV supply	Consideration shall be given to utilising a local LV supply for the auxiliary loads. However, depending on the voltage level of the LV power supply as an alternative to a power supply at 10 kV, a step-down transformer may still be required, which in the end would result	okay.			Yes

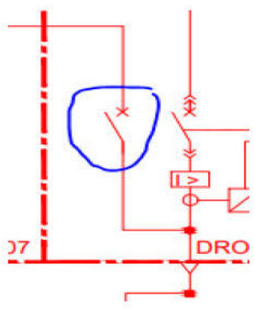
					on the same level of investments for the LV auxiliary installation of the substation.					
						New comment "TO BE ADDRESSED AT IDC Stage"				
59	[redacted]	...DR-HV-000003 Charging Station SLD	sheet1			DC panel showing 2 DC bus . Please clarify purpose of keeping two DC bus.				
60		...DR-HV-000003 Charging Station SLD	sheet1			Does the surgearrester placed at the correct location of the DC switchgear unit?				
61		...DR-HV-000003 Charging Station SLD	sheet1			Each DC switchgear cubicle showing 2 withdrawable unit. please clarify?				
62		...DR-HV-000003 Charging Station SLD	sheet1			Is there any requirement for hamonic filtering unit?				
63		D+WP56-ARD-P3-BE-DR-HV-000002, SCADA architecture				Drawing legend unclear. Is it proposed copper/CAT6 connection from the platform to the substation? Or is it a combination of communications medias? Would it be preferable to have a fibre connection here as to avoid any electrical interferences and distance issues? Depending on the RFID system proposed, this may require additional network switches/media converters.				
63		D+WP56-ARD-P3-BE-DR-HV-000002, SCADA architecture				Drawing shows the connection between charging depot and Malahide Substation. Would this not be a connection into the Telecoms Relay Room in Malahide? Malahide TPH would also be the next location in line				

						with the train network. To be confirmed with Telecoms/Tom Q				

For DRN

DART+ Coastal BEMU - SET ELE HV TEL Package
Technical Review Record

Report: DART+ Coastal BEMU Project - SET ELE HV TEL Package - IDC2 v5
Received: 14/11/2023

No.	Comment By	Document	Doc Section Ref	IE Comment (IDC)	Consultant Response	IÉ Comment (IDC2)	Consultant Response to IÉ Review	IÉ Comment (IDC2v2)	Consultant Response to IÉ Review	IÉ Comment (IDC2v3)	Consultant Response to IÉ Review	IÉ Comment (IDC2v4)	Consultant Response to IÉ Review	IÉ Comment (IDC2v4.1)	Consultant Response to IÉ Review	IÉ Comment (IDC2v5)	Consultant Response to IÉ Review	Issue Status (Closed)
1	[redacted]	...DR-HV-000003 Charging Station SLD	sheet1	DC panel showing 2 DC bus . Please clarify purpose of keeping two DC bus. 	The separate bus is to provide a redundant configuration in the event of failure of HSCB. This explanation was accepted in the IDC meeting.	Please clarify if the below is an isolator Switch or an MCB. This Switch does not appear to be connected with an EPR 3.3.4.5 in the HV FRS does not include a redundant busbar. The logic behind the additional bus bar is not clear. Section 3.3 does not include the design criteria for the additional bus bar.	As discussed in the IDC, the bypass provides a level of redundancy in case of a failure of the HSCB. This detail has been part of the design since P03. We are deviating from the FRS for the BEMU substation design where it is not appropriate. No change to the design. The report has been updated to include this in section 3.3.5 Charging Section.	Comment to be dicussed and agreed during detailed design stage.										Yes
2		...DR-HV-000003 Charging Station SLD	sheet1	Does the surgearrester placed at the correct location of the DC switchgear unit?	The surge arresters have been relocated so as to have them outside the cubicle. The number of surge arresters has been reduced by using one surge arrester per each of the 6 OCR feeders.	Okay noted												Yes
3		...DR-HV-000003 Charging Station SLD	sheet1	Each DC switchgear cubicle showing 2 withdrawable unit. please clarify?	The SLD has been updated to show only a single withdrawable unit.	Okay noted												Yes

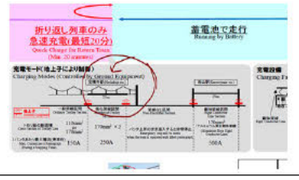
4	[redacted]	...DR-HV-000003 Charging Station SLD	sheet1	Is there any requirement for hamonic filtering unit?	None identified in prelim design as the suppliers equipment will have to comply with the EMC requirements which may or may not require filters. It is up to the Contractor to determine the need for that, on the basis that the harmonic emission from the BEMU charging substation at the Point Of Connection with the 10 kV network of ESB shall be compliant with the applicable technical standards (i.e. IEEE Std. 519).	Okay noted												Yes
5		D+WP56-ARD-P3-BE-DR-HV-000002, SCADA architectu re		Drawing legend unclear. Is it proposed copper/CAT6 connection from the platform to the substation? Or is it a combination of communications medias? Would it be preferable to have a fibre connection here as to avoid any electrical interferences and distance issues? Depending on the RFID system proposed, this may require additional network switches/media converters.	Exact solution will be developed by the Contractor. It is not necessary to specify the details of the connection provided the Contractor delivers a functional and reliable solution. Nevertheless, in the revised diagram, an RFID reader is located by the charging area. From this reader, copper/CAT 6 connections to each positioning sensor on the charging roads are drawn out. The connection between the RFID reader and the access switch located at the substation area is made through an optical fibre.	Okay noted.												Yes
6		D+WP56-ARD-P3-BE-DR-HV-000002, SCADA architectu re		Drawing shows the connection between charging depot and Malahide Substation. Would this not be a connection into the Telecoms Relay Room in Malahide? Malahide TPH would also be the next location in line with the train network. To be confirmed with Telecoms/Tom Q	This connection is internal to IE and not of special relevance to the Contractor. Furthermore, this diagram is intended to show in an indicative way that the connection between the SCADA at Drogheda BEMU charging station and the SCADA at Malahide Substation is to be done by using an existing fibre that runs through the different station TER's that can be found along the railway	Okay comment closed												Yes

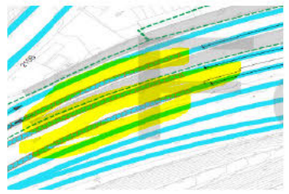
					between Malahide and Drogheda. The diagram has been revised to show this idea better.													
7	[redacted]	General Comment		What consideration been given to communications to/from lineside telephones in the area of the charging roads & Substation areas? Do they need to ability to contact ECO or some other person?	Lineside telephones are to be provided on the platforms for use of the drivers to speak to the ECO. The connection of the telephones to the ECO will be an IE decision, the contractor shall only deliver the cable to the Drogheda TER for connection into the Telecoms network. Additional information added to section 3.11.3.													Yes
8		General Comment	hazard assessment, ARP-0283	Should the safety requirement not include the EPO devise which according to the DRM responses will be located in the charging station?	Emergency shut down of the power supply to the OCR is provided locally via EPO buttons located at the BEMU Charging Substation and additional EPOs at the charging platforms. No update is required in the documents.	Noted. will the EPO devices provided at platform 2, 3, and Road 4? please advise.	The devices are located on the platform as decribed in 3.11.2 of the report	noted										Yes
9		General Comment	Hazard Assessment, ARP-0348 and ARP-0349	Repeated hazard, please update.	Hazards ARP-0348 & ARP-0349 are not a repeated hazard, they are two separate hazards covering the same location. Therefore no update required.													Yes
10		General Comment	Harard Owner	Change IE Ops to IE-RU-Ops. IE-IM-Ops are not responsible for Drivers	Noted - will be updated in the next revision of the hazard log.													Yes
11		...SP-HV-000001 B2 Tech Spec Electrical Equipment	Front Cover Typo	Document mentions the Independant Emergency Shutdown System (IESS). Should be "ESS"?	Noted. IESS revised to ESS in both documents The reference made to the IESS is as follows, however: "Emergency shut down of the power supply to the OCR will be provided locally via EPO buttons located at the BEMU Charging Substation. It is also possible to provide additional EPOs													Yes

	[redacted]				at the charging platforms" .														
12		...DR-HV-000002 SCADA Architecture		Add a Colour Code the relevant asset owner. It is unclear who is respnsible for what. See Line 7 above, I've seen no reference to IM Ops in any document to date.	Its not clear what the value of identifying the asset owner will have for the procurement of the BEMU charging infrastructure as the Contractor has no concern regarding the asset ownership within IE departments, therefore we have not updated the document.														Yes
13		...DR-EL-000001 OCR For BEMUs Charging Drogheda Stn Layout	EPO	Add EPO locations	Noted. EPO locations have been added.														Yes
14		D+WP56-ARP-P3-BE-RP-CX-000201	3.3.2	Static contact force while charging will be 85N. Will this impact the design?	The contact force is not expected to have any impact on the design of the OCR due to the low forces involved.														Yes
15		D+WP56-ARD-P3-BE-DR-EL-000002		OCR FOR BEMUS CHARGING DROGHEDA STATION CROSS SECTIONS: sheet 1. Note 3: PReliminary deisgn based on historic GI? was more recent surveys carried out?	Up to date GI is not yet available.	noted													Yes
16		D+WP56-ARD-P3-BE-DR-HV-000004		EARTHING SYSTEM ARRANGEMENT AT DROGHEDA BEMU SUBSTATION. sheet 2 of 2. Very minor comment "VECINITY" typo?	Noted, drawing updated	noted													Yes
17		D+WP56-ARD-P3-BE-RP-HV-000002	3.5.1	"The load could be done in any of the 3 charging tracks intended to the load operation." Does this mean that 2 by HLU could be charged on platform 2, 1 by HLU on platform 3 and 1 by HLU on Service road 4?	HLUs can be charged in any combination of 4 HLUs at the 6 charging positions. Response accepted at IDC meeting.														Yes

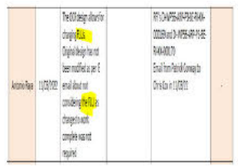
18	[redacted]	D+WP56-ARD-P3-BE-RP-HV-000002	3.5.1	"The 18.6 min is the time that it would take for the HLU to recharge, from the state of charge that it is estimated to have when arriving to the charging station, up to full charge" Should the actual state of charge be stated for clarity for the detail design stage purposes?	Such details are not available to include in the design at this stage. Response accepted at IDC meeting.													Yes
19		D+WP56-ARD-P3-BE-RP-HV-000002	3.9	Emergency shutdown system: 1. "It is also possible to provide additional EPOs at the charging platforms." Where will these be positioned to provide access to staff but avoid interference by others. 2. Assume also we should decid if they are required or not rather than "it is also possible" "If remote intervention is required from the ECO, the SCADA system of the BEMU charging substation will be able to provide that functionality." Assume this is required and document should be more definitive?	EPOs at the charging platforms are included in the requirements. ECO also has the capability to switch off the charging if needed. No update required in the document.													Yes
20		D+WP56-ARD-P3-BE-RP-HV-000002	4.5	"All conductive parts inside CCZ/OCLZ zones shall be earthed by connection to earth wire / traction earth with a wire of sufficient section to withstand short circuit currents" I assume this includes the equipment and support columns isutatioed between service road 4 & 5? Does this also include the exisiting slab track and its re-inforcing? Should this be specifically mentioned in this section?	The principle is to avoid being specific to ensure that there is no basis for variations for anything excluded. It is correct that all metallic elements within the zones shall be earthed through a VLD. Response was accepted at IDC meeting.	noted												Yes
21		...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report	2.2.2 Also in other section, for example: 3.3.2	"The length of each OCR section has been defined in order to cover the position of the pantographs considering all the BEMUs configuration ", There are inconsistencies between various doc regarding the configuration for BEMU allowed under charging station, for example, one of the responses i recieved for BEMU scope of service documents was charging st to be designed to charge single HLU, also, my	The requirements are clear that each OCR section shall charge a single HLU. There are no FLU BEMUs. Response was accepted at IDC meeting.													Yes

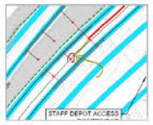
				understainding no FLU is to be considered as part of the design for charging st, please clarify this point? 														
22		...RP-HV-000002 B2 SET Prelim Design Rpt	4.4	"However, in this case, the installation of manually operated isolating switches are proposed in order to simplify the system and considering that the disconnectors currently installed in the existing electrification are also manually operated.", in the report it advise on the use of Manual swicthes while in the SLD shown as motorised, please align.	Switches are to be manually operated. M - denoting motor removed in updated SLD.	Noted, could you please advise if switch status/indication will be shown on the ECO desk?	This is a detailed design aspect to be defined by the D&B contractor and according to the FRS section 5.20.1 as mentioned in the document section 4.4.	Comment closed for the purpose of this doc only, comment to be addressed at D&B										Yes
23		General Comment	general	to my understanding, 2 of the 3 charging roads could potentially be in the energised position while the 3rd one on the OFF position, could the one in the off position not impacted negatively by the induced volatge imposed by the other energised OCRs? if so, please advise? I also suggest you add a risk in the risk/hazard log for further assessment/mitigation at D&B stage.	Not clear what additional hazards can be imposed by this. The non-energised will have some coupling but as it is DC current flowing, the induced voltages will be limited. In any case, the non-energised OCR sections shall be considered live at all times unless isolated according to procedure. Response accepted at IDC meeting.	comment closed for the purpose of this doc only.												Yes
24		...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report	3.3.2	"The OCR will be supported by means structures located approximately every 10 m as shown in the layout drawing D+WP56-ARD-P3-BE-DR-EL-000001. OCR structures will be designed for working life of 60 years according to standard CCE-TMS-410.", i also suggest to reference the Dart+ West OHLE structure report which the CRE has a copy of that doc.	Not clear what is the purpose of the cross-reference. The design for the OCR structures has taken into account the relevant IE standards, FRS etc. The Dart West document has been reviewed and requirements where relevant have been included in the design. No update to the documents are required.	comment closed as the reference to the doc are now shown in charging reoad preliminary design report (non SET) SECTION 3.3.3												Yes
25		...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim	3.3.2	"Currently, the OCR design assumes that the trains will stop coming from the Malahide side. However, in principle, trains approaching from the north side could also use charging facilities in Up Main track stopping at the "End position for	Yes, markers will be provided for individual HLUs coming from the Dundalk direction, however no update to the document is required.													Yes

	[redacted]	Design Report		2HLU/FLU" indication shown on the drawing." Will this also accomodate 2 uncloupled HLU?														
26		...DR-HV-000003 Charging Station SLD	n/a		Yes. The redundant bonding between the tracks will provide sufficient return circuit cables. No update required.													Yes
27		...DR-HV-000002 SCADA Architectu re	n/a	Can RailBAM RFID tags be used for operation with battery charger RFID reader?	We have not defined the exact model of RFID tag to be used. The contractor will select a model that meets the requirements. Response accepted at IDC meeting.													Yes
28		General Comment	n/a	from reviewing the currently installed BEMU charging facilities in Japan, its apparent that the OHLE at the end of the electrified section required some reinforcement works in order to accomendate the BEMU facilities, please see screenshot below, has this been considered by the design and if those OHLE changes applicable to the project? if it's required, will the BEMU project facilities the OHLE changes? please advise.	There is no information indicating that the BEMU will do any battery charging from the OHLE. Therefore no reenforcement of the OHLE is being considered in the Malahide area within the scope of the current BEMU project. Response accepted at IDC meeting.												Yes
29		...SP-HV-000001 B2 Tech Spec Electrical Equipmen t	Table 5	should this not also state the nominal volatge of 1500v?	Yes, this is added in an updated document.													Yes
30		...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report		please clarify the functionliaties of the EPO device specifically for BEMU substation. 	Emergency shut down of the power supply to the OCR will be provided locally via EPO buttons located at the BEMU Charging Substation. Preliminary design report defines these functionalities. Response was accepted at IDC meeting.													Yes

31	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	sheet1	as this drawing showing the proposed CMS routes, etc, I suggest you add a line or legend for these two structures stating the fact that these are part of the CMS and mainly for OHLE Track Feeders. 	It is expected that the Contractor has enough of an understanding to realise that the troughing relates to the cable provision. The response was accepted at the IDC meeting.													Yes
32		...DR-CX-000201 BEMU B3 Charging Road GA	sheet 1/2	please advise what is this shaded area? 	This cross-hatched area shows the track circuits that are potentially affected by trains operating over the platform 2 negative return. However for the purposes of this diagram, the information is not relevant to the Contractor. This response was accepted at the IDC meeting.													Yes
33		...RP-HV-000002 B2 SET Prelim Design Rpt	2.1Power Supply from ESBN	"The power supply to the compound will be delivered from an existing feeder cable ", should this not be "the power supply to the BEMU substation..."?	The compound may be understood to refer to the equipment comprising the substation. Text is updated in the document.													Yes
34		...RP-HV-000002 B2 SET Prelim Design Rpt	3.2Applicable Design Standards	please reference the relevant IE standars, including but not limited to, I-ETR-4004, I-ETR-4703, etc	Noted, standards have been included in the tender documents package. Further standards mentioned here are only the most relevant standard applicable. No change is made to the document.	comment closed for the purpose of this doc												Yes
35		...RP-HV-000002 B2 SET Prelim Design Rpt	General	All plan figures should have a north arrow. 	Noted, north arrows have been added to the tender document drawings.	North arrows **not** added to Figure 1: Layout of the existing 10 kV ESBN power supply to the depot at Drogheda (solid red lines: MV Network Objects – Underground Electricity Cables). Or Figure 7: Spotting plan	Added to the drawings within the report.											Yes

	[redacted]					for the ongoing GI on the Drogheda area (tentative). **Comment is very minor so if further updates to report are required, please add north arrows, but if no further updates required, comment can be closed.**												
36		...DR-EL-000002 OCR For BEMUs Charging Drogheda Stn X Sections	General	AutoCAD SHX Text in pdf, remove for future revisions. https://knowledge.autodesk.com/support/autocad/troubleshooting/caas/sfdcarticles/sfdcarticles/Drawing-text-appears-as-Comments-in-a-PDF-created-by-AutoCAD.html#:~:text=Enter%20EPDFSHX%20(version%202016.1)%20respectively,value%20to%200%20(zero).	Noted.	No further comment.													Yes
37		...DR-EL-000002 OCR For BEMUs Charging Drogheda Stn X Sections	Sheet 2 of 5	Should there be a note regarding the staff depot access footbridge and the requirement for the first 1.2m from floor level to be solid?	Bridge already has a parapet. No note required.	No further comment.													Yes
38		...DR-EL-000003 OCR OCLZ and CCZ P03	General	AutoCAD SHX Text in pdf, remove for future revisions. https://knowledge.autodesk.com/support/autocad/troubleshooting/caas/sfdcarticles/sfdcarticles/Drawing-text-appears-as-Comments-in-a-PDF-created-by-AutoCAD.html#:~:text=Enter%20EPDFSHX%20(version%202016.1)%20respectively,value%20to%200%20(zero).	Noted.	No further comment.													Yes
39		...DR-EL-000003 OCR OCLZ and CCZ P03	Sheet 2 of 4	Should there be a note regarding the staff depot access footbridge and the requirement for the first 1.2m from floor level to be solid?	Bridge already has a parapet. No note required.	No further comment.													Yes

40	[redacted]	D+WP56-ARP-P3-BE-RP-CX-000201	3.3.4	Piles on the existing platforms may need to be mini piles (dywidag or similar) due to height restrictions, width restrictions and the platform build up.	Pile design is indicative as there is no up to date GI information available. Pile design to be carried out with GI inforamtion by contractor. No Further action required.	No further comment													Yes
41	[redacted]	...DR-EL-000002 OCR For BEMUs Charging Drogheda Stn X Sections	Sheets 1, 2, 3 & 4	See comment above on Section 3.3.3 of D+WP56-ARP-P3-BE-RP-CX-000201 B3 Charging Road – OLE & Lineside Civils Preliminary Design Report	The referenced comment is not found.	No further comment													Yes
42	[redacted]	...DR-HV-000003 Charging Station SLD	Sheets 1, 2, 3 & 4	See comment above on Section 3.3.3 of D+WP56-ARP-P3-BE-RP-CX-000201 B3 Charging Road – OLE & Lineside Civils Preliminary Design Report	The referenced comment is not found.	No further comment													Yes
43	[redacted]	D+WP56-ARP-P3-BE-RP-PW-APX002 B3 HL B3 Charging Rd OLE & LSC PDR App B B3 Haz Log IDC	APR-0312	use of small piling rig when working on existing platforms 	Noted, however this will be for the Contractor to establish in their construction planning. Pile design to be carried out with GI inforamtion by contractor. No Further action required	No further comment													Yes
44	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	decisio n log	is this decison log correct/Still applicable? as to my understanding FLU BEMU is no longer applicable, please advise.	Only where there are new or revisions to existing documents would the FLU considerations be removed or revised. Log records this. No further action required.	comment closed for the purpose of this doc													Yes
45	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	decisio n log	is this decison log correct/Still applicable? as to my understanding the charging facilities to allow trains coming from both directions although trains coming from Malahide are most likely, please advise. 	BEMUs could conceivably come from the Dundalk direction if required due to shunting movements over the viaduct. However predominantly the expectation is that the BEMUs will arrive from the Dublin side. Stopping markers will be provided for both directions, no update to the document is required.	is the provided answer not contradict with the decision log? should this log not get updated?	Design supersedes any development decision log. The item has been removed from the decision log. The stopping markers apply in each direction.												Yes
46	[redacted]	...RP-HV-000002 B2	4.6, Table 9	please refer to my comment no 35.	Additional standards added to the document.														Yes

	[redacted]	SET Prelim Design Rpt																
47		...DR-CX-000201 BEMU B3 Charging Road GA	sheet 1 of 2	should this cable route not get extended to the next OHLE structure as per the greenline in the screenshot below? where the MOS is located? 	MOS will be located on the mast carrying the portal frame to the platform 2 OCR. However it will be up to the Contractor to decide how this should be implemented in the detailed design. No further action required.	comment closed for the purpose of this doc												Yes
48		...DR-HV-000002 SCADA Architecture		Remove arrow and text "adjacent TER Portmarnock"	Drawing updated.													Yes
49		...DR-HV-000003 Charging Station SLD		Please identify the Telecoms feed on the SLD	As the SCADA is not conventionally identified on the SLD, telecoms is not shown, however feed is added for Telecoms in the updated SLD.	I can't see it.	Will be added in updated SLD D+WP56-ARD-P5-BE-DR-HV-000003 P02											Yes
50		...RP-HV-000002 B2 SET Prelim Design Rpt	3.2	Please include Telecoms FRS	Document added.													Yes

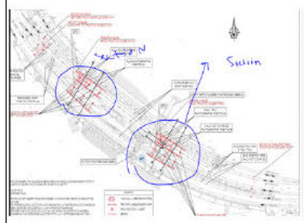
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51	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	General	Where is the Telecoms element of this Prelim Design Report? I would have expected the following areas to be covered. Transmission - SDH, PDH & GigE Admin PABX Lineside PABX CCTV Access Control Power Requirements Space Allocation in Equipment Rooms & BEMU Substation	None of there areas are within the scope of the BEMU charging infrastructure scope of supply. Please clarify exactly what information that is relevant to the scope of the BEMU project should be included.	What transmission technology will be used for the SCADA solution? Is an additional cable route required to avoid a single point of failure? What additional admin telephones are required? Does the existing system have the capacity to accomodate requirements? What additional Lineside phones are required? Is there any changes required to existing lineside phones to satisfy Section Z of the Rule Book in relation to communication with the ECO? What additional CCTV is required at the BEMU? Does the existing system have sufficent capacity? Same for Access control. Does the new platform structures cause an obsruction to existing cameras (DOO & Station CCTV), Passenger Information Signs. Will they be safe to maintain after commissioning of the OHLE? New Telecom Rooms/locations will require a Telecoms UPS **PC Note:** PC / BW will arrange specific meeting with SET Telecoms to close out this comment.	As agreed in the meeting held on 29th November with IE, the details of the telecoms scope was discussed and conclusions were made on the nature of the interfaces between the BEMU charging substation systems and the telecoms network. These are summarised as follows: SCADA communications channel provided through DWDM ring extension of SCADA network from Malahide through Telecoms fibre to Drogheda. Additional TER at Drogheda will be required to accommodate the additional equipment and needs further planning. Additional admin telephones provided in the substation for each container connected into existing Telecoms switch in Drogheda station services room. Platform and lineside phones in depot to connect to ECO or signaller connected into Telecoms switch in Drogheda station servcies	accepted .									Yes

							room. Additional CCTV cameras directed towards OCR and fed to suitable monitoring facilities. Currently proposed for CME depot control room. Access Control interface equivalent to existing substations to allow ECO to cancel alarms on entry to substation from door sensor. Sighting issues relating to location of masts to be considered specifcally in relation to signal sighting. Maintenance of raised structures to be assessed by D&B contractor to ensure adequate clearance including for maintenance. D&B scope telecoms will be UPS backed.										
52	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	General	Is fast Charging at Drogheda still the operational concept for the BEMU	Yes	Noted													Yes
53		...DR-HV-000003 Charging Station SLD		Order of platform incorrect. Should be Platform 2, 3 and 4.	Drawing updated for contract documents.	Okay Noted													Yes
54		...DR-EL-000001 OCR For BEMUs Charging Drogheda Stn Layout		Line type used for traction return is the same as OCR feeder	The dashed line is meant to indicate cable connections rather than indicate the specific functionality of the connection. No change required.	Okay Noted													Yes

55	[redacted]	...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report	2.2.1.1	This section describes 12 return cables per charging section. The charging layout drawing shows only one set of traction return cables.	Cables are not segregated between charging sections. This is a design detail that will be defined by the contractor if needed. No further action required.	There is a difference in the statement mentioned in section 2.2.1.1 and the drawing.	It is not clear that there is any inconsistency. Traction cables for different sections are not segregated but LV/comms may be in a separate duct if the D&B Contractor deems it appropriate. This is a detailed design issue.	Please clarify the highlighted text in section 2.2.1.1 below, is the per sections means the charging road per ends as highlighted in the image below? also is the 12 return cables are the total number for all the return cables? i.e. charging roads at either sides?	As can be seen in the SLD (D+WP56-ARD-P5-BE-DR-HV-000003), every one of the 3 charging roads (each comprising two sections of OCR) is to be fed by 2	Comments noted and closed at this stage, will revisit during the detail design stage.							Yes

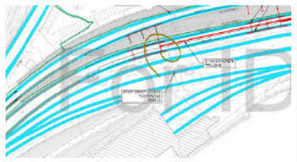
Cable troughing will chiefly accommodate the 6 traction OCR feed cables and 12 traction return cables for each of the charging sections. In addition to these traction power cables, additional control cables, either fibre optic and/or copper cables will be included within the trough between the platform area and the substation. Immunisation measures will be included in the contractor's design to avoid operational malfunction due to interference associated with the proximity of cables.



| | | |

	[redacted]								s of the charging road to the negative of the traction substation.									
56		...DR-EL-000001 OCR For BEMUs Charging Drogheda Stn Layout		Has the location of the OCR been considered when designing the traction return location.	Yes according to Charging Road GA. The running rails sections impedence is negligable and therefore the connection points to the rails are not material to the overall circuit performance. Response was accepted at the IDC meeting.	Okay response note and comments closed at this stage.												Yes
57		...DR-EL-000001 OCR For BEMUs Charging Drogheda Stn Layout		Is the location of the rail to rail bonds in the most effective location.	Considering that return current injection point is not rather distributed, it is practically indifferent where the bonding cable is located. Response was accepted at the IDC meeting.	Okay response note and comments closed at this stage.												Yes
58		...DR-EL-000001 OCR For BEMUs Charging Drogheda Stn Layout		Are details required for rails to bonding cables	Interface to be developed at detailed design stage as this will be between IE and the contractor to coordinate. No further action required.	Is there any power study carried out to detrmine the size of the cable, return circuit and bonding connection?	Yes, power studies were completed to produce cable sizing etc.	Can you please provide the details?	The return circuit was sized based on the current-carryi	Comments noted and closed at this stage will revisit during the detail design stage.								Yes

									ng capacity required by the charging profile of the BEMU and the voltage drop from the charging station and the charging area.									
59	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	4.2.1	Should the overall length of each train configuration be included in this section e.g. One half length Unit (HLU) - 81.96m	HLU dimensions are shown in the sketch drawing in the document. We have no better information at this time. No further action required.	Okay noted												Yes

60	[redacted]	...DR-CX-000201 BEMU B3 Charging Road GA	sheet 1 & 2	does the length of the CMS support where the negative returns cables location? as the return cables located further?	Detailed design of the interface between the return current cables and running rails shall be dealt with in the detailed design stage. No change is made to the drawing. No further action required.	comment closed for the purpose of this doc only, comment to be explored further at D&B.												Yes
61	[redacted]	...DR-EL-000001 OCR For BEMUs Charging Drogheda Stn Layout	all	add lineside switches names and location to the layout plan, papply comment to the relevant crossections. 	As the tender pack is now issued, not clear that the drawing needs to be updated. It is assumed that the Contractor has enough of an understanding to comprehend the overall scheme. No further action required.	updating the Layout plan not just for tender contractor purposes, its mainly to have a complete design record for both internal and D&B contractors, please provide.	It is not a scope of services requirement to maintain earlier stage documentation current to the next stage design development.	reject, please refer to SET 9100 standards on DDR, IDC, and DRN stage.	Please provide further clarification regarding where in SET-AMS-008/I-SET-9100 there is a requirement to maintain earlier phase historic design	comment closed for the purpose of preliminary design stage only								Yes

											documents consistent with latter documents. In the case where there are necessary changes that need to be informed to the contractor regarding design evolution, releva									

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											nt drawings will be updated with the changes, however it is not proposed to make any other updates to documents that will not form part of the contract documents. Please pro								

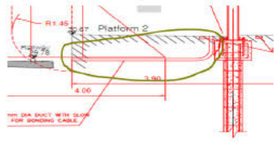
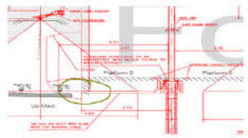
										vide an instruction request if preferential updates to documents are required.									
62	[redacted]	...DR-EL-000003 OCR OCLZ and CCZ P03	all	should lineside switches not added here, showing the proposed bonding connection?	As the tender pack is now issued, not clear that the drawing needs to be updated. It is assumed that the Contractor has enough of an understanding to comprehend the overall scheme. No further action required.	please refer to my comment response no. 61	Please see response above.	please see response above.	In the case where there are necessary changes that need to be informed to the contracto	comment closed for the purpose of preliminary design stage only								Yes

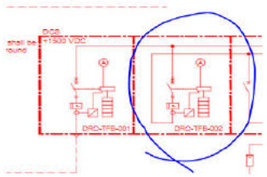
											r regarding design evolution, relevant drawings will be updated with the changes, however it is not proposed to make any other updates to documents that will not form part of									

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											the contract documents. Please provide an instruction request if preferential updates to documents are required.								

For D

63	[redacted]	...DR-EL-000003 OCR OCLZ and CCZ P03	1 of 4, et ALL	is this the connection between the structure and the return/track? if so, should VLD not required here?  with the utilisation of EW, is this connection required on every mast on the up main as shown in all crossection? please advise? 	Although VLD not shown, is included in the requirements so the Contractor will need to comply. Response accepted at the IDC meeting. Contractor shall undertake detailed design to ensure that bonding requirements are fulfilled. The routing will be a detailed design decision.	comment closed for the purpose of this doc only, comment to be explored further at D&B.												Yes
64		...DR-EL-000001 OCR For BEMUs Charging Drogheda Stn Layout	notes	Note 1 advise the OCR layout considers one FLU while not 2 advise the opposite, please advise?	There are no FLUs considered anymore.													Yes
65		...SP-HV-000001 B2 Tech Spec Electrical Equipment	2.11.1	according to the FRS, the diesel generator nominal volatge 400v while in here 440v, please advise on the inconsistency?	It is irrelevant what the specific output voltage for the genset is. It is up to the Contractor to provide the most suitable value for these, which in any case will be around the 400 V. Document updated.	comment closed for the purpose of this doc only												Yes
66		...DR-HV-000003 Charging Station SLD		should there not be a negative return connection to this track also? 	There is sufficient redundancy considering two double HLUs charging for there not be require further cables. No change to the design is required.	why this is the only track without reduncancy/duplicated connection?	As explained in the IDC meeting, there is no need due to the amount of bonding and the number of cables in the return circuit. In any case the design has since been changed.	comment closed fot the purpose of this doc.										Yes

67	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	4.4	"It is considered that there should be one outgoing feeder from Traction Power Substation and one outgoing feeder from ESS to each OCR section of the three charging roads. Preliminarily, 3x300 mm2 Cu insulated cables are considered for each outgoing feeder, so 6 insulated copper cables of 300 mm2 will connect to each OCR section." is this still applicable to the current proposed sectioning diagram? as to my understanding the 6TFB was in the older versions of the SLDs where 2 NP and 2 1500vdc switchboard proposed. 	This is incorrect as the value engineering resulted in a rationalisation of the switching arrangements resulting in only one 3x300mm2 cable set for each OCR. Document updated to make this clearer.	noted. However, I noticed this element in the SLD, is this required?	Yes, this is the redundant HSCB to be operated when the primary is failed in conjunction with the bypass as descibed in the IDC meeting.	whats the purpose of having the secondary busbar? As its additional equipment, please advise.	It allows to bypass any of the 6 HSBC that happens to be taken out of operation.	comment closed for the purpose of preliminary design stage.						Yes
68	[redacted]	...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report	2.2.1.1	Has proposal of use of GRP troughing been discussed with SET - this type of troughing is not in use within SET nationally. Preference is for a concrete troughed solution	GRP only being applied on the embankment now. Concrete elsewhere as shown in the General Arrangement drawing in D+WP56-ARP-P3-BE-DR-CX-000201 P02.	Is GRP the only option for the embankment? Could the buried route be extended from the turning chamber to the interface with the concrete troughing	We are trying to avoid disturbing the embankment and therefore not bury anything on the steep gradient.	How do you intend on installing the GRP? For minimal distubance of the embankment, an elevated route similar to that installed along the Inchicore to CHerryville route would be a better alternative.	The traction cables for the feed and return have an approximate combined weight	Why cannot a concrete troughing route be semi-buried as you intend to do with the GRP now? Previous response was that there was no option to bury anything due to embank	Grp troughing has been specified due to the easier manual handling properties considering the difficulty of installing the route on the embankment. However the actual method and	Narrative in document and comment in associated drawings (e.g. D+WP56-ARP-P3-BE-DR-CX-00201) need to be updated to	Considering that the contract is already signed with the D&B contractor we do not propose to do further revisions to the package. As the comm	**PM Team Note:** SET require text to be updated in order for submission to move to DRN.	Document D+WP56-ARD-P3-BE-RP-HV-000002 and D+WP56-ARP-P3-BE-RP-CX-000201 updated to reference that the trough material may be concre			Yes

											of more than 100kg/m. A raised cable route would require substantial foundations to distribute the load to avoid subsidence. A semi-buried solution provides a better	ment risk.	materials will be subject to reevaluation in the detailed design stage.	reflect that the use of GRP is be evaluated & agreed with IÉ as part of the detailed desig n.	ent log has this issue captured it is expected that details such as this will be confirmed during the detailed design phase of the project.		te or GRP depending on the evaluation during the detailed design phase. D+WP56-ARP-P3-BE-DR-CX-00201 updated with label to identify trough material alternatives.			

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											co mp ro mis e an d the sim ple st to inst all con sid eri ng the bul k an d diff icul ty ha ndl ing suc h he avy cab les. Ple ase pro vid e an inst ruc tio n req ues t if pre fer ent ial up dat es to									

									document s are req uir ed.									
69	[redacted]	...RP-CX-000201 B3 Charging Road OLE & Lineside Civils Prelim Design Report	2.2.1.1	Has reference been made to the SET cable installation standard as part of the design proposal - I-SIG-2271	Standards have been included in the tender documents and this standard is now in the revised preliminary design report.	accepted												Yes
70	[redacted]	...DR-HV-000004 Earthing System	Genera l	Where have changes, if any, to the earthing requirements for the existing GSM-R site been considered 	As the GSM-R mast is deemed to be remote from the OCR areas, charging and stray current issues are expected to be substantially mitigated, revisions to the mast earthing have currently not been considered. Please advise if special considerations have been adopted in the Dart area such as at Malahide.	Awaiting response conerning DART implementations	Awaiting answer.	Addition al earthing arrange menst were applied as determin ed by the Traction Engineeri ng Team. Same would apply here. If Project Traction Team have deemed no additiona l earthing is required - please close	Giv en the me asu res to limi t str ay curren t to be im ple me nte d an d the rel ati ve dist anc e fro m the sub sta tio	Was the Project Traction Team engage d with on this issue? Not clear from Consult ant respons e	It is confirm ed that the review process include d represe ntative s from the tractio n power discipli ne.							Yes

									n to the GSM-R BST, no special earthing measures are being considered. Please provide an instruction request if preferential updates to design is required.									
71	[redacted]	...DR-HV-000004 Earthing System	General	Where have changes to the earthing arrangement for existing on platform & wayside equipment been included	These are to be addressed by compliance with EN 50122 parts 1 and 2 by the D&B contractor.	accepted												Yes

72	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	General	Telecoms System Omitted from Prelim Design - needs to be included for all aspects.	As there is only limited Telecoms included in the scope of the BEMU charging substation comprising Lineside Telephones, substation intrusion alarms, access control, CCTV and SCADA connections. All of these will interface with the IE telecoms networks in the appropriate location at Drogheda. No further action required.	telecoms requirements need to be included regardless of how limited the project viw these items	Issues were discussed and clarifications agreed in meeting on 29th Nov. Primary consideration is the need for an additional TER at Drogheda to accommodate DWDM extension hardware. Further investigation for this is proceeding.	Please provide references to where the additional required information in the document has been included	D+WP56-ARD-P3-BE-RP-TL-000001 Contains the B1 and B3 CCTV Prelim Design. The SCADA prelim design can be found in section 3.9 of D+WP56-ARD-P3-BE-RP-HV-	What does the "TEL"in the document title refer to? Regardless, references to the appropriate documents detailing the associated telecoms requirements must be included in this document - this is not a preferential request.	The following drawings have been updated to include reference to the intrusion detection, telephones and SCADA connections. D+WP56-ARP-P3-BE-DR-CX-00201 D+WP56-ARP-P3-BE-DR-CX-00202 D+WP56-ARD-P5-BE-DR-HV-00002 D+WP56-ARD-P5-BE-DR-TL-00001 D+WP56-ARD-P5-BE-DR-EL-00001 The SSP D+WP56-ARD-P3-BE-DR-SL-00001 already included the						Yes

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											000002BEMUB2Substations-SETPreliminaryDesignReport. Regardless the scope of the Telecoms was discussed and agreed as per comment 51. Please see BE		relevant telephones.								

										MU Contract sections 6-14 to 6-17 for more detailed information. In the case where there are necessary changes that need to be informed to the contractor reg								

											ard ing des ign evo luti on, rel eva nt dra win gs will be up dat ed wit h the cha nge s, ho we ver it is not pro pos ed to ma ke any oth er up dat es to doc um ent s tha t will not for m par t of the con									

									tract documents. Please provide an instruction request if preferential updates to documents are required.									
73	[redacted]	...RP-HV-000002 B2 SET Prelim Design Rpt	General	Need to include how the charging infrastructure will affect existing infrastructure - especially on platform as none have been installed to comply with an electrified system	All earthing and bonding shall comply with EN 50122-1 and the Electricity FRS inside the CCZ/OCLZ areas and be designed by the contractor. It is not evident if there are further requirements needed.	accepted												Yes
74	[redacted]			RFID reader could be interfered with by vandals causing spurious operation.	The RFID link is not designed to offer high integrity functionality but only as a mitigation by normally switch off power to the OCR when not in use. In the event that the RFID reader does not correctly detect the tag, the substation will need to be remotely operated. Such workarounds will be developed by the contractor	accepted												Yes

					in the detailed design. While vandalism that causes the RFID to be disabled may occur, this is not believed to be a significant threat. The trains body will offer some shielding for the RFID reader antennae from jamming signals.													
75	[redacted]	...DR-HV-000004 Earthing System	General	Please indicate the dimension of substation layout (containerised room). Please clarify the equipment room arrangement and associated occupational risks	The dimensions of the containers may be based on a standard ISO container "40 foot container" however it is possible that the Contractor may need to alter the dimensions in order to accommodate the internal equipment, hence dimensions are not provided as this would unnecessarily constrain the design. No further action required.	Okay noted and comments closed at this stage.. Suitablility of containers to be assessed at detailed design.												Yes
76		...DR-HV-000003 Charging Station SLD		Please clarify about the ESS capacity sizing.	The end of life ESS capacity is 2344kWh based on the charging characteristic for 3 double HLU trains as outlined in note 2. No further action required.	Comment related more to the calculation sizing of the battery and the Traction equipment of the BEMU substation to support the train charging time and power. It i s not clear how the charging time has been calculated? please provide.	Charging time is defined by the rolling stock manufacturer - please refer to the Fleet project.	Okay Noted										Yes
77		...RP-HV-000002 B2 SET Prelim Design Rpt	General	Electrification has a concern about its operation and safety aspect since this is new sytem IE. ELE Require more time to reviewing	Noted, however as the tender has now been issued, concerns will need to be addressed during the detailed design phase.	Okay noted												Yes
78		...RP-HV-000002 B2 SET Prelim Design Rpt	General	Please include the risk/hazard associated with heating and fire of Battery storage system.	These are already included in the hazard register to be issued separately.	Okay noted												Yes
79		...DR-HV-000003 Charging Station SLD		Road 4 only shows one return connetion where as in other road shows 2.	The reason for this is because the overall traction circuit is designed for two trains charging simultaneously with an additional cable for redundancy. As there are a significant amount of bonding between the tracks, a further double cable is not	Okay response noted and comments closed at this stage.												Yes

					warranted. No further action required.													
80	[redacted]	...DR-HV-000004 Earthing System	General	Concerns with the proposed BEMU charging substation .i.e. external container arrangements, which is opposed to a new block built substation in line with the rest of the electrification infrastructure on DART. Please clarify.	Containers are specified in order to allow the entire system to be relocated once electrification arrives at Drogheda. It will also provide a more economical solution in line with the shorter operational period of the installation.	Okay response noted and comments closed at this stage.												Yes
81		...DR-HV-000003 Charging Station SLD	return circuit			Are the voltage logger provided at the NP side for stray current control purpose or monitoring purpose?	Voltage logging provided for monitoring purposes.	Okay noted										Yes
82		...DR-HV-000003 Charging Station SLD	SLD			SLD shows two Rectifier breakers between the rectifier cubicle and DC switchgear cubicle and also at the ESS side too. Does it really required? Could you please advise on the following elements Does the DC Bus feed supply from Rectfier unit and ESS at the same time? If two supplies are independant what are protection arrangement provided with in the shared bus arranegement	The ESS shall provide it's own self contained protection in accordance with relevant standards. It is possible that the loads are jointly shared between the rectifier and the ESS. The specifics of the protection arrangements in this situation is an aspect of the detailed design that we expect that the D&B contractor to develop.	Okay Noted									Yes

83	[redacted]	General Comment	General	what are the arrangement for bring and taking out the heavy components like the traction transformers in and out the proposed contarised substation arrangment	Equipment can still be lifted into the compound from the car park.	is there enough space between the containeres for taking in and out heavy equipments? **(PC Note: This comment moved from 'civils' pack.)**	The removal of equipment is limited by the door size to the container. If larger equipment is required to be removed, the entire container can be lifted out for replacement. Given the limited lifetime of the installation, provision of specific aids for the replacement of transformers and simiilar equipment is not consdered. If major work is required, then the entire container would be returned to the supplier for implementing the repair.	Okay Noted										Yes
84		General Comment	General			Bonding of gabion mesh needs to be considered further. (PC Note: This comment moved from 'civils' pack.)	Agreed, additional bonding may be required following assessment of the detailed design consistent with the arrangments for other nearby metallic structures. This will be addressed in the detailed design phase.	okay noted										Yes
85		General Comment	General			Consider a dedicated cable from the ESBN substation to the Charging substation incomer busbars **(PC Note: This comment moved from 'civils' pack.)**	Noted, however it is anticipated that there is a dedicated cable duct between the substation and the incomer busbar that will be solely occupied by the ESBN cable. This will be elaborated	Okay noted										Yes

							in the contractors detailed design.												
86	[redacted]	General Comment	General			Location for metering needs to be considered also. (PC Note: This comment moved from 'civils' pack.)	Noted, it is expected that metering arrangements will be included in the Contractors detailed design subject to acceptance by the Engineer.	Okay Noted											Yes

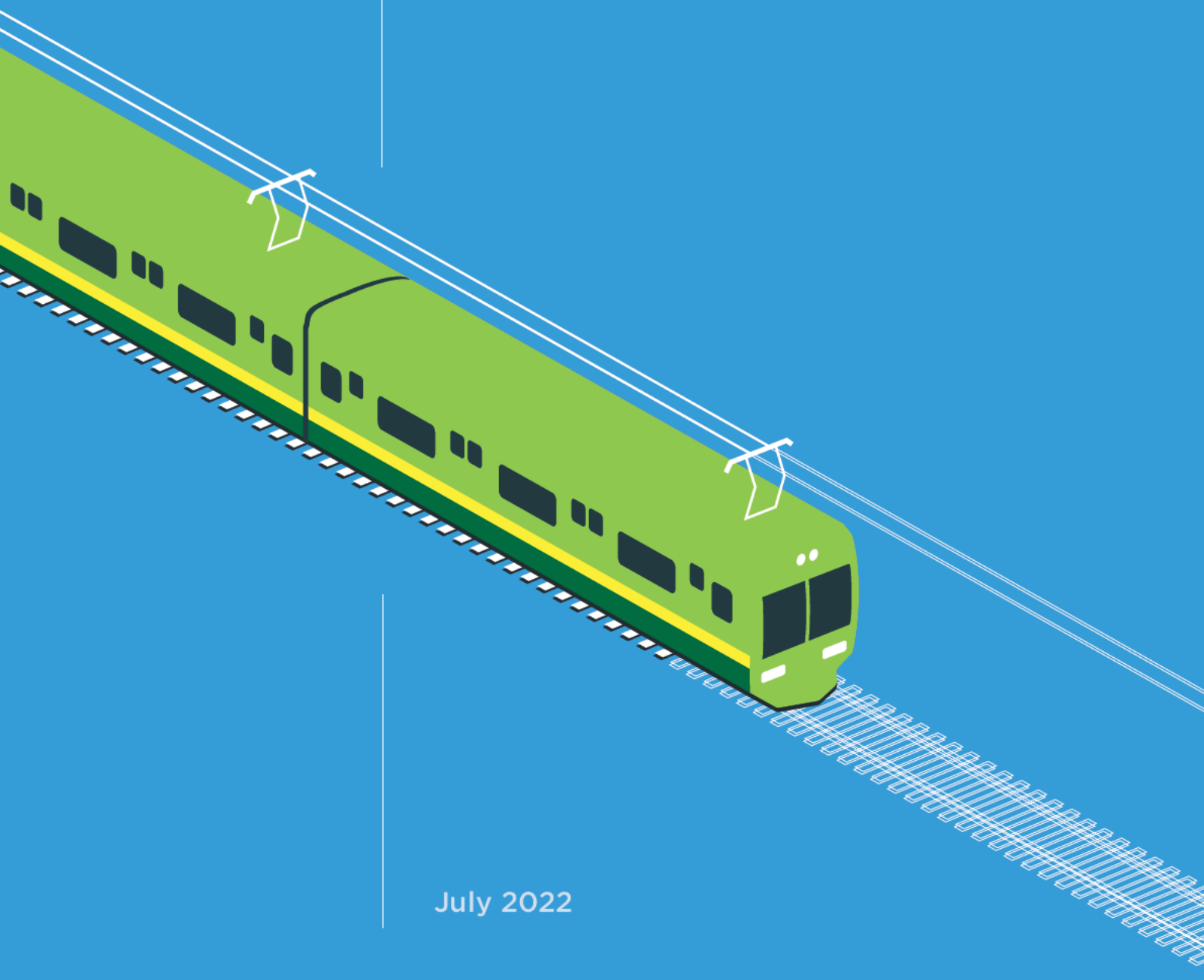
For DRM

Report:	BEMU Planning Report P02 - D+WP56-ARP-P4-BE-RP-RO-000003			
Received:	19/07/2022			
No.	Comment By	Report Section Ref	IE Comment (P01)	Consultant Response
1	[redacted]	Figure 2-1	can we replace this image, the quality isnt great	This has been replaced with a better quality image
2		Figure 2-3	caption says this shows Platform 2/3 but only 1 platform is shown here - can we include a plan view of the station instead to demonstrate the location of the 3 platforms	This has been done.
3		3.2.3	second sentence refrs to drawings - can we include a reference to relevant drawing numbers	There are a number of them. I think we just reference the planning drawings that accompany the planning application.
4		4	under option 3 - references made to 'TER' and 'SCADA', are these defined anywhere in the document?	Definitions included.
5		7.1	include EIA in brackets after the title of this section	This is not an EIA, so I think the environmental assessments title is correct. We are doing an EIA screening and other environmental assessments to accompany the planning application - including EIA in title is incorrect.
6		1.1	bullet points for key elements - amend 2nd point to '3no. platforms' until later in the document when we can provide context for he platform locations	amended - this section has been changed to take account of NTA comments as well. The project description in Section 3 has also been updated in line with NTA comments, IE comments and changes made vis a vis mesh at overbridge, etc.
7		1.2	amend 'DART+' to 'DART+ Programme'	amended
8		8.3	last sentence of this section, amend 'DART+ CN' to 'DART+ Coastal North'	change made
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BEMU

Planning Report



July 2022

DART+ PROGRAMME

ARUP

Document Verification

Project title	DART+ BEMU
Document title	Planning Report
Job number	297733
Document ref	D+WP56-ARP-P4-BE-RP-RO-000003
File reference	

Revision	Date				
		Filename	D+WP56-ARP- P4-BE-RP-RO-000003		
P01	15/06/2022	Description	For IÉ review and comment		
			Prepared by	Checked by	Approved by
		Name	[redacted]		
		Signature			
P02	15/07/2022	Filename			
		Description	For Final Issue		
			Prepared by	Checked by	Approved by
		Name	[redacted]		
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ☑

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1. INTRODUCTION

1.1 This Planning Application - BEMU Programme Overview

Iarnród Éireann (IÉ) are introducing new rolling stock called Battery Electric Multiple Units (BEMUs). The BEMU project (subject of this planning application) is being proposed ahead of the full electrification of the railway line which is proposed through the DART+ Programme. The benefit is twofold – it will remove diesel trains from the network, replacing them with battery operated units, which delivers a significant benefit in terms of decarbonization of the network, ahead of the full electrification. It also delivers an interim capacity increase measure, with one additional train per hour during peak periods.

The BEMU rolling stock has been procured and is due for delivery in 2024. IÉ have identified the Northern Line as the most suitable route for potential BEMU deployment between Dublin City and Drogheda.

In advance of the final electrification and other works to Drogheda station being undertaken (as part of the DART+ Coastal North project), the BEMU will operate from a stabling/charging facility (which will be in place until DART+ Coastal North is operational). A BEMU train is a train that can be powered from overhead line traction, where such infrastructure exists; and powered from an on-board battery traction elsewhere. There is no diesel fuel associated with BEMU trains.

For BEMUs to operate successfully on the Northern Line, charging facilities are required to recharge the batteries to enable operations. IÉ has identified Drogheda MacBride Station as the preferred charging station location. The intent is that the new rolling stock would operate under electrical power as far as Malahide, and from there, onwards to Drogheda, the rolling stock would operate under battery power. At Drogheda, the batteries would be charged, before operations are reversed on the return journey.

The proposed development comprises three key infrastructure elements:

- New Electricity Supply Board (ESB)/traction substation at Marsh Road;
- New overhead line charging facilities at 2no. platforms and 1no. depot track at Drogheda MacBride Station; and
- Associated cable routes between the substation and charging facility.

All the proposed works are within the curtilage of CIÉ property at Drogheda MacBride Station.

In advance of the final electrification and other works to Drogheda station being undertaken (as part of the DART+ Coastal North project), the BEMU will operate from a stabling/charging facility (which will be in place until DART+ Coastal North is operational). Following electrification of the Northern Line (as part of the DART+ Coastal North project), the substation and charging infrastructure will be decommissioned and there is the expectation that the various components may be reused elsewhere to support BEMU operations.

In addition to the proposed development, which is subject of this planning application, there will also be minor works to the depot and stabling road progressed under exempt development rights awarded to statutory undertakers. Specialist assessments and reports included as part of this

application have considered all proposed development (planning application and exempt development) to ensure potential cumulative effects are identified and addressed.

As outlined above, while the proposed development is a standalone project, it forms part of a wider programme of works being proposed by IÉ, namely the DART+ Programme. An overview of the DART+ Programme and the BEMU project is provided below and further within the specialist reports (including the EIA Screening Report) which will accompany this planning application.

1.2 Associated Railway Order - DART+ Programme Overview

The DART+ Programme is a transformative programme of projects that aims to modernise and improve existing rail services in the Greater Dublin Area (GDA). It will provide a sustainable, electrified, reliable and more frequent rail service, improving capacity on rail corridors serving Dublin. The scope of works for the programme is summarised in Figure 1-1.

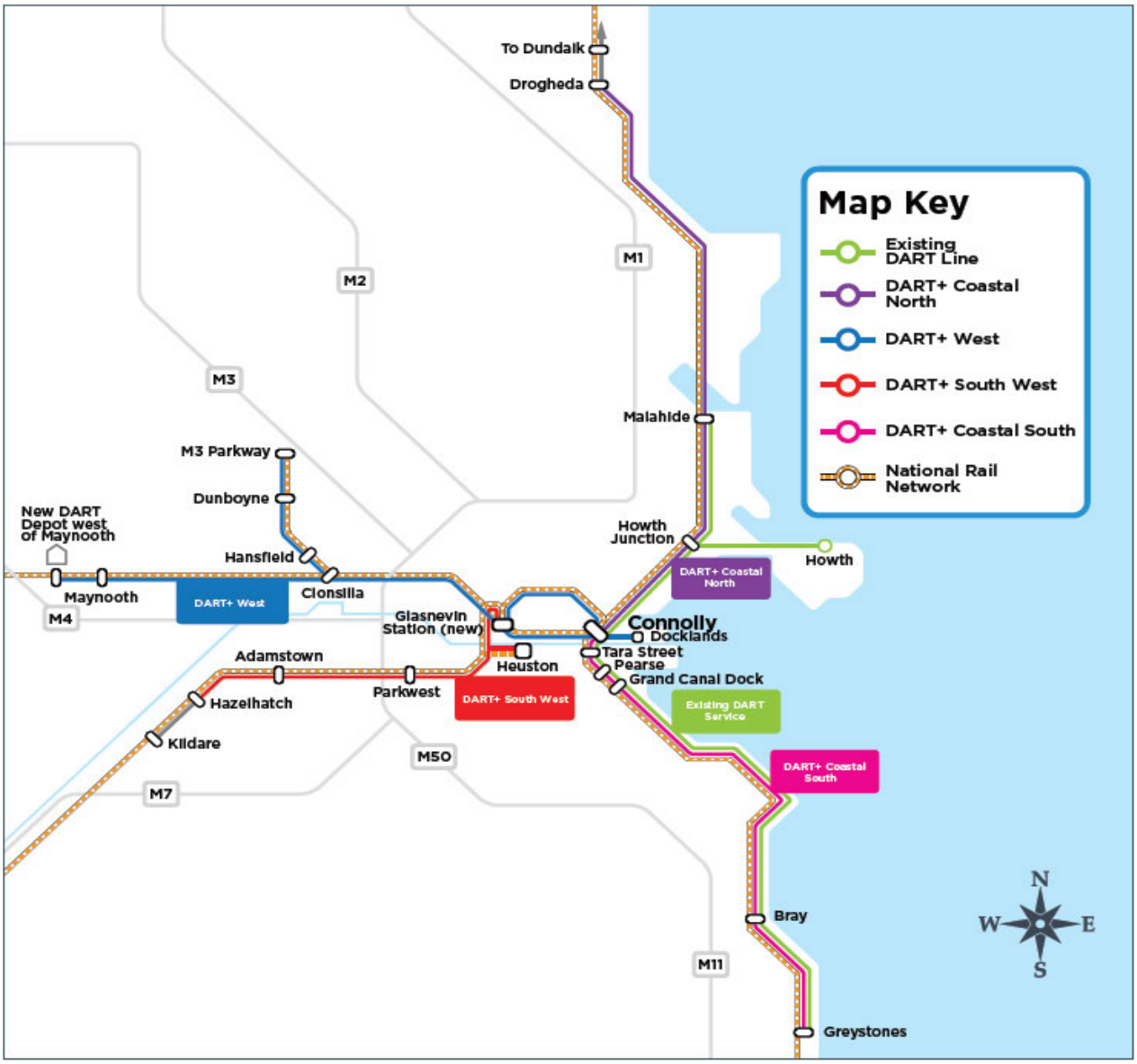


Figure 1-1 DART+ Programme of Works Overview

The current DART network is 50km long, extending from Malahide/Howth to Greystones. The DART+ programme will increase the length of the DART network to 150km of railway corridor through the electrification and upgrade of existing lines transforming commuter train travel in the Greater Dublin Area (GDA).

The DART+ Programme is required to facilitate increased train capacity to meet current and future demands which will be achieved through a modernisation of the existing railway corridors. It will also contribute to Ireland's transition to a low carbon and climate resilient society. The DART+ Programme comprises the following improvement projects across the four main rail corridors:

- DART+ West - Maynooth and M3 Parkway to the City Centre;
- DART+ South West - Hazelhatch & Celbridge to the City Centre;
- DART+ Coastal North - Drogheda to the City Centre;
- DART+ Coastal South - Greystones to the City Centre; and
- DART+ Fleet - Purchase of new train fleet to increase train services.

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

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

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

1.3 Purpose and Structure of the Planning Report

The purpose of this Planning Report is to demonstrate how the development proposal complies with pertinent regional and local planning policies. In drawing conclusions for this application, reference is also made to the findings of various technical reports which are submitted in support of the application.

The remainder of this document is structured as follows:

Section 2 describes the site location and context

Section 3 describes the development proposal

Section 4 summarises the substation location selection process

Section 5 details the pre-application discussions held with Louth County Council

Section 6 assesses relevant policy compliance

Section 7 gives a summary of environmental assessments carried out to support the application

Section 8 assesses other material considerations

Section 9 provides a summary and conclusion

1.4 Supporting Documents

The following documents have been compiled to support this application for full permission:

- Application Form and Fee
- Plans and Drawings
- Planning Report (this report)
- Environmental Impact Assessment Screening Report
- Appropriate Assessment Screening Report and Natura Impact Statement
- Flood Risk Assessment
- Heritage Impact Assessment Report
- Landscape and Visual Impact Assessment Report
- Construction Environmental Management Plan (CEMP)

Whilst this report summarises the key elements and findings of those other application documents and sets out how the proposal complies with prevailing planning policies; it is important that the application submission be read as a whole.

2. SITE AND SURROUNDING CONTEXT

2.1 Site Context

All proposed works are to be located within the Drogheda MacBride Station, in Drogheda, Co. Louth. Figure 2-1 shows the location of the proposed development, with the overall development site (outlined in red). The entire site is within CIÉ property (outlined in blue).

Figure 2-2 and Figure 2-3 show the site layout plan including proposed substation compound, charging facilities and cabling routes.

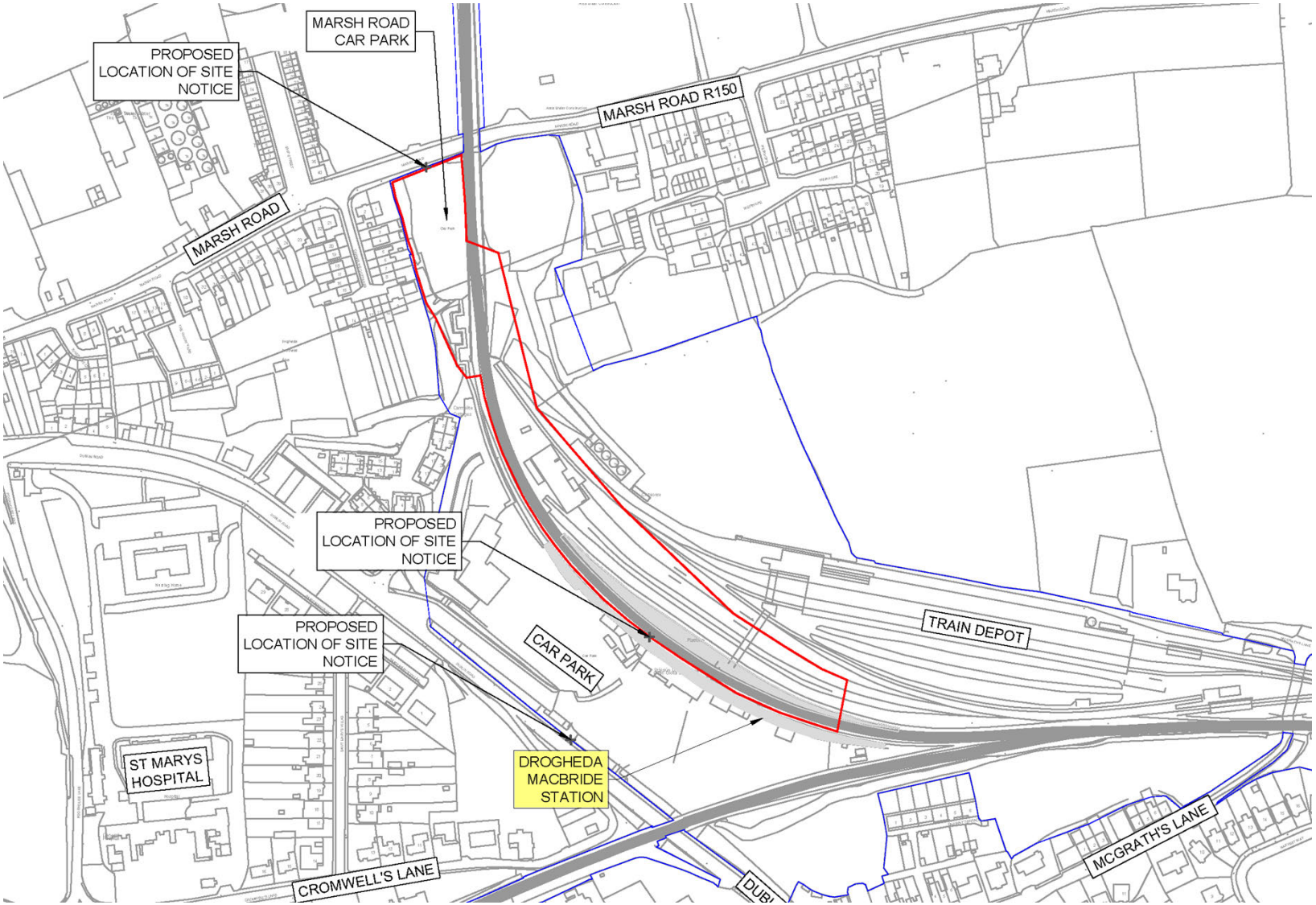


Figure 2-1 Location of the Proposed Development

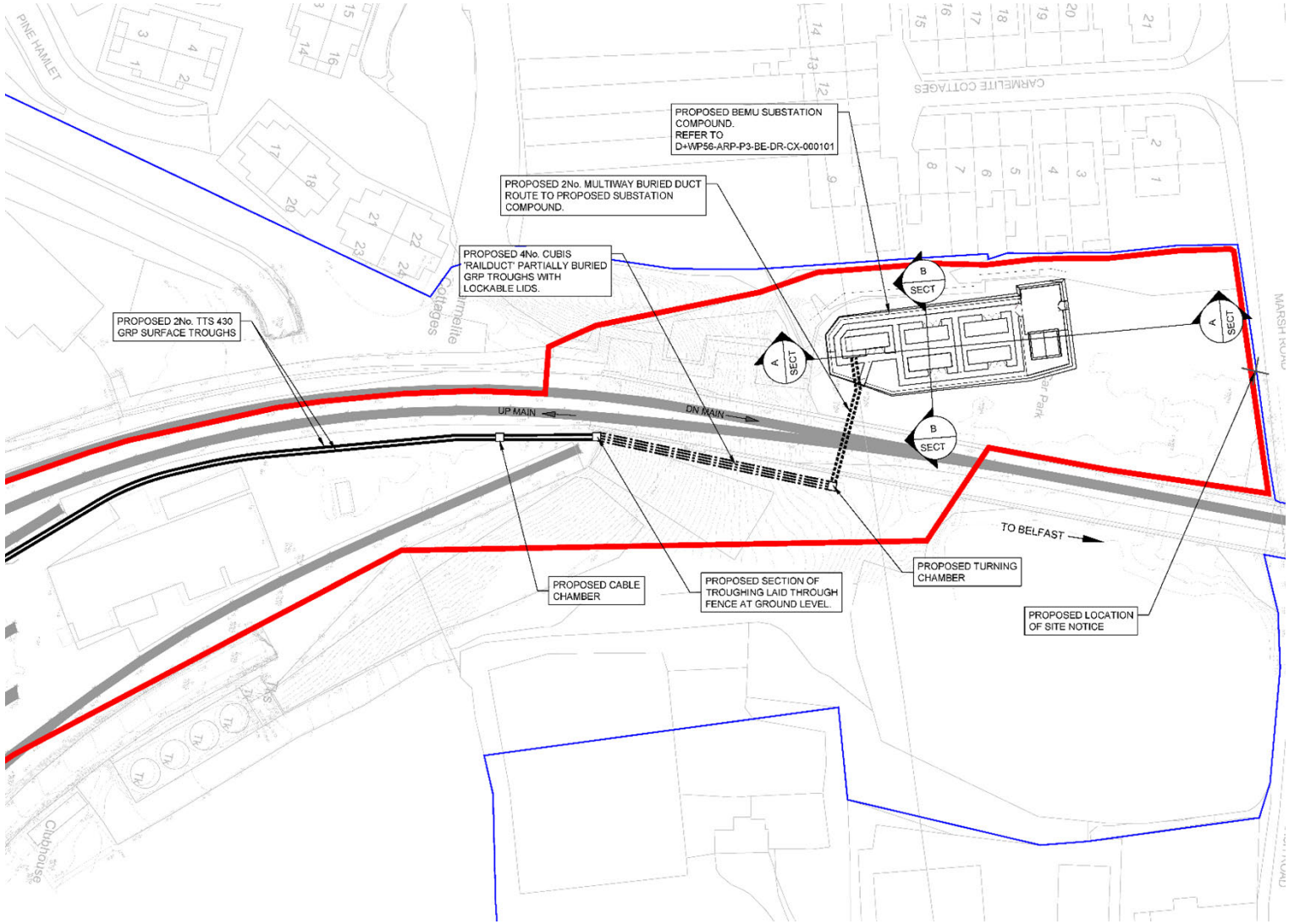


Figure 2-2 Site Layout Plan (Marsh Road end)

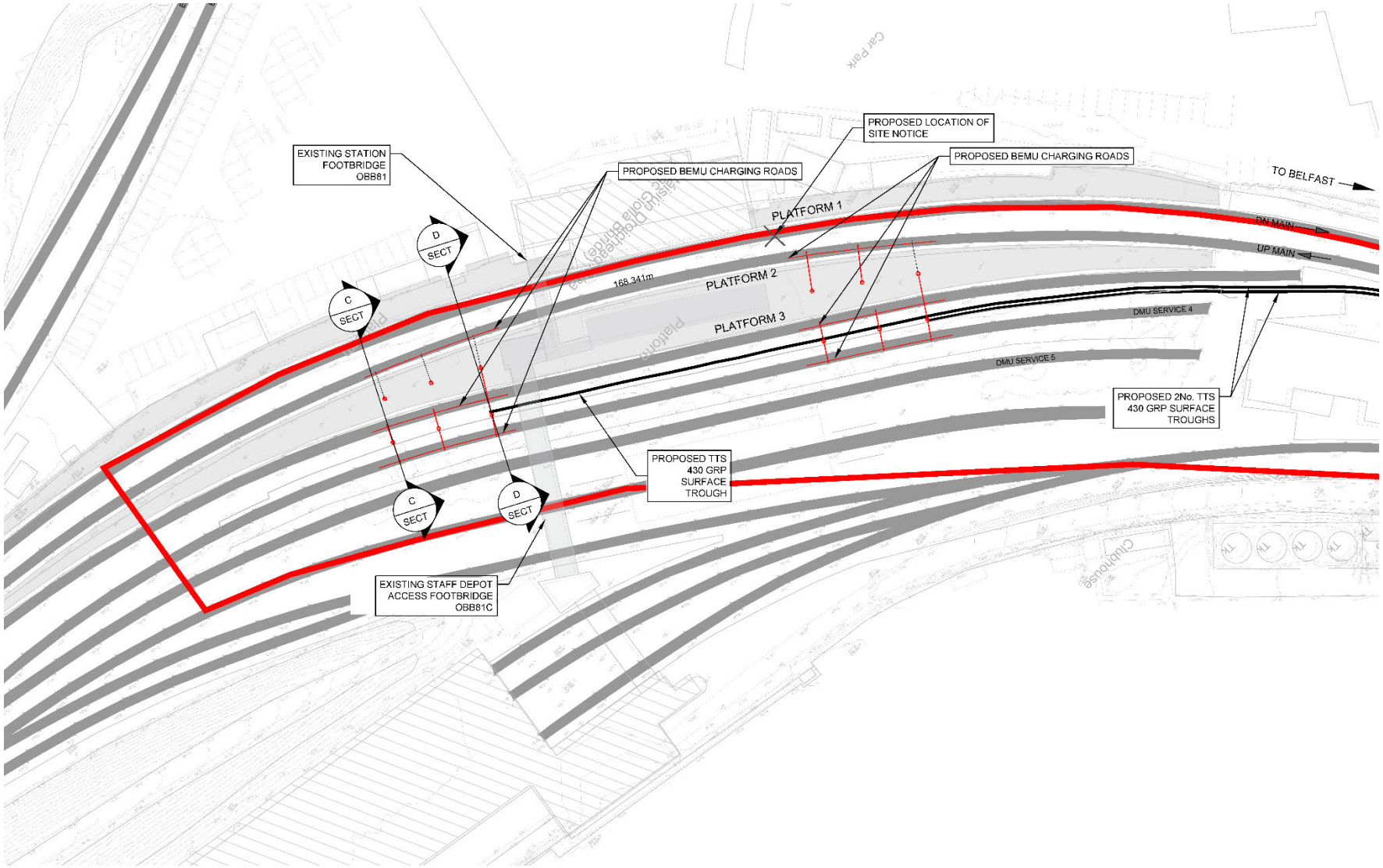


Figure 2-3 Site Layout Plan (Drogheda MacBride Station end)

The proposed substation will be located within the lower carpark at Drogheda MacBride Station and is accessed by vehicle from Marsh Road. A pedestrian stairway provides access to the main station from the car park, with the pedestrian stairs located at the southern end of the car park.

shows the existing carpark from Marsh Road, facing south.



Image 2-1 View of Marsh Road Carpark Entrance (facing south)

The redline boundary for the proposed development is 1.75ha. The site for the construction compound is approximately 2,500m^2. It is located at the Marsh Road carpark and the compound is approximately 80m long and 45m wide at the northern end, narrowing to 25m wide at the south. This is the location of the proposed ESB/traction substation which will have an overall area of approximately 700m^2.

The cables from the proposed ESB/traction substation to the overhead line charging infrastructure will be laid from the proposed substation under the viaduct and up the embankment on the eastern side, to the platforms and depot area, where the charging infrastructure is located.

The charging infrastructure (charging roads) will be located in Drogheda MacBride Station and Depot. Figure 2-3 is shows a site layout plan of proposed charging infrastructure and Image 2-2 shows the existing platform 3 where the charging roads are planned. The proposal is that charging will take place on the Up Main line (platform 2), the Siding line (platform 3) and the DMU Service 4

line (Depot Road 4). The charging structures will comprise a series of overhead line cantilever and portal structures supporting the charging contact.



Image 2-2 View from Drogheda MacBride Station (Platform 3) where charging roads are planned (facing northwest)

2.2 Planning History

Planning Ref: 09/510074

The proposed substation would be located within the lower car park which services the station, and which is accessed from Marsh Road. Planning permission for this car park was granted by Louth County Council in 2009. The permitted development comprised:

"Development on lands adjacent to Drogheda (MacBride) Railway Station (which is a protected structure, RPS No. DB-055), Drogheda, County Louth. The development will consist of works adjoining and adjacent to a protected structure (viaduct railway bridge, PRS No. DB-184) comprising of the construction of 100 no. additional car parking spaces, accessed from Marsh Road. The development also provides for an external stairwell link to the existing station car park, landscaping, lighting, CCTV and all associated site development works, with new vehicular entrance and associated signage at Marsh Road."

Planning Ref: 10/510055

Planning permission was granted in 2010 for minor maintenance upgrades to the main station building, comprising of:

"Development at McBride Railway Station, which is a Protected Structure. Dev. consists of removal of glass screens & counter to Ticket Office & Waiting Room, introduction of new glass double door to Waiting Room, re-instatement of original arch to Ticket Office, demolition of existing partition wall in Ticket Office & construction of new partition walls in new positions, installation of 5nr automatic ticket gates with associated screens & all assoc.works".

Other Applications within Blueline Boundary

A small number of historic planning applications have been identified outside of the development redline, yet within the landowner limits. See Table 2-1. These applications pose no incompatibilities with the proposed development.

Table 2-1 Relevant Planning History

Planning Reference	Applicant	Location	Description	Decision	Decision Date
99/510044	Meteor Mobile Communications Ltd.	MacBride Railway Station	Replace lighting pole with 20m monopole, antennae for mobile phone purposes, equipment container	Grant	28/04/1999
00/510255	Iarnród Éireann	MacBride Railway Station	Construction and operation of an arrow fleet train servicing centre, maintenance workshop, administration building, single storey train wash bld. workshop together with associated word and EIS statement.	Grant	18/01/2001
08/510091	Iarnród Éireann	MacBride Railway Station	The removal of the existing entrance doors, flanking windows & masonry wall under the windows in the southwest wall of the ticket hall & the provision of a free standing glazed entrance screen with automatic sliding doors within the existing entrance	Grant	30/07/2008
08/510169	CIE	MacBride Railway Station	Removal of 3 no. 48 sheet, 6.4m X 3.2m illuminated static advertising signs from boundary wall facing Dublin Rd at junction with entrance road to Railway Station & replacement with 2 no. illuminated trivision rotating 6.4m X 3.2m advertising signs.	Grant	22/12/2008
05/510138	Iarnród Éireann	MacBride Railway Station	Construction of boundary wall, DMU, Train Depot. McBride Station Drogheda	Grant	03/08/2005

3. THE PROPOSAL

3.1 Overview of the Proposed Project

As outlined in Section 1, the BEMU project is being proposed ahead of the full electrification of the railway line which is proposed through the DART+ Programme. The benefit is twofold – it will remove diesel trains from the network, replacing them with battery operated units, which delivers a significant benefit in terms of decarbonization of the network, ahead of the full electrification. It also delivers an interim capacity increase measure, with one additional train per hour during peak periods.

In advance of the final electrification and other works to Drogheda station being undertaken (as part of the DART+ Coastal North project), the BEMU will operate from a temporary stabling/charging facility which will be in place until DART+ Coastal North is operational.

The design of the substation has been cognisant of this temporary requirement and as a result, the design provides for modular construction, in containerised units, which can be easily decommissioned, moved, and reused elsewhere at a later date. Once the DART+ Coastal North project is operational, the BEMU ESB/traction substation and charging facilities will no longer be required and will be decommissioned. The BEMU trainsets can continue to be operated as EMU trainsets on the Northern Line or be deployed elsewhere on the network.

3.2 Description of the Proposed Works

3.2.1 ESB/Traction Substation

The ESB/traction substation is required to provide a controlled charging current to the stabled trains on the platforms in Drogheda Station. Drawings of the proposed substation are provided in the planning drawings which accompany this planning application. The substation comprises several separate containerised units and a block work building located within a palisade fenced substation compound.

The substation compound will be located at the south end of the Marsh Road carpark. The substation compound layout will maintain the current public access to the stairs leading to the station ticket office.

The substation buildings include a small block-built building housing the Electricity Supply Board Network (ESBN) equipment providing current at 10kV AC. Adjacent to this is located a container, housing the main AC control switchboards and transformer. Additional containers will be provided to house the rectifier and DC control switchboards and Energy Storage System (ESS). Each of these containerised units will be placed on a concrete slab foundation and will include cable ducts between each of the units. Details of the cable routes and ducts within the substation compound will be further developed during the design. There will be a maximum of five containers, but this will depend on the final equipment design to be developed by the suppliers of the equipment. The proposed colouring for the substation is juniper green which has been selected to assist with visually integrating the structures into the background. The proposed substation compound is also set low relative to the properties in Carmelite Cottages with additional plating to assist with screening lower level views towards the compound.

The containerised design will allow the installation to be easily relocated when the BEMU service is replaced, and charging is no longer required. This minimises impact to the site which can revert to the previous use as a carpark.

Road access is provided from the R150 Marsh Road to the immediate north of the site. This regional road is currently used for access to the existing Mornington Road ESB substation, from Marsh Lane further to the east of the Boyne Viaduct. As such, adequate third party access for a substation of this nature is provided from the Marsh Road. The site is also located wholly on CIÉ property. The substation can also be accessed on foot via the stairway which leads from the lower carpark to the main station. Walkways and step access will be provided to allow maintenance personnel easy access to inspect and carry out repairs within the secured compound.

Whilst the lower carpark where the substation is to be located is used, given the distance and level differential from the station entrance, it is not as heavily utilised as the main station carpark and discussions with internal IÉ Stakeholder Buildings & Facilities and Operations teams have confirmed that the Marsh Road carpark is indeed rarely used. It is proposed that the car parking spaces will be re-configured to retain as many spaces as possible. There are currently 98 spaces within the carpark which will reduce down to 44 spaces for the duration of the operation of the substation. Once decommissioned, the car parking provision will be returned to its current number.

The existing drainage system will require some alteration for the substation compound with some of the carpark drainage being altered. Where the new substation compound is located, new filter drains will be installed. The existing surface water drain from the south west embankment will tie into the new filter drains before the compound drainage discharges back into the original drainage system prior to passing through the petrol interceptor.

The proposal is to retain the public staircase leading up to the station from the carpark. The CCTV cameras in the existing carpark will be reconfigured to ensure adequate coverage of the route through the carpark to the staircase.

A landscape design has been prepared for the proposed substation and the proposed landscape drawings accompany the planning application as part of the planning drawings. The proposed landscape design includes protection of existing vegetation where practicable and additional planting on the slope to the rear of the Carmelite Cottages to provide low level screening (without impacting the Boyne Viaduct).

3.2.2 Cables between Substation and Overhead Charging Infrastructure

Protected below-ground cable ducts adjacent to the existing 10kV cable route to the depot building will provide power from the ESBN substation at Mornington Road. This will be via the existing cable which runs beneath the carpark. A cable joint chamber will be constructed adjacent to the compound to splice in the 10kV cable.

From the substation compound the cables will be laid in a buried multi-duck system. The multiduct will run across the car park, beneath the arches of the viaduct and terminate at a turning chamber at the base of the embankment. The turning chamber will be of modular GRP (glass reinforced plastic) construction to aid construction. The size of the chamber will be such that allows for the bending radius of the cables. The duct system will be backfilled with a sufficient depth of fill to allow vehicles to cross over it.

From the turning chamber, the cables will exit and be laid in a partially buried surface trough. The trough will be of GRP construction and have lockable lids. These troughs will extend up the embankment to exit through the palisade fence at the north eastern edge of the station. The purpose of utilising lightweight modular troughing in this location, that is shallow buried, is the difficulty in accessing heavy plant in this location for the construction of any cable route. By being surface accessible, the cables can easily be dropped in, as opposed to being pulled. Troughing with lockable lids will be utilised. Existing vegetation on the embankment will be disturbed to the extent needed to allow the troughing to be laid. Vegetation will be protected as far as reasonably practicable.

When vegetation grows back post construction, this will aid in covering the troughing which may offer additional protection and reduce the visual impact.

The steepest section of this slope is approximately 1 in 2. The troughing can be laid on the surface if required. Ground level identification markers will be added to ensure sufficient notice of presence of cables without attracting undesired attention.

The lightweight and modular nature of the system also lends itself to be being easily dismantled at the end of its operational lifespan.

The ducting and troughing will accommodate a set of cables which will supply each of the charging road overhead contact equipment, running between the tracks at the edge of the service slab on Depot Road 4 and connecting to the charging equipment via a portal frame.

Once within the confines of the station, GRP troughing will continue to be utilised as the means of conveying the charging cables to the charging roads. Where practicable, these will be partially buried within the ballast.

Cable troughing will chiefly accommodate the 6no. traction OCR feed cables and 12no. traction return cables for each of the charging sections. In addition to these traction power cables, additional control cables, either fibre optic and/or copper cables will be included within the trough between the platform area and the substation.

3.2.3 Charging Facilities at Platform 2, Platform 3 and Depot Road 4

Platforms 2, 3 and depot road (depot track) 4 will be equipped with overhead contact rails that will enable the BEMUs to be easily charged upon arrival at the station. Drawings of the proposed charging infrastructure are included in the planning drawings which accompany the planning application. The equipment consists of galvanised metal structures, suspended from 12 masts and will comprise 2no. portal frames, 4no. double cantilever and 4no. single cantilevers. These will be located at each end of the platforms and depot road aligned with the pantograph of the train. The pantograph will extend when the train is ready to be charged and contact with the insulated overhead conductor rail (OCR) aligned over the train.

Since the bar is energised with 1500V DC, arrangements similar to that for the existing DART will be employed here including ensuring a safe clearance between the public and staff for the live parts and means to shut off the power in the event of emergencies. Furthermore, the OCR will not be powered unless there is a train in position that needs to be charged.

The OCR will be suspended using several cantilevered arms from masts set into the platform surface located approximately along the centre line of platforms 2/3. A further set of masts will be placed alongside the depot road 4 track. The mast heights will be approx. 8 metres high to be sufficient to support the cantilever arms and the weight of the structure. Refer to the planning drawings, which accompany this planning application, for sections of the OCR including elevations. Some cable ducts will be installed within the platform structure and will provide a route for bonding cables. Power cables will be mechanically protected to ensure they would not be accessible to the public.

The precise arrangement of the live parts of the OCR will be dependent on the BEMU manufacturer's design however the minimum clearance distances of 3.0m defined in the EN 50122-1 Standard (CENELEC 2011) will be observed.

The OCR will be located close to the existing private access IE staff pedestrian overbridge at the station. To ensure against the risk of accidental contact with the overhead electrical infrastructure, the existing steel mesh fixed to the parapet of the overbridge will need to be replaced with a finer steel mesh. The proposed mesh will be IP2x[1] with an aperture of no greater than 12.5 mm, which will protect against an object greater than 12.5mm (approximately a fingers width) passing through.

Within the depot at the train station, passive provision will be made for a diesel back-up generator which would provide sufficient power to charge the trains should there be problems with reliability of the ESBN connection. The passive provision would allow the generator to be located at the northern end of the depot where the turntable is currently located should it ever be required.

Details of all proposed works mentioned above are included in the planning drawings pack, accompanying this application.

[1] This is the International Protection (IP) code necessary to prevent access to hazardous parts with fingers and protects against ingress of solid foreign objects having a diameter of 12.5 mm and greater. The IP code defined in the second edition of "IEC60529 Degrees of protection provided by enclosures (IP code)".

4. SUBSTATION LOCATION SELECTION PROCESS

To determine a suitable location for the ESB/traction substation, a number of possible sites were first identified within the following criteria:

1. Sufficient space for the BEMU substation building and compound. The areas required are as follows:
    - Overall compound: 1,700 m^2
    - ESB Room: 171 m^2
    - Substation Building: 220 m^2

    Whilst some refinement of these figures may be achieved as the design progresses, they set a guide for the scale of site needed.
2. Road access is required for maintenance including installation and replacement of large equipment such as transformers.
3. Third Party access is required for ESB staff without entering the operational railway.
4. The site should be on CIÉ land.

At this stage, three sites were deemed appropriate for further assessment. Option 1 – Marsh Rd Carpark, Option 2 – Main Station Carpark, and Option 3 – East of Railway Terraces, can be seen in below.

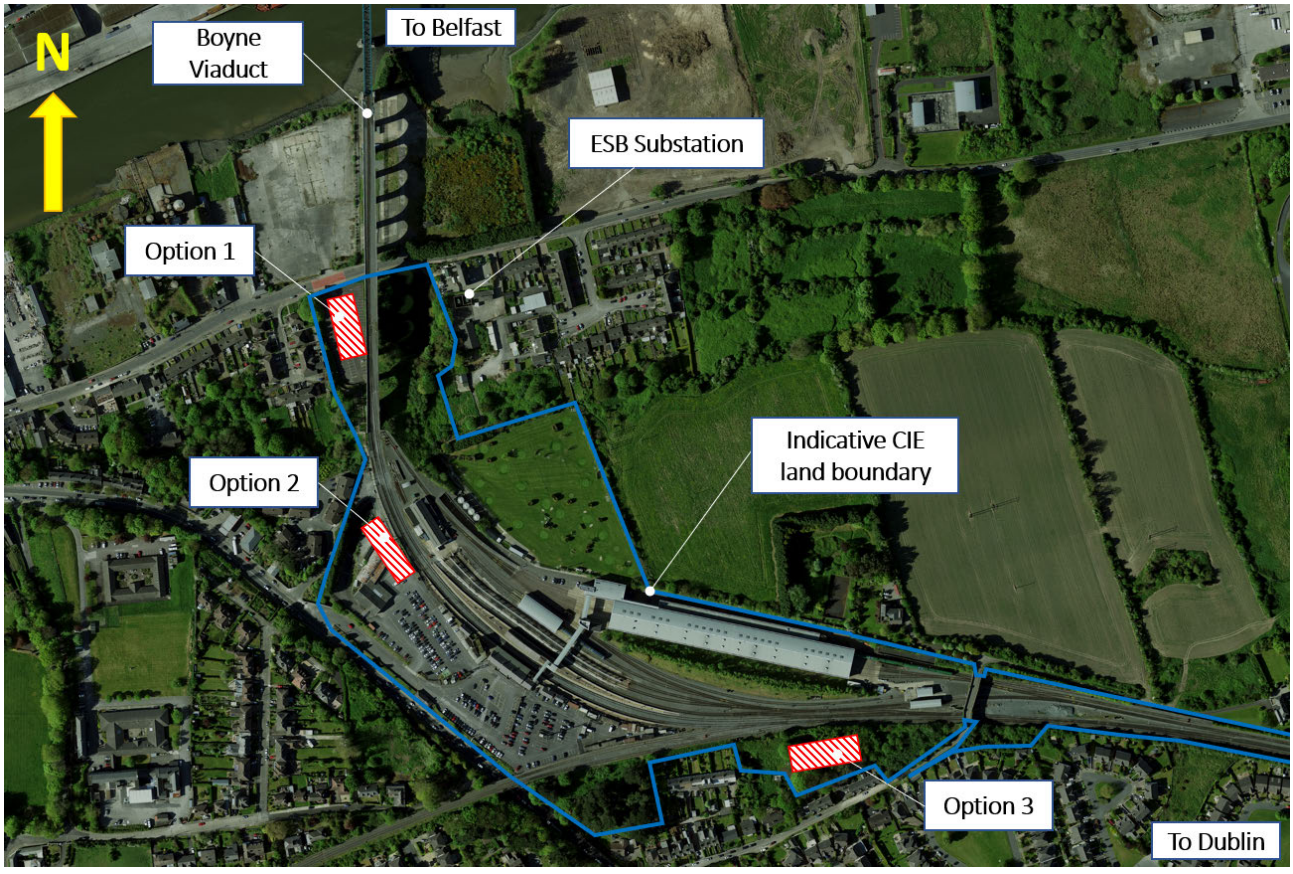


Figure 4-1 Plan Showing Possible Substation Locations

Other locations which were considered but not taken forward as they do not meet the minimum requirements were:

- Existing Drogheda substation – the existing substation is located within the depot building and designed to only supply the depot building itself (lighting, services, wheel lathe, train wash, etc.). This is a much smaller load compared to that required to charge the BEMUs. Therefore, in terms of the additional equipment needed and the size of the accommodation, which is also constrained by the building, it is not suitable to be upgraded.
- Pitch and Putt course – not taken forward as although it is on CIE land it is subject to a 25-year sporting lease.
- Area of land adjacent to Dublin Road, south of the Dublin Road Underbridge – not taken forward as topography does not allow for vehicle access off the Dublin Road.

Following further evaluation of Options 1 to 3, including a review of policy, civil engineering, SET (Signalling, Electrical and Telecoms) assessment, flooding, heritage, noise and vibration, and biodiversity, Option 1 was identified as the most suitable location. The comparison of options is summarised below:

1. Option 1 – Marsh Road Car Park
   The Marsh Road car park is a developed, level site with good existing road access, situated within close proximity to the existing Mornington Road ESB substation. There is no SET infrastructure in the vicinity which would be impacted. Whilst the cable routes to Platform 2 would be longer than in the other options, the route does not present any particular technical difficulties. Any loss of carparking on the private lands is deemed temporary and insignificant.

2. Option 2 – East of Railway Terraces
   This site requires the most development of all the options as it is currently undeveloped and has a notable level difference across the site and between the site and the access road. It is also zoned as A1 – Existing Residential, therefore would be non-compliant with policy. A new entrance would need to be constructed off the narrow Railway Terraces/McGrath's Lane which could constrain access to the site. This location is also the least technically convenient in terms of SET, being on the south of the turnouts on the mainline. In the event of supply being provided from the Mornington Road ESB Substation, this would involve establishing a lengthy cable route along the Railway Terraces road.

3. Option 3 – Main Station Car Park
   Whilst this option is in close proximity to the Telecommunications Equipment Room (TER) for SCADA (supervisory control and data acquisition) connections as well as the relative simplicity of cable routes to the platforms, this option comes with two main challenges:

   a) The current track and SET stores would need to be relocated to a different, currently unidentified location.
   b) The number of available parking spaces in the main station car park would be reduced – and while this is also a result at Option 1, Marsh Rd is currently considered underutilised and not conveniently accessible to the station. The impact is deemed significantly more adverse at Option 3 location, being the main car park for the station with appropriate accessibility.

5. PRE-APPLICATION CONSULTATION

In accordance with Section 247 of the Planning and Development Act, 2000 (as amended), pre-application consultation was sought with Louth County Council. The intent of consultation discussions was to confirm the proposed approach for the planning application, outline specific environmental information required, and gain Louth County Council's position on any issues.

The pre-application meeting was held on 6th May 2022. In attendance were members of the Iarnród Éireann BEMU project team, Arup consulting team, and Louth County Council's Transport Planning and Planning Departments. Any queries or requests for specific information have been addressed through this planning report or supplementary technical reports and drawings.

6. POLICY AND DEVELOPMENT CONTEXT

6.1 Regional Policy

6.1.1 Trans-European Network for Transport

The Trans-European Network for Transport (TEN-T) is a European Union policy directed towards the implementation and development of a Europe-wide network of roads, railway lines, inland waterways, maritime shipping routes, ports, airports and rail-road terminals. The aim of the EU's Transport Policy is to promote a mobility that is efficient, safe, secure and environmentally friendly. Regulation (EU) No 1315/2013 sets out the requirements for rail infrastructure that form part of the TEN-T infrastructure network, both Core (2030) and Comprehensive (2050), and states under Article 12(2)(d), the following:

"Member States shall ensure that the railway infrastructure:

(d) save in the case of isolated networks, is fully electrified as regards line tracks and, to the extent necessary for electric train operations, as regards sidings;"

The BEMU project is consistent with the objectives of the Trans-European Network for Transport. It will involve the creation of a rail mode transport which is cleaner and less dependent on oil, and more energy efficient. It will allow for more efficient transportation along the east coast of Ireland, and encourage greater use of public transportation, reducing the dependency on car-based commuting.

6.2 National Policy

6.2.1 Project Ireland 2040: National Planning Framework

The National Planning Framework (NPF) is the Government's high-level strategic plan for shaping the future growth and development of the country by 2040. It is a framework to guide public and private investment, to create and promote opportunities to protect and enhance the environment.

There are 10 "National Strategic Outcomes" several of which are relevant to the proposed development:

"1. Compact Growth:

Carefully managing the sustainable growth of compact cities, towns and villages will add value and create more attractive places in which people can live and work. All our urban settlements contain many potential development areas, centrally located and frequently publicly owned, that are suitable and capable of re-use to provide housing, jobs, amenities and services, but which need a streamlined and co-ordinated approach to their development, with investment in enabling infrastructure and supporting amenities, to realise their potential. Activating these strategic areas and achieving effective density and consolidation, rather than more sprawl of urban development, is a top priority."

This BEMU project, being an important stage of the wider electrification of the Drogheda to Malahide line will, by providing a more efficient public transport infrastructure, make urban areas and zoned lands along the route, more attractive areas in which to live and work in.



Figure 6-1 National Strategic Outcomes (*Source: Project Ireland 2040)*

"4. Sustainable Mobility:

In line with Ireland's Climate Change mitigation plan, we need to progressively electrify our mobility systems moving away from polluting and carbon intensive propulsion systems to new technologies such as electric vehicles and the introduction of electric and hybrid traction systems for public transport fleets, such that by 2040 our cities and towns will enjoy a cleaner, quieter environment free of combustion engine driven transport systems."

The BEMU project is entirely consistent with this Strategic Outcome in terms of the provision of Battery Electric Multiple Units on a busy public transportation route along the east coast of Ireland.

"8. Transition to a Low Carbon and Climate Resilient Society:

The National Climate Policy Position establishes the national objective of achieving transition to a competitive, low carbon, climate-resilient and environmentally sustainable economy by 2050. This objective will shape investment choices over the coming decades in line with the National Mitigation Plan and the National Adaptation Framework. New energy systems and transmission grids will be necessary for a more distributed, renewables-focused energy generation system, harnessing both the considerable on-shore and off-shore potential from energy sources such as wind, wave and solar and connecting the richest sources of that energy to the major sources of demand."

The BEMU project will encourage less car-based travel and will comply with the objective to reduce carbon emissions in the country.

6.2.2 National Development Plan 2021-2030

The current National Development Plan (NDP) sets out the ten-year capital expenditure ceilings which will support economic, social, environmental and cultural development across Ireland, incorporating a total public investment of [redacted]. It takes account of the Covid-19 crisis and related recovery plans, to ensure alignment with the new Programme for Government, to strengthen the alignment with the NPF and to enhance the link with the new Climate Action Plan and other sectoral policies.

The BEMU project is identified in the NDP under the wider DART+ programme:

The DART+ programme will be a cornerstone of rail investment within the lifetime of Project Ireland 2040 and represents the single biggest investment in the Irish rail network. The programme comprises a number of infrastructural projects – DART+ West, DART+ South West, DART+ Coastal North to Drogheda via Balbriggan, and DART+ Coastal South – ***and also a significant expansion of fleet, both battery electric (BEMUs)*** *and electric multiple units (EMUs).*

To deliver the National Strategic Outcomes set out in the NPF, the NDP presents the following relevant Strategic Investment Priorities which apply to the BEMU project:

National Planning Framework NSO	NDP Strategic Investment Priority	NDP reference to DART+ (BEMU inclusive)
NSO 2: Enhanced Regional Accessibility	Public Transport	*"Investment in the DART+ programme will address some of the constraints on the Dublin City Centre rail network and provide for additional services for intercity rail services."*
NSO 4: Sustainable Mobility	DART+	*"The DART+ programme will be a cornerstone of rail investment within the lifetime of Project Ireland 2040 and represents the single biggest investment in the Irish rail network."*
NSO 8: Transition to a Climate-Neutral and Climate-Resilient Society	An additional 500,000 sustainable mobility journeys per day by 2030. Comprehensive integrated public transport network for Ireland's cities connecting more people to more places.	*"Delivering priority public transport programmes including BusConnects, DART+ Expansion Programme and MetroLink so that increased transport demand is met by greener public transport."*

Strategic Investment Priorities have been influenced by the national objective of transitioning by 2050 to a competitive, low-carbon, climate-resilient and environmentally sustainable economy and society. As identified above, the DART+ Coastal North project will contribute to achieving these objectives.

6.2.3 National Investment Framework for Transport in Ireland (December 2021)

The Department of Transport has prepared and finalised the National Investment Framework for Transport in Ireland (NIFTI). NIFTI is the Department of Transport's high-level strategic framework to support the consideration and prioritisation of future investment in land transport.

As part of NIFTI, a wide range of supporting analysis has been conducted to identify key transport challenges, needs and constraints, both today and in the future.

The NIFTI states:

"The right transport investment helps to deliver high-quality travel and supports positive outcomes for society, the environment and the economy. However, these outcomes do not happen by chance. It is important to have in place a framework to guide transport investment and deliver the infrastructure and services we need. That is the purpose of NIFTI.

New transport investments will have to demonstrate their alignment with NIFTI. By extension, this will ensure that investment is aligned with the NPF and its National Strategic Outcomes, resulting in a consistent approach to investment across Government, with transport supporting our growth and development goals. In this way, NIFTI will ensure that transport enables the NPF."

The NIFTI notes that the NDP identities DART+ (including BEMU infrastructure) as one of the infrastructure projects required in the next decade.

In order to address the challenges identified in the supporting analysis, NIFTI establishes four Investment Priorities: Decarbonisation, Protection and Renewal, Mobility of People and Goods in Urban Areas, and Enhanced Regional and Rural Connectivity. Future transport projects must align with these priorities to be considered for funding. Moreover, as the National Strategic Outcomes are embedded in NIFTI, future investment made in accordance with the priorities will support the delivery of the National Planning Framework over the coming decades.

The BEMU project will comply with the Investment Priorities. It will assist in the decarbonisation of the transport system. It will help in the protection of the environment. It will improve the mobility of people in a sustainable manner. Finally, it will improve regional connectivity between Dublin, Meath and Louth.

6.2.4 Department of Transport: Statement of Strategy 2021-2023

The Statement of Strategy does not refer to specific projects. However, there are a number of objectives outlined in the Strategic Approach that are relevant to the BEMU project development:

"Aligned with the National Planning Framework and the National Economic Plan we will maintain and develop high quality sustainable road, public transport and active travel networks to enable economic activity, essential services and social connections between and within our cities, regions and communities.

We will encourage and support transport networks and services that are environmentally, economically and socially sustainable, in line with the UN Sustainable Development Goals.

We will prioritise the decarbonisation of transport and low carbon technology in line with the EU Green Deal and ambitious government policies.

We will continue to invest in active travel and in our public transport networks, greenways and alternative technologies."

6.2.5 Climate Action Plan 2021

This plan sets a roadmap for taking decisive action to halve the country's emissions by 2030 and reach net zero no later than 2050, as committed to in the Programme for Government.

The Climate Action Plan 2021 sets out a detailed sectoral roadmap designed to deliver a 51% reduction in greenhouse gas (GHG) emissions by 2030. This doubles the ambition of the 2019 Climate Action Plan and will require significant reductions from all sectors.

An action identified to reduce emission in the transport sector is:

"The proposed pathway in transport is focused on accelerating the electrification of road transport, the use of biofuels, and a modal shift to transport modes with lower energy consumption (e.g. public and active transport)."

The plan states that transport accounts for approximately 20% of Ireland's greenhouse gas (GHG) emissions. Road transport is responsible for 96% of those GHG emissions. Promoting cleaner, safer and more sustainable mobility is critical for climate policy.

To meet the required level of emissions reduction, by 2030 the Plan sets out a number of targets, the following of which are relevant:

"Provide for an additional 500,000 daily public transport and active travel journeys

"Increase the fleet of EVs and low emitting vehicles (LEVs) on the road to 945,000, comprising of: [inter alia]

- *an expanded electrified rail network."*

Action 240 is directly relevant:

"Commence delivery of DART+ Programme and continue heavy rail fleet investment."

The BEMU project will be in compliance and will contribute towards the targets identified in the Climate Action Plan. It will help reduce GHG emissions by:

- The provision of a more efficient public transport route, thereby encouraging a modal shift towards public transportation;
- It will become part of the electrified rail network in Ireland.

The BEMU project is part of the DART+ Programme which is identified as a specific action in the plan.

6.2.6 Transport Strategy for the Greater Dublin Area 2016-2035

The Transport Strategy for the Greater Dublin Area 2016-2035 was published by the National Transport Authority. It provides a framework for the planning and delivery of transport infrastructure and services in the GDA.

It states that heavy rail (DART and Commuter Rail) provides the core high-capacity infrastructure and services that are central to the GDA's public transport system. It further states that whilst the rail network has continued to be developed over recent decades, significant work still remains to be done to create a fully integrated rail network.

The strategy assesses a number of options with regard to various transport corridors in the GDA including the Dublin to Belfast Corridor. It is the intention of the Strategy to:

"Implement the DART Expansion Programme, which will provide DART services as far north as Drogheda; to Hazelhatch on the Kildare Line (including a tunnel connection from the Kildare Line to link with the Northern / South-Eastern Line); to Maynooth in the west and to the M3 Parkway;"

The Strategy further states:

"The DART Expansion Programme which is a cornerstone project of the strategy, will see the DART system expanded, providing fast, high-frequency electrified services to Drogheda on the Northern Line, Hazelhatch on the Kildare Line, Maynooth and M3 Parkway on the Maynooth/Sligo Line, while continuing to provide DART services on the South-Eastern Line as far south as Greystones."

The Transport Strategy also outlines objectives for Transport Services and Integration noting that:

"The DART services will operate to a high frequency with adequate capacity to cater for the passenger demand. It is anticipated that DART services in the city centre section of the network will operate to a regular ten minute service frequency in the peak hours from 2016 and will transition to a five minute service frequency following the completion of the DART Expansion Programme."

The draft Transport Strategy for the Greater Dublin Area 2022 – 2042 has also recently been published and is currently out for public consultation. The draft strategy identifies 'battery-electric carriages' as a major forthcoming scheme in the Public Fleet expansion.

The BEMU project is in accordance with all existing and emerging policies and objectives of the Transport Strategy for the Greater Dublin Area.

6.3 Regional Policy

6.3.1 Eastern & Midland Regional Assembly, Regional Spatial & Economic Strategy 2019-2031

A Regional Spatial and Economic Strategy (RSES) is a strategic plan which identifies regional assets, opportunities and pressures and provides appropriate policy responses in the form of Regional Policy Objectives. At this strategic level it provides a framework for investment to better manage spatial planning and economic development throughout the Region.

The RSES sets out sixteen Regional Strategic Outcomes, three of which are relevant to the BEMU project:

"Sustainable Settlement Patterns:

Better manage the sustainable and compact growth of Dublin as a city of international scale and develop Athlone, Dundalk, Drogheda and a number of key complementary growth settlements of sufficient scale to be drivers of regional growth. (NSO 1, 7, 10)"

The BEMU project will assist in the development of urban settlements along the east coast rail network, and also Drogheda as a destination in which to live and work in.

"Compact Growth and Urban Regeneration

Promote the regeneration of our cities, towns and villages by making better use of under-used land and buildings within the existing built-up urban footprint and to drive the delivery of quality housing and employment choice for the Region's citizens. (NSO 1)"

The BEMU project will encourage the development of underutilised zoned lands along the east coast rail network via provision of a more efficient public transport route.

"Integrated Transport and Land Use

Promote best use of Transport Infrastructure, existing and planned, and promote sustainable and active modes of travel to ensure the proper integration of transportation and land use planning. (NSO 2, 6, 8,9)"

The BEMU project will assist in achieving a more balanced approach to the integration of transportation and development, both in terms of employment and residential locations. It will make locations along the east coast rail network more favourable for both employers and residents.

The 'DART Expansion' – which includes the introduction of the BEMU fleet - is heavily referenced and supported in the document, including in relation to the development of the Dublin Metropolitan Area, and Drogheda.

Regional Policy Objective 5.2 states:

"Support the delivery of key sustainable transport projects including Metrolink, DART and LUAS expansion programmes, BusConnects and the Greater Dublin Metropolitan Cycle Network and ensure that future development maximises the efficiency and protects the strategic capacity of the metropolitan area transport network, existing and planned."

Regional Policy Objective 8.8: supports delivery of the rail projects set out in Table 8.2, subject to the outcome of appropriate environmental assessment and the planning process.

One of the projects set out in Table 8.2 is:

"DART Expansion Programme – new infrastructure and electrification of existing lines, including provision of electrified services to Drogheda or further north on the Northern Line, Celbridge – Hazelhatch or further south on the Kildare Line, Maynooth and M3 Parkway on the Maynooth/Sligo Line, while continuing to provide DART services on the South-Eastern Line as far south as Greystones."

6.4 Louth County Development Plan 2021-2027

The Louth County Development Plan 2021-2027 was adopted on 30th September 2021 and came into effect on 11th November 2021. The Plan 2021-2027 has superseded the Drogheda Borough Council Development Plan 2011-2017 and the North Drogheda and Environs Local Area Plan.

A key priority of the plan is to promote the continued sustainable and compact growth of the town as a regional driver of city scale with a target population of 50,000 by 2031. This will be supported by objectives to regenerate the town centre, promote compact growth in the town's hinterlands and enhance the role of Drogheda as a self-sustaining strategic employment centre on the Dublin-Belfast Economic Corridor.

The Plan states the following in relation to Drogheda:

"The goal of achieving compact growth will require improved accessibility, sustainable mobility and the requisite infrastructure to enable Drogheda to grow as a Regional Growth Centre (RGC). The

town will benefit from the extension of the DART service and improvements will be required to MacBride station relating to accessibility."

The plan recognises that the "DART Expansion Programme", and consequently the BEMU fleet introduction, is an important growth enabler for Drogheda as it would improve the connectivity to Dublin due to the increased frequency of services, making the town more accessible and attractive for economic investment and employment generating development.

The following policies and objectives in the plan are relevant:

"SS13: To support investment in public and sustainable transport infrastructure and services in Drogheda including the progression of the DART Expansion Programme which includes the electrification of the rail line and the extension of DART services to Drogheda

MOV 2: To facilitate the integration of land use with sustainable transportation infrastructure in accordance with the requirements of RPO 8.1 in the RSES by supporting the creation of a critical mass of population and employment related development that would maximise investment in public transport infrastructure and create compact, sustainable settlements.

MOV 7: To support a modal shift away from the private car to more sustainable forms of transport, such as public transport, cycling and walking and the attainment of any national targets relating to modal change published during the life of this Plan.

MOV 9: To support investment in sustainable transport infrastructure that will make walking, cycling or public transport more attractive and appealing, and facilitates accessibility for all, regardless of age, physical mobility, or social disadvantage.

MOV 12: To support the DART Expansion Programme including new infrastructure and the electrification of existing lines along the northern rail line to Drogheda."

The proposed development supports the overall vision in the Plan, particularly in relation to the development of Drogheda as a Regional Growth Centre.

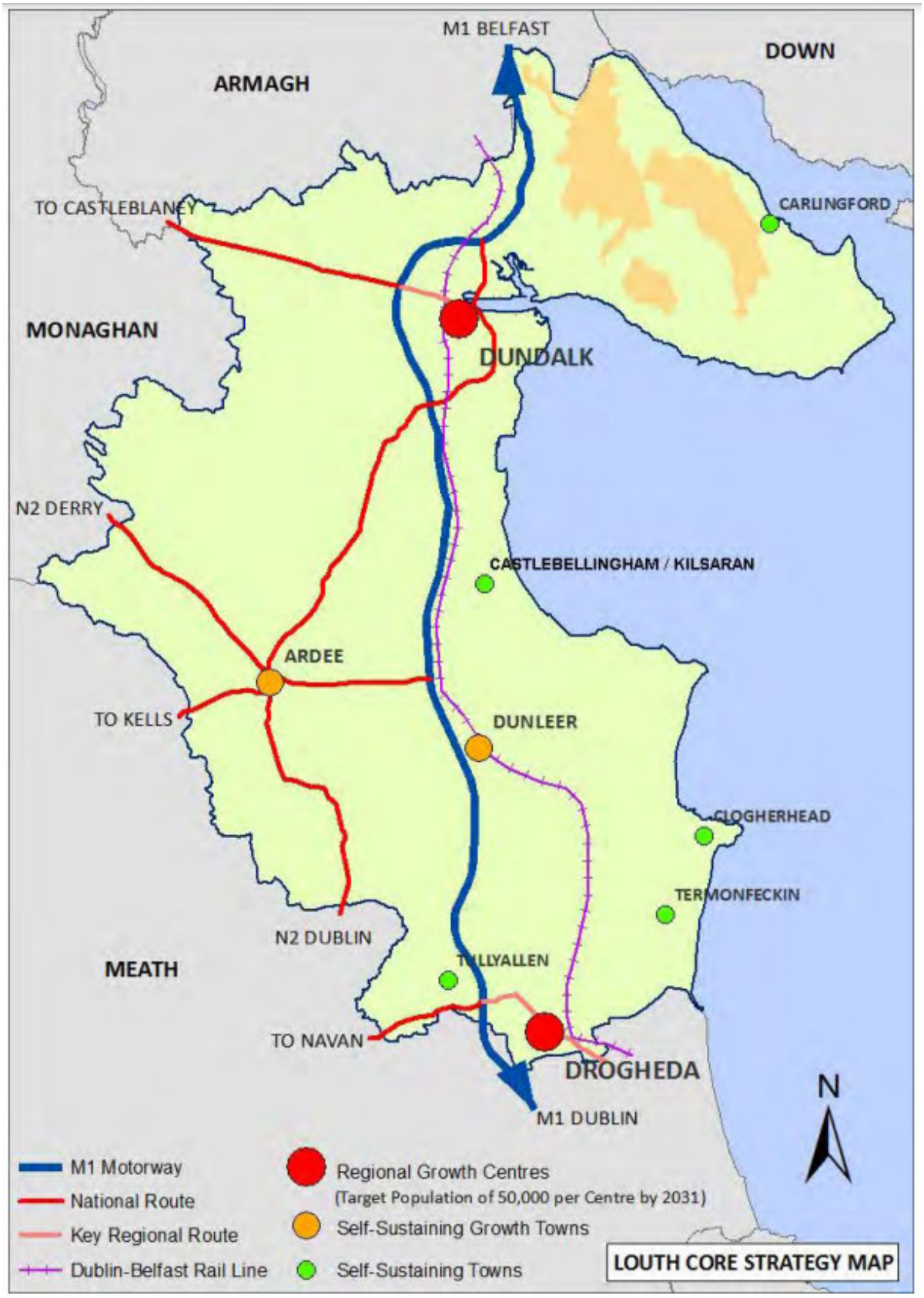


Figure 6-2 **Louth Core Strategy Map (*Source: Louth County Development Plan 2021-2027)***

Zoning Objectives

The proposed development is located within an area which is zoned as J1: Transportation Development Hub. Lands to the immediate west are zoned A1: Existing Residential. Lands to the north of Marsh Road are zoned D1: Regeneration.

The proposed development is considered to be in accordance with the relevant zoning objective.

Protected Structures

There are a number of protected structures in or adjoining Drogheda MacBride Station, including the Boyne Viaduct. Any works associated with the proposed development that may affect protected structures have been carefully assessed, details of which are provided in the supplementary Heritage Impact Assessment Report (HIAR) included with this application and summarised in Section 8.1 below.

Flooding

In accordance with the Strategic Flood Risk Assessment (SFRA) for the Louth County Development Plan 2021 – 2027, *where development is proposed within an area of potential flood risk (Flood Zone A or B), a flood risk assessment of appropriate scale will be required and this assessment must take into account climate change and associated impacts.*

Of note from the SFRA in respect of this area, is the following:

RPO–Regeneration of lands at McBride Station *– The predicted Flood Zone A & B extents encroaches on the land between the River Boyne and the Marsh Road zoned for future employment use. the extent of the flooding is limited to the lands north of Marsh Road and does not extend to the remaining land zoned adjacent to McBride Station for future employment and residential use south of Marsh Road. An open space area has been zoned to maintain the floodplain along the Silverstream watercourse.*

Although the majority of the proposed substation area is at low risk of fluvial flooding (i.e., Flood Zone C), the substation area is at moderate to high risk (Flood Zones A or B) of tidal flooding. A Flood Risk Assessment (FRA) has been carried out to support this application and will be summarised in Section 7.3 of this report.

7. ENVIRONMENTAL ASSESSMENTS

7.1 Environmental Impact Assessment

The prescribed classes of development and thresholds that trigger a mandatory EIA are set out in Schedule 5 of the Planning and Development Regulations 2001, as amended. A review of the project types listed in the aforementioned Schedule 5, as amended, has been carried out. The proposed development is a type set out in Part 2 Class 10 (c) of Schedule 5 but it does not exceed the relevant quantity, area or other limit specified in that part. Therefore, it is a sub-threshold development and has been screened for EIA as described below.

Arup has prepared an EIA Screening Report on behalf of IÉ to assist in determining whether an EIA is required for the proposed development. The information provided in this report provides details on the characteristics of the proposed development and its likely significant effects (if any) on the environment. It also provides the relevant details under each of the criteria set out in Schedule 7A of the Planning and Development Regulations 2001, as amended. This information will assist the competent authority, Louth County Council to undertake the EIA screening as required under Section 103 of the Planning and Development Regulations 2001, as amended.

Based on the information provided in this report, it is the opinion of Arup that there is no real likelihood of significant effects on the environment arising from the proposed development and that an EIA is not required.

The final determination on EIA Screening will be made by the competent authority, Louth County Council.

7.2 Appropriate Assessment Screening and Natura Impact Assessment

An Appropriate Assessment (AA) is required if significant effects on European sites arising from a proposed development cannot be ruled out at the screening stage, either alone or in combination with other plans or projects. It is the responsibility of the competent authority to make a decision as to whether or not the proposed development is likely to have significant effects on European sites, either individually or in combination with other plans or projects. As set out in the AA Screening Report provided by Scott Cawley Ltd. (provided in supporting materials for this application), an Appropriate Assessment of the proposed development is required as it cannot be concluded, on the basis of objective information, that the proposed development, either individually or in combination with other plans or projects, will not have a significant effect on the following European sites: River Boyne and River Blackwater SAC, Boyne Coast and Estuary SAC, Boyne Estuary SPA, River Nanny Estuary and Shore SPA, Dundalk Bay SPA, Stabannan- Braganstown SPA, Skerries Islands SPA, and Rockabill SPA.

As such, a Natura Impact Statement (NIS) was prepared by Scott Cawley Ltd. in support of this application. The purpose of the NIS is to provide an examination, analysis and evaluation of the potential impacts of the proposed development on the above mentioned European sites and to present findings and conclusions with respect to the proposed development in light of the best scientific knowledge in the field. The NIS will inform and assist the competent authority, Louth County Council, in carrying out its Appropriate Assessment as to whether or not the proposed development

will adversely affect the integrity of the European sites, either alone or in combination with other plans and projects, taking into account their conservation objectives.

It has been objectively concluded by Scott Cawley Ltd. that the proposed development will not adversely affect (either directly or indirectly) the integrity of any European site, either alone or in combination with other plans or projects.

Both the AA Screening Report and NIS are provided as part of the supporting materials for this planning application.

7.3 Flood Risk Assessment

A FRA has been carried out as part of this Planning Application for the proposed BEMU substation at Marsh Road car park and charging facilities at Drogheda MacBride Station.

Although the majority of the proposed substation area is at low risk of fluvial flooding (i.e., Flood Zone C), the substation area is at moderate to high risk (Flood Zones A or B) of tidal flooding. To ensure the substation remains safe and operational during and after a flood event, the finished floor levels will be raised above the 1 in 200-year tidal flood level with a 300mm freeboard allowance. The substation and all proposed works are outside the 1 in 100-year fluvial flood extents and as such, raising of development levels will not have an impact on fluvial flooding elsewhere.

Pedestrian access is considered at low risk during a tidal event, due to access provision from the existing stairs on the south end of the car park. Safe access and egress for vehicles will occur when high tide recedes, which is anticipated to be within one hour.

With above considered, a Flood Emergency Plan will be developed for the substation location. The plan will detail triggers for activation, including receipt of a timely flood warning, and a plan will set out arrangements for access and egress, both for pedestrians, vehicles, and emergency services ahead of a flood event.

In conclusion, the FRA has demonstrated that the risks relating to flooding to the proposed development are moderate but can be managed and therefore comply with Department of Environment, Heritage and Local Government and OPW and Louth County Council planning guidance.

8. OTHER MATERIAL CONSIDERATIONS

8.1 Heritage and Archaeological Impacts

There are no recorded archaeological sites located with the proposed development site and the only example within a study area extending for 500m from its boundary comprises a Mound located approximately 390m to the southwest. It is, therefore, concluded that the proposed development will result in no predicted impacts on the known archaeological resource. While the archaeological potential of the location is considered to be low, the possibility for the presence of sub-surface archaeological features cannot be discounted and will require mitigation. Appropriate measures are included within the Construction Environmental Management Plan (CEMP), which accompanies this planning application, to ensure that any unexpected discoveries are treated appropriately by the nominated contractor.

An Archaeological and Architectural Heritage Impact Assessment has been prepared for the proposed development and is included as part of this planning package. The report examines the property and history of Drogheda Railway Station and environs and seeks to identify the importance of the buildings in architectural heritage terms and the impact of the proposals on the structures within and around the station complex. The assessment found no significant impacts are predicted during the construction or operational phases of the proposed development.

8.2 Landscape and Visual Considerations

A Landscape and Visual Impact Assessment (LVIA) was undertaken to assess the potential impacts of the proposed development. An LVIA report was produced and is included as part of this planning application. This includes a number of photomontages from viewpoint locations in the vicinity of the proposed development. These viewpoint locations were agreed in advance with Louth County Council.

The LVIA concluded that the proposed development will not give rise to significant landscape and visual impacts. The proposed overhead charging facilities are located with the existing operational station area and the structures and in-keeping with the prevailing character of the area. The proposed sub-station compound is located within an existing carpark area and set back towards the base of rising slope. Additional planting is provided on the slope to enhance screening from Carmelite Cottages.

8.3 Proposed Boyne Greenway Route from Drogheda to Mornington

Meath County Council have recently submitted an application to An Bord Pleanála for permission to carry out works relating to the construction of a Boyne Greenway walking and cycling route east of Drogheda Town to Mornington Village. The initial section of the proposed Greenway from Ship Street/railway viaduct to the Drogheda Wastewater Treatment Plant on Marsh Road comprises of a shared pedestrian/cycle facility, 4m wide, on a flexible pavement segregated by a kerb from the adjacent carriageway of Marsh Road (R150) for approximately 1km. The greenway will be constructed by using an existing disused verge area on the north side of the Marsh Road (R150).

The proposed greenway has been considered carefully in the layout and access design of the BEMU project, particularly in relation to works occurring within IÉ's carpark at Marsh Rd. Currently this IÉ

owned carpark, which acts as an overflow for the main railway station carpark, is significantly underutilised. It is not considered a valuable public asset in terms of vehicle parking for this area of Drogheda and is not currently identified as an essential element of the Boyne Greenway project. Nonetheless, any loss of carparking will be insignificant and of a temporary nature for the duration of the BEMU operations prior to electrification of the full line. Therefore, neither proposals are expected to impact negatively upon each other.

Integration of active travel and railway networks remains a priority for IÉ, and continued engagement between all stakeholders will ensure sustained synergy on both projects. As both the DART+ Coastal North and the Boyne Greenway projects progress, ongoing discussions will be pursued to collaborate proactively on sustainable solutions.

9. SUMMARY AND CONCLUSION

The BEMU project is being proposed as an interim capacity increase measure, ahead of the full electrification of the railway proposed under the DART+ Coastal North project. As previously identified, the BEMU project will allow the enhancement of the capacity and service on the network, ahead of the proposed implementation of the DART+ Coastal North project.

The proposed development will have a long term positive effect on the population in Drogheda. The proposal not only provides additional rail services from Drogheda to Dublin for those existing residents, but will also encourage sustainable, compact, integrated land use patterns within urban areas. Regional and intercity connectivity will be greatly improved, enhancing accessibility, and easing existing pressures from increasing demand.

The BEMU project introduces a rail transport mode which is cleaner, less dependent on oil, and more energy efficient. It will allow for efficient transportation along the east coast of Ireland, and encourage greater use of public transportation, reducing the dependency on car-based commuting. It encourages *Compact Growth*, *Sustainable Mobility* and provides a *Transition to a Low Carbon and Climate Resilient Society*.

As detailed in the previous sections, careful consideration has been given to the location of the required infrastructure and compliance of proposed works with national, regional and local policy. The proposal has also been assessed for compatibility with existing and future development proposals. Finally, all technical and environmental matters associated with the proposed development have been thoroughly evaluated and deemed acceptable. In particular, any concerns which may have arisen relating to car parking provision, flooding, heritage and visual impacts have been mitigated.

In summary, this application has been designed and informed by specialist assessments relating to the site and surrounds, pre-application consultation, the objectives of the relevant national, regional and local policy, as well as ongoing stakeholder engagement. Planning permission should therefore be granted accordingly.

Document Verification

Project title	DART+ BEMU
Document title	Planning Report
Job number	297733
Document ref	D+WP56-ARP-P4-BE-RP-RO-000003
File reference	

Revision	Date	Filename	D+WP56-ARP-P4-BE-RP-RO-000003
P01	15/06/2022	Description	For IÉ review and comment

	Prepared by	Checked by	Approved by
Name	[redacted]		
Signature			

Filename	
Description	

	Prepared by	Checked by	Approved by
Name			
Signature			

Filename	
Description	

	Prepared by	Checked by	Approved by
Name			
Signature			

Issue Document Verification with Document ☑

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1. INTRODUCTION

1.1 This Planning Application - BEMU Programme Overview

Iarnród Éireann (IÉ) are introducing new rolling stock called Battery Electric Multiple Units (BEMUs). A BEMU train is a train that can be powered from overhead line traction, where such infrastructure exists; and powered from on-board battery traction elsewhere. There is no diesel fuel associated with BEMU trains.

The BEMU rolling stock has been procured and is due for delivery in 2024. The provision of BEMUs will enhance the capacity and service on the network. IÉ have identified the Northern Line as the most suitable route for potential BEMU deployment between Dublin City and Drogheda.

For BEMUs to operate successfully on the Northern Line, charging facilities are required to recharge the batteries to enable operations. IÉ has identified Drogheda MacBride Station as the preferred charging station location. The intent is that the new rolling stock would operate under electrical power as far as Malahide and from there, onwards to Drogheda, the rolling stock would operate under battery power. At Drogheda, the batteries would be charged, before the operations are reversed on the return journey.

IÉ is seeking planning permission for the infrastructure needed to enable this BEMU rolling stock, hereafter referred to as the 'proposed development'. The proposed development comprises three key elements, namely:

- New ESB/traction substation at Marsh Road;
- New overhead line charging facilities at Platform 2 and 3 and Depot Track 4 at Drogheda MacBride station; and
- Associated cable routes between Substation and Charging Facility.

In addition to the proposed development, which is subject of this planning application, there will also be minor works to the depot and stabling road progressed under exempt development rights awarded to statutory undertakers. Specialist assessments and reports included as part of this application have considered all proposed development (planning application and exempt development) to ensure potential cumulative effects are identified and addressed.

While the proposed development is a standalone project, it forms part of a wider programme of works being proposed by IÉ, namely the DART+ Programme. An overview of the DART+ Programme and the BEMU project is provided below and further within the specialist reports (including the EIA Screening Report) which will accompany this planning application.

1.2 Associated Railway Order - DART+ Programme Overview

DART+ is a transformative programme of projects that aims to modernise and improve existing rail services in the Greater Dublin Area (GDA). It will provide a sustainable, electrified, reliable and more frequent rail service, improving capacity on rail corridors serving Dublin. The scope of works for the programme is summarised in Figure 1-1.

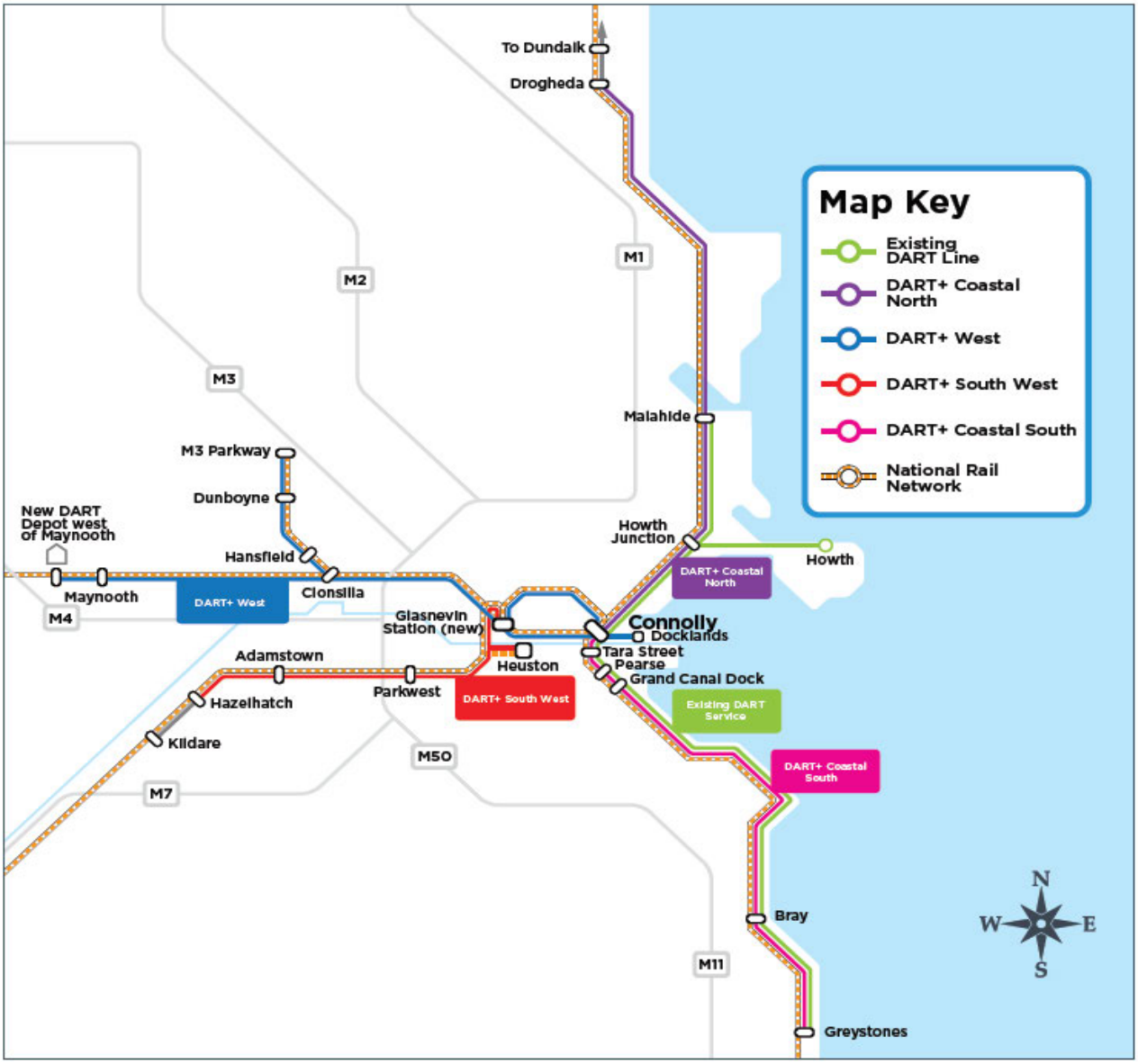


Figure 1-1 DART+ Programme of Works Overview

The current DART network is 50km long, extending from Malahide/Howth to Greystones. The DART+ programme will increase the length of the DART network to 150km of railway corridor through the electrification and upgrade of existing lines transforming commuter train travel in the Greater Dublin Area (GDA).

The DART+ Programme is required to facilitate increased train capacity to meet current and future demands which will be achieved through a modernisation of the existing railway corridors. It will also contribute to Ireland's transition to a low carbon and climate resilient society. The DART+ Programme comprises the following improvement projects across the four main rail corridors:

- DART+ West - Maynooth and M3 Parkway to the City Centre;
- DART+ South West - Hazelhatch & Celbridge to the City Centre;
- DART+ Coastal North - Drogheda to the City Centre;
- DART+ Coastal South - Greystones to the City Centre; and
- DART+ Fleet - Purchase of new train fleet to increase train services.

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

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

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

1.3 Purpose and Structure of the Planning Report

The purpose of this Planning Report is to demonstrate how the development proposal complies with pertinent regional and local planning policies. In drawing conclusions for this application, reference is also made to the findings of various technical reports which are submitted in support of the application.

The remainder of this document is structured as follows:

Section 2 describes the site location and context

Section 3 describes the development proposal

Section 4 summarises the substation location selection process

Section 5 details the pre-application discussions held with Louth County Council

Section 6 assesses relevant policy compliance

Section 7 gives a summary of environmental assessments carried out to support the application

Section 8 assesses other material considerations

Section 9 provides a summary and conclusion

1.4 Supporting Documents

The following documents have been compiled to support this application for full permission:

- Application Form and Fee
- Plans and Drawings
- Planning Report (this report)
- Environmental Impact Assessment Screening Report
- Appropriate Assessment Screening Report and Natura Impact Statement
- Flood Risk Assessment
- Heritage Impact Assessment Report
- Landscape and Visual Impact Assessment Report
- Construction Environmental Management Plan (CEMP)

Whilst this report summarises the key elements and findings of those other application documents and sets out how the proposal complies with prevailing planning policies; it is important that the application submission be read as a whole.

2. SITE AND SURROUNDING CONTEXT

2.1 Site Context

All proposed works are to be located within the Drogheda MacBride Station, in Drogheda, Co. Louth. Figure 2-1 shows the location of the proposed development, with the overall development site (outlined in red). The entire site is within CIE property (outlined in blue).

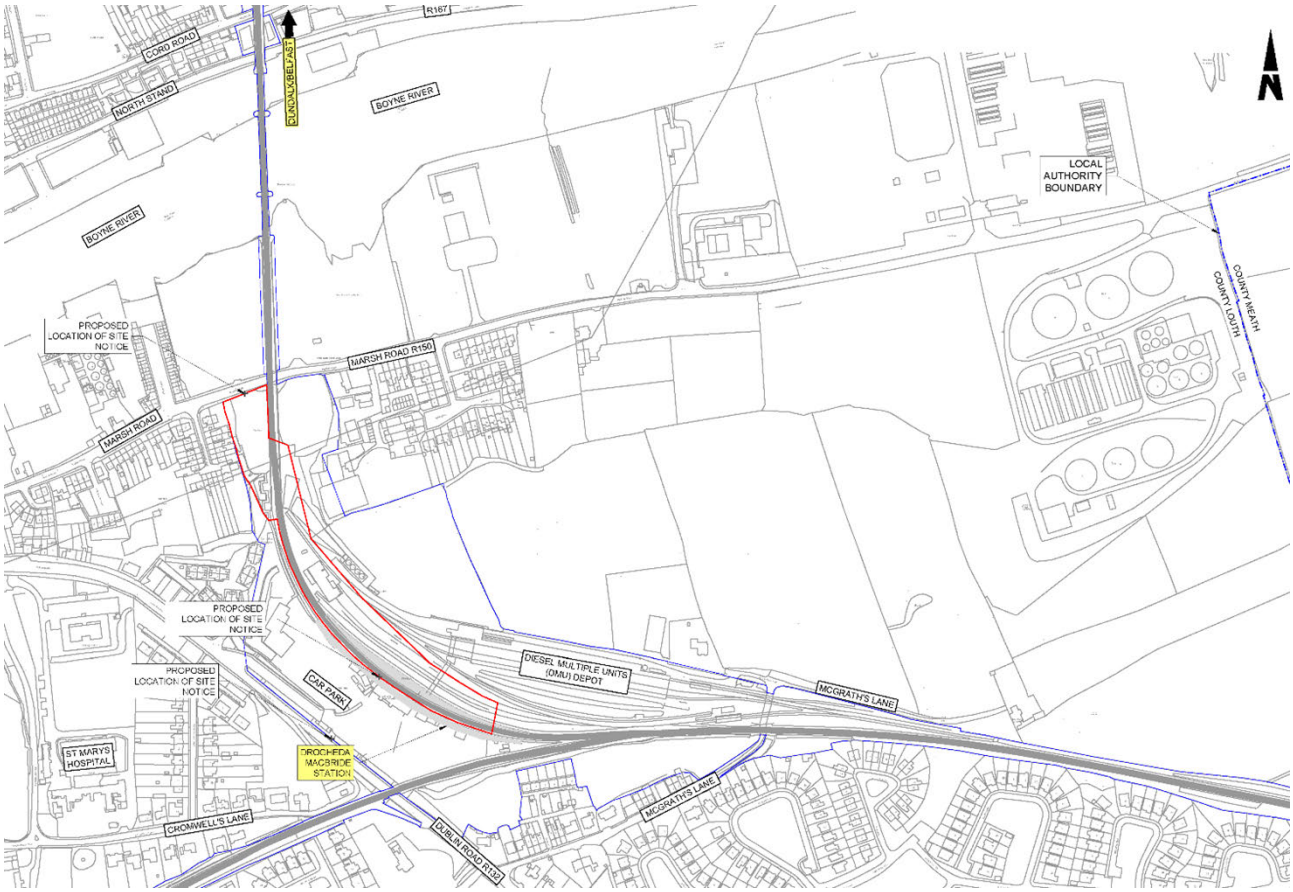


Figure 2-1 Location of Proposed Development

The proposed substation will be located within the lower carpark at Drogheda MacBride Station and is accessed by vehicle from Marsh Road. A pedestrian stairway provides access to the main station from the car park, with the pedestrian stairs located at the southern end of the car park.

Figure 2-2 shows the existing carpark from Marsh Road, facing south.



Figure 2-2 View of Marsh Road Carpark Entrance (looking south)

The proposed ESB/traction substation site is located at the southern end of the Marsh Road carpark and the substation compound is approximately 80m long and 45m wide at the northern end, narrowing to 25m wide at the south. This gives a total site area of approximately 2,500m^2. The proposed substation compound will be approximately 700m^2.

The cables from the proposed ESB/traction substation to the overhead line charging infrastructure will be laid from the proposed substation under the viaduct and up the embankment on the eastern side, to the platforms and depot area, where the charging infrastructure is located.

The overhead electrical charging infrastructure (charging roads) will be located in Drogheda MacBride Station and Depot. Figure 2-3 shows the existing platform 2/3 where the charging roads are planned. The proposed charging will take place on the Up Main line (platform 2), the Siding line (platform 3) and the DMU Service 4 line (Depot Track 4). The charging structures will comprise a series of overhead line cantilever and portal structures supporting the charging contact.



Figure 2-3 View from Drogheda MacBride Station (Platform 2/3) where charging roads are planned (facing northwest)

2.2 Planning History

Planning Ref: 09/510074

The proposed substation would be located within the lower car park which services the station, and which is accessed from Marsh Road. Planning permission for this car park was granted by Louth County Council in 2009. The permitted development comprised:

"Development on lands adjacent to Drogheda (MacBride) Railway Station (which is a protected structure, RPS No. DB-055), Drogheda, County Louth. The development will consist of works adjoining and adjacent to a protected structure (viaduct railway bridge, PRS No. DB-184) comprising of the construction of 100 no. additional car parking spaces, accessed from Marsh Road. The development also provides for an external stairwell link to the existing station car park, landscaping, lighting, CCTV and all associated site development works, with new vehicular entrance and associated signage at Marsh Road."

Planning Ref: 10/510055

Planning permission was granted in 2010 for minor maintenance upgrades to the main station building, comprising of:

"Development at McBride Railway Station, which is a Protected Structure. Dev. consists of removal of glass screens & counter to Ticket Office & Waiting Room, introduction of new glass double door to Waiting Room, re-instatement of original arch to Ticket Office, demolition of existing partition wall in Ticket Office & construction of new partition walls in new positions, installation of 5nr automatic ticket gates with associated screens & all assoc.works".

Other Applications within Blueline Boundary

A small number of historic planning applications have been identified outside of the development redline, yet within the landowner limits. See Table 2-1 overleaf. These applications pose no incompatibilities with the proposed development.

Planning Reference	Applicant	Location	Description	Decision	Decision Date
99/510044	Meteor Mobile Communications Ltd.	MacBride Railway Station	Replace lighting pole with 20m monoplole, antennae for mobile phone purposes, equipment container	Grant	28/04/1999
00/510255	Iarnród Éireann	MacBride Railway Station	Construction and operation of an arrow fleet train servicing centre, maintenance workshop, administration building, single storey train wash bld. workshop together with associated word and EIS statement.	Grant	18/01/2001
08/510091	Iarnród Éireann	MacBride Railway Station	The removal of the existing entrance doors, flanking windows & masonry wall under the windows in the southwest wall of the ticket hall & the provision of a free standing glazed entrance screen with automatic sliding doors within the existing entrance	Grant	30/07/2008
08/510169	CIE	MacBride Railway Station	Removal of 3 no. 48 sheet, 6.4m X 3.2m illuminated static advertising signs from boundary wall facing Dublin Rd at junction with entrance road to Railway Station & replacement with 2 no. illuminated trivision rotating 6.4m X 3.2m advertising signs.	Grant	22/12/2008
05/510138	Iarnród Éireann	MacBride Railway Station	Construction of boundary wall, DMU, Train Depot. McBride Station Drogheda	Grant	03/08/2005

Table 2-1 Relevant Planning History

3. THE PROPOSAL

3.1 Overview of the Proposed Project

The BEMU project is being proposed as an interim capacity increase measure, ahead of the full electrification of the railway line which is proposed through the DART+ Coastal North project. In advance of the final electrification and other works to Drogheda station being undertaken (as part of the DART+ Coastal North project), the BEMU will operate from a temporary stabling/charging facility to be implemented during the interim phase of operations. Hence the charging infrastructure has an expected operational lifespan of approximately 5-10 years.

The design of the substation has been cognisant of this temporary requirement and as a result, the design provides for modular construction, in containerised units, which can be easily decommissioned, moved, and reused elsewhere at a later date. Once the DART+ Coastal North project is operational, the BEMU ESB/traction substation and charging facilities will no longer be required and will be decommissioned. The BEMU trainsets can continue to be operated as EMU trainsets on the Northern Line or be deployed elsewhere on the network.

3.2 Description of the Proposed Works

3.2.1 Substation and Cable Route

The ESB/traction substation is required to provide a controlled charging current to the stabled trains on the platforms in Drogheda Station. Drawings of the proposed substation are provided in the drawings pack provided with this application. The substation comprises several separate containerised units and a block work building located within a paladin fenced substation compound.

The substation compound will be located at the south end of the Marsh Road car park. The compound layout will maintain the current public access to the stairs leading to the station ticket office. The CCTV cameras in the existing car park will be reconfigured to ensure adequate coverage of the route through the car park to the staircase.

Whilst this car park does have some occupancy, given the distance and level differential from the station entrance, it is not often used by commuters of the railway station. Discussions with internal IÉ Stakeholder Buildings & Facilities and Operations have confirmed that the Marsh Road car park is rarely busy and is considered underutilised IÉ land. To facilitate the substation compound in an efficient manner, car parking spaces will be re-configured to retain as many spaces as possible. There are currently 98 spaces within the car park which will be reduced to 44 spaces once the substation and compound is in operation. As mentioned above, due to the temporary nature of the BEMU infrastructure car parking spaces will be reinstated prior to the launch of the DART+ Coastal North project to cater for the significant increase in rail capacity associated with it.

The substation buildings include a small block-built building housing the Electricity Supply Board Network (ESBN) equipment providing current at 10kV AC. Adjacent to this is located a container, housing the main AC control switchboards and transformer. Additional containers will be provided to house the rectifier and DC control switchboards and Energy Storage System (ESS). Each of these containerised units will be placed on a concrete slab foundation and will include cable ducts between each of the units. Details of the cable routes and ducts within the substation compound will be further

developed during the design. There will be a maximum of five containers, but this will depend on the final equipment design to be developed by the suppliers of the equipment. The proposed colouring for the substation is juniper green which has been selected to assist with visually integrating the structures into the background. The proposed substation compound is also set low relative to the properties in Carmelite Cottages with additional planting to assist with screening lower level views towards the compound.

The containerised design will allow the installation to be easily relocated when the BEMU service is replaced, and charging is no longer required. This minimises impact to the site which can revert to the previous use as a carpark.

Road access is provided from the R150 Marsh Road to the immediate north of the site. This regional road is currently used for access to the existing Mornington Road ESB substation, from Marsh Lane Lane further to the east of the Boyne Viaduct. As such, adequate third party access for a substation of this nature is provided from the Marsh Road. The site is also located wholly on CIÉ property. The substation can also be accessed on foot via the stairway which leads from the lower carpark to the main station. Walkways and step access will be provided to allow maintenance personnel easy access to inspect and carry out repairs within the secured compound.

The existing drainage system will require some alteration for the substation compound with some of the carpark drainage being altered. Where the new substation compound is located, new filter drains will be installed. The existing surface water drain from the south west embankment will tie into the new filter drains before the compound drainage discharges back into the original drainage system prior to passing through the petrol interceptor.

A landscape design has been prepared for the proposed substation and is included in the planning drawings pack, accompanying this application. The proposed landscape design includes protection of existing vegetation where practicable and additional planting on the slope to the rear of the Carmelite Cottages to provide low level screening (without impacting the Boyne Viaduct). Further details of the Landscape and Visual Impact Assessment carried out for this application can be found in Section 8.2.

Noise emissions from the installation will be consistent with regular ESBN substations and any potential effects from noise are considered in the EIA screening report submitted in support of this application. In line with this, some ventilation or air conditioning plant may operate from time to time to prevent equipment being exposed to unacceptable temperature.

3.2.2 Cables between Substation and Overhead Charging Infrastructure

Protected below-ground cable ducts adjacent to the existing 10kV cable route to the depot building will provide power from the ESBN substation at Mornington Road. This will be via the existing cable which runs beneath the carpark. A cable joint chamber will be constructed adjacent to the compound to splice in the 10kV cable.

From the substation compound a buried cable route will pass beneath the first viaduct arch and ascend the embankment on the east side. Due to the steep gradient, the cable route in this area will be laid in a semi-buried cable trough. Existing vegetation on the embankment will be disturbed to the extent needed to allow the troughing to be laid.

The ducting and troughing will accommodate a set of cables which will supply each of the charging road overhead contact equipment, running between the tracks at the edge of the service slab on depot road 4 and connecting to the charging equipment via a portal frame.

3.2.3 Charging Facilities at Platform 2 and Platform 3 and Depot Road 4

Platforms 2, 3 and depot road 4 will be equipped with overhead contact rails that will enable the BEMUs to be easily charged upon arrival at the station. Drawings of the proposed charging infrastructure are included in the planning drawings pack, accompanying this application. The charging infrastructure will comprise the provision of overhead line charging infrastructure at Platform 2 and 3 and charging track 4 at Drogheda MacBride station, in two separate locations at each end of the platforms and depot track aligned with the pantograph of the train. These structures will be galvanised metal structures, suspended from 12 masts and will comprise 2 portal frames, 4 double cantilever and 4 single cantilevers. The pantograph will extend when the train is ready to be charged and contact with the insulated overhead conductor rail (OCR) aligned over the train.

Since the bar is energised with 1500V DC, arrangements similar to that for the existing DART will be employed here including ensuring a safe clearance between the public and staff for the live parts and means to shut off the power in the event of emergencies. Furthermore, the OCR will not be powered unless there is a train in position that needs to be charged.

The OCR will be suspended using several cantilevered arms from masts set into the platform surface located approximately along the centre line of platforms 2/3. A further set of masts will be placed alongside the depot road 4 track. The mast heights will be approx. 8 metres high to be sufficient to support the cantilever arms and the weight of the structure. Some cable ducts will be installed within the platform structure and will provide a route for bonding cables. Power cables will be mechanically protected to ensure they would not be accessible to the public.

The precise arrangement of the live parts of the OCR will be dependent on the BEMU manufacturer's design however the minimum clearance distances of 3.0m defined in the EN 50122-1 Standard (CENELEC 2011) will be observed.

Within the depot passive provision will be made for a diesel back-up generator which would allow the generator to be located at the northern end of the depot where the turntable is currently located should it ever be required.

Details of all proposed works mentioned above are included in the planning drawings pack, accompanying this application.

4. SUBSTATION LOCATION SELECTION PROCESS

To determine a suitable location for the ESB/traction substation, a number of possible sites were first identified within the following criteria:

1. Sufficient space for the BEMU substation building and compound. The areas required are as follows:
    - Overall compound: 1,700 m^2
    - ESB Room: 171 m^2
    - Substation Building: 220 m^2

    Whilst some refinement of these figures may be achieved as the design progresses, they set a guide for the scale of site needed.
2. Road access is required for maintenance including installation and replacement of large equipment such as transformers.
3. Third Party access is required for ESB staff without entering the operational railway.
4. The site should be on CIÉ land.

At this stage, three sites were deemed appropriate for further assessment. Option 1 – Marsh Rd Carpark, Option 2 – Main Station Carpark, and Option 3 – East of Railway Terraces, can be seen in Figure 4-1 below.

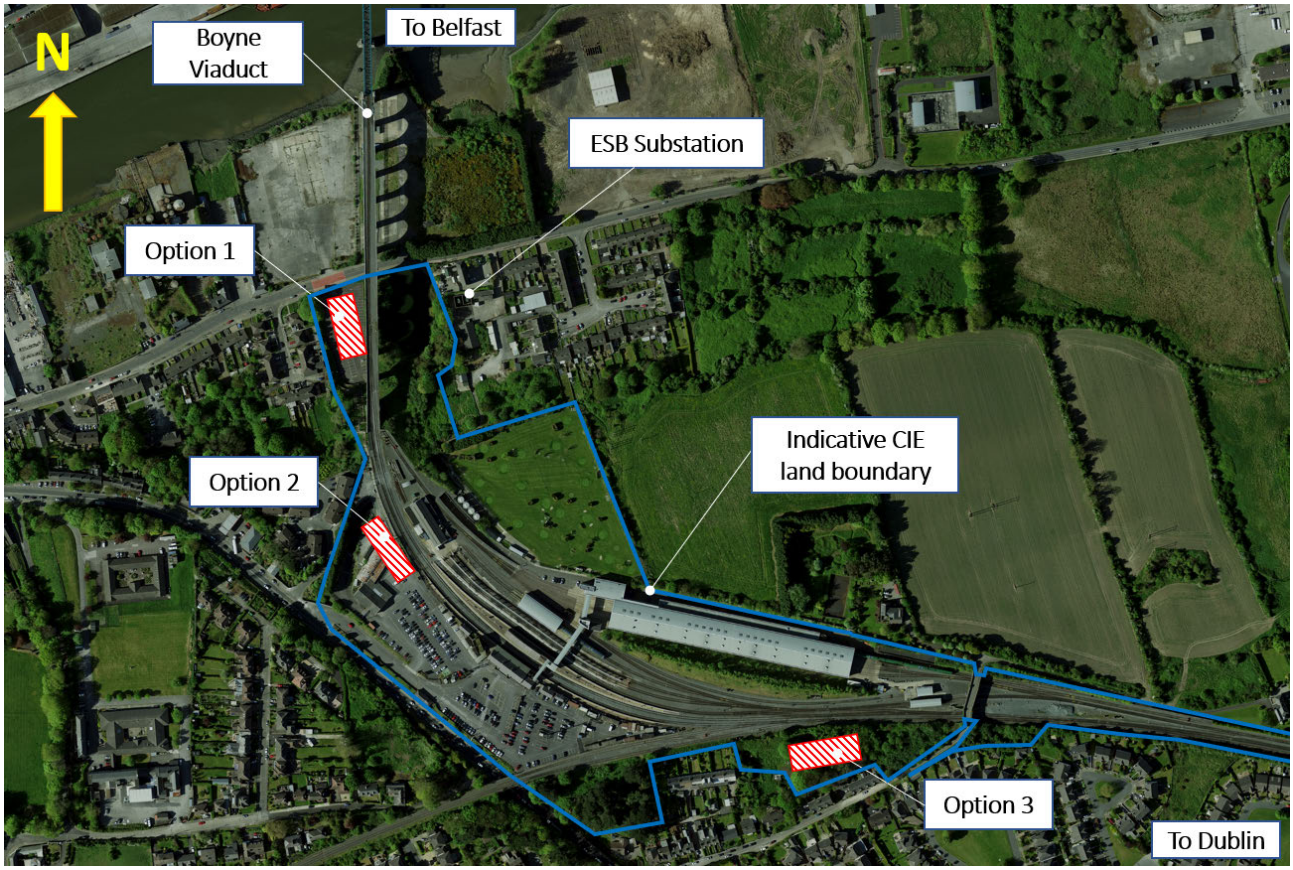


Figure 4-1 Plan showing possible substation locations

Other locations which were considered but not taken forward as they do not meet the minimum requirements were:

- Existing Drogheda substation – the existing substation is located within the depot building and designed to only supply the depot building itself (lighting, services, wheel lathe, train wash etc). This is a much smaller load compared to that required to charge the BEMUs. Therefore, in terms of the additional equipment needed and the size of the accommodation, which is also constrained by the building, it is not suitable to be upgraded.
- Pitch and Putt course – not taken forward as although it is on CIE land it is subject to a 25-year sporting lease.
- Area of land adjacent to Dublin Road, south of the Dublin Road Underbridge – not taken forward as topography does not allow for vehicle access off the Dublin Road.

Following further evaluation of Options 1 to 3, including a review of policy, civil engineering, SET (Signalling, Electrical and Telecoms) assessment, flooding, heritage, noise and vibration, and biodiversity, Option 1 was identified as the most suitable location. The comparison of options is summarised below:

1. Option 1 – Marsh Road Car Park
   The Marsh Road car park is a developed, level site with good existing road access, situated within close proximity to the existing Mornington Road ESB substation. There is no SET infrastructure in the vicinity which would be impacted. Whilst the cable routes to Platform 2 would be longer than in the other options, the route does not present any particular technical difficulties. Any loss of carparking on the private lands is deemed temporary and insignificant.

2. Option 2 – East of Railway Terraces
   This site requires the most development of all the options as it is currently undeveloped and has a notable level difference across the site and between the site and the access road. It is also zoned as A1 – Existing Residential, therefore would be non-compliant with policy. A new entrance would need to be constructed off the narrow Railway Terraces/McGrath's Lane which could constrain access to the site. This location is also the least technically convenient in terms of SET, being on the south of the turnouts on the mainline. In the event of supply being provided from the Mornington Road ESB Substation, this would involve establishing a lengthy cable route along the Railway Terraces road.

3. Option 3 – Main Station Car Park
   Whilst this option is in close proximity to the TER for SCADA connections as well as the relative simplicity of cable routes to the platforms, this option comes with two main challenges:

   a) The current track and SET stores would need to be relocated to a different, currently unidentified location.
   b) The number of available parking spaces in the main station car park would be reduced – and while this is also a result at Option 1, Marsh Rd is currently considered underutilised and not conveniently accessible to the station. The impact is deemed significantly more adverse at Option 3 location, being the main car park for the station with appropriate accessibility.

5. PRE-APPLICATION CONSULTATION

In accordance with Section 247 of the Planning and Development Act, 2000 (as amended), pre-application consultation was sought with Louth County Council. The intent of consultation discussions was to confirm the proposed approach for the planning application, outline specific environmental information required, and gain Louth County Council's position on any issues.

The pre-application meeting was held on 6th May 2022. In attendance were members of the Iarnród Éireann BEMU project team, Arup consulting team, and Louth County Council's Transport Planning and Planning Departments. Any queries or requests for specific information have been addressed through this planning report or supplementary technical reports and drawings.

6. POLICY AND DEVELOPMENT CONTEXT

6.1 Regional Policy

6.1.1 Trans-European Network for Transport

The Trans-European Network for Transport (TEN-T) is a European Union policy directed towards the implementation and development of a Europe-wide network of roads, railway lines, inland waterways, maritime shipping routes, ports, airports and rail-road terminals. The aim of the EU's Transport Policy is to promote a mobility that is efficient, safe, secure and environmentally friendly. Regulation (EU) No 1315/2013 sets out the requirements for rail infrastructure that form part of the TEN-T infrastructure network, both Core (2030) and Comprehensive (2050), and states under Article 12(2)(d), the following:

"Member States shall ensure that the railway infrastructure:

(d) save in the case of isolated networks, is fully electrified as regards line tracks and, to the extent necessary for electric train operations, as regards sidings;"

The BEMU project is consistent with the objectives of the Trans-European Network for Transport. It will involve the creation of a rail mode transport which is cleaner and less dependent on oil, and more energy efficient. It will allow for more efficient transportation along the east coast of Ireland, and encourage greater use of public transportation, reducing the dependency on car-based commuting.

6.2 National Policy

6.2.1 Project Ireland 2040: National Planning Framework

The National Planning Framework (NPF) is the Government's high-level strategic plan for shaping the future growth and development of the country by 2040. It is a framework to guide public and private investment, to create and promote opportunities to protect and enhance the environment.

There are 10 "National Strategic Outcomes" several of which are relevant to the proposed development:

"1. Compact Growth:

Carefully managing the sustainable growth of compact cities, towns and villages will add value and create more attractive places in which people can live and work. All our urban settlements contain many potential development areas, centrally located and frequently publicly owned, that are suitable and capable of re-use to provide housing, jobs, amenities and services, but which need a streamlined and co-ordinated approach to their development, with investment in enabling infrastructure and supporting amenities, to realise their potential. Activating these strategic areas and achieving effective density and consolidation, rather than more sprawl of urban development, is a top priority."

This BEMU project, being an important stage of the wider electrification of the Drogheda to Malahide line will, by providing a more efficient public transport infrastructure, make urban areas and zoned lands along the route, more attractive areas in which to live and work in.



Figure 6-1: National Strategic Outcomes ***Source: Project Ireland 2040***

"4. Sustainable Mobility:

In line with Ireland's Climate Change mitigation plan, we need to progressively electrify our mobility systems moving away from polluting and carbon intensive propulsion systems to new technologies such as electric vehicles and the introduction of electric and hybrid traction systems for public transport fleets, such that by 2040 our cities and towns will enjoy a cleaner, quieter environment free of combustion engine driven transport systems."

The BEMU project is entirely consistent with this Strategic Outcome in terms of the provision of Battery Electric Multiple Units on a busy public transportation route along the east coast of Ireland.

"8. Transition to a Low Carbon and Climate Resilient Society:

The National Climate Policy Position establishes the national objective of achieving transition to a competitive, low carbon, climate-resilient and environmentally sustainable economy by 2050. This objective will shape investment choices over the coming decades in line with the National Mitigation Plan and the National Adaptation Framework. New energy systems and transmission grids will be necessary for a more distributed, renewables-focused energy generation system, harnessing both the considerable on-shore and off-shore potential from energy sources such as wind, wave and solar and connecting the richest sources of that energy to the major sources of demand."

The BEMU project will encourage less car-based travel and will comply with the objective to reduce carbon emissions in the country.

6.2.2 National Development Plan 2021-2030

The current National Development Plan (NDP) sets out the ten-year capital expenditure ceilings which will support economic, social, environmental and cultural development across Ireland, incorporating a total public investment of [redacted] from 2021-2030. It takes account of the Covid-19 crisis and related recovery plans, to ensure alignment with the new Programme for Government, to strengthen the alignment with the NPF and to enhance the link with the new Climate Action Plan and other sectoral policies.

The BEMU project is identified in the NDP under the wider DART+ programme:

The DART+ programme will be a cornerstone of rail investment within the lifetime of Project Ireland 2040 and represents the single biggest investment in the Irish rail network. The programme comprises a number of infrastructural projects – DART+ West, DART+ South West, DART+ Coastal North to Drogheda via Balbriggan, and DART+ Coastal South – ***and also a significant expansion of fleet, both battery electric (BEMUs)*** *and electric multiple units (EMUs).*

To deliver the National Strategic Outcomes set out in the NPF, the NDP presents the following relevant Strategic Investment Priorities which apply to the BEMU project:

National Planning Framework NSO	NDP Strategic Investment Priority	NDP reference to DART+ (BEMU inclusive)
NSO 2: Enhanced Regional Accessibility	Public Transport	*"Investment in the DART+ programme will address some of the constraints on the Dublin City Centre rail network and provide for additional services for intercity rail services."*
NSO 4: Sustainable Mobility	DART+	*"The DART+ programme will be a cornerstone of rail investment within the lifetime of Project Ireland 2040 and represents the single biggest investment in the Irish rail network."*
NSO 8: Transition to a Climate-Neutral and Climate-Resilient Society	An additional 500,000 sustainable mobility journeys per day by 2030. Comprehensive integrated public transport network for Ireland's cities connecting more people to more places.	*"Delivering priority public transport programmes including BusConnects, DART+ Expansion Programme and MetroLink so that increased transport demand is met by greener public transport."*

Strategic Investment Priorities have been influenced by the national objective of transitioning by 2050 to a competitive, low-carbon, climate-resilient and environmentally sustainable economy and society. As identified above, the DART+ Coastal North project will contribute to achieving these objectives.

6.2.3 National Investment Framework for Transport in Ireland (December 2021)

The Department of Transport has prepared and finalised the National Investment Framework for Transport in Ireland (NIFTI). NIFTI is the Department of Transport's high-level strategic framework to support the consideration and prioritisation of future investment in land transport.

As part of NIFTI, a wide range of supporting analysis has been conducted to identify key transport challenges, needs and constraints, both today and in the future.

The NIFTI states:

"The right transport investment helps to deliver high-quality travel and supports positive outcomes for society, the environment and the economy. However, these outcomes do not happen by chance. It is important to have in place a framework to guide transport investment and deliver the infrastructure and services we need. That is the purpose of NIFTI.

New transport investments will have to demonstrate their alignment with NIFTI. By extension, this will ensure that investment is aligned with the NPF and its National Strategic Outcomes, resulting in a consistent approach to investment across Government, with transport supporting our growth and development goals. In this way, NIFTI will ensure that transport enables the NPF."

The NIFTI notes that the NDP identities DART+ (including BEMU infrastructure) as one of the infrastructure projects required in the next decade.

In order to address the challenges identified in the supporting analysis, NIFTI establishes four Investment Priorities: Decarbonisation, Protection and Renewal, Mobility of People and Goods in Urban Areas, and Enhanced Regional and Rural Connectivity. Future transport projects must align with these priorities to be considered for funding. Moreover, as the National Strategic Outcomes are embedded in NIFTI, future investment made in accordance with the priorities will support the delivery of the National Planning Framework over the coming decades.

The BEMU project will comply with the Investment Priorities. It will assist in the decarbonisation of the transport system. It will help in the protection of the environment. It will improve the mobility of people in a sustainable manner. Finally, it will improve regional connectivity between Dublin, Meath and Louth.

6.2.4 Department of Transport: Statement of Strategy 2021-2023

The Statement of Strategy does not refer to specific projects. However, there are a number of objectives outlined in the Strategic Approach that are relevant to the BEMU project development:

"Aligned with the National Planning Framework and the National Economic Plan we will maintain and develop high quality sustainable road, public transport and active travel networks to enable economic activity, essential services and social connections between and within our cities, regions and communities.

We will encourage and support transport networks and services that are environmentally, economically and socially sustainable, in line with the UN Sustainable Development Goals.

We will prioritise the decarbonisation of transport and low carbon technology in line with the EU Green Deal and ambitious government policies.

We will continue to invest in active travel and in our public transport networks, greenways and alternative technologies."

6.2.5 Climate Action Plan 2021

This plan sets a roadmap for taking decisive action to halve the country's emissions by 2030 and reach net zero no later than 2050, as committed to in the Programme for Government.

The Climate Action Plan 2021 sets out a detailed sectoral roadmap designed to deliver a 51% reduction in greenhouse gas (GHG) emissions by 2030. This doubles the ambition of the 2019 Climate Action Plan and will require significant reductions from all sectors.

An action identified to reduce emission in the transport sector is:

"The proposed pathway in transport is focused on accelerating the electrification of road transport, the use of biofuels, and a modal shift to transport modes with lower energy consumption (e.g. public and active transport)."

The plan states that transport accounts for approximately 20% of Ireland's greenhouse gas (GHG) emissions. Road transport is responsible for 96% of those GHG emissions. Promoting cleaner, safer and more sustainable mobility is critical for climate policy.

To meet the required level of emissions reduction, by 2030 the Plan sets out a number of targets, the following of which are relevant:

"Provide for an additional 500,000 daily public transport and active travel journeys

"Increase the fleet of EVs and low emitting vehicles (LEVs) on the road to 945,000, comprising of: [inter alia]

- *an expanded electrified rail network."*

Action 240 is directly relevant:

"Commence delivery of DART+ Programme and continue heavy rail fleet investment."

The BEMU project will be in compliance and will contribute towards the targets identified in the Climate Action Plan. It will help reduce GHG emissions by:

- The provision of a more efficient public transport route, thereby encouraging a modal shift towards public transportation;
- It will become part of the electrified rail network in Ireland.

The BEMU project is part of the DART+ Programme which is identified as a specific action in the plan.

6.2.6 Transport Strategy for the Greater Dublin Area 2016-2035

The Transport Strategy for the Greater Dublin Area 2016-2035 was published by the National Transport Authority. It provides a framework for the planning and delivery of transport infrastructure and services in the GDA.

It states that heavy rail (DART and Commuter Rail) provides the core high-capacity infrastructure and services that are central to the GDA's public transport system. It further states that whilst the rail network has continued to be developed over recent decades, significant work still remains to be done to create a fully integrated rail network.

The strategy assesses a number of options with regard to various transport corridors in the GDA including the Dublin to Belfast Corridor. It is the intention of the Strategy to:

"Implement the DART Expansion Programme, which will provide DART services as far north as Drogheda; to Hazelhatch on the Kildare Line (including a tunnel connection from the Kildare Line to link with the Northern / South-Eastern Line); to Maynooth in the west and to the M3 Parkway;"

The Strategy further states:

"The DART Expansion Programme which is a cornerstone project of the strategy, will see the DART system expanded, providing fast, high-frequency electrified services to Drogheda on the Northern Line, Hazelhatch on the Kildare Line, Maynooth and M3 Parkway on the Maynooth/Sligo Line, while continuing to provide DART services on the South-Eastern Line as far south as Greystones."

The Transport Strategy also outlines objectives for Transport Services and Integration noting that:

"The DART services will operate to a high frequency with adequate capacity to cater for the passenger demand. It is anticipated that DART services in the city centre section of the network will operate to a regular ten minute service frequency in the peak hours from 2016 and will transition to a five minute service frequency following the completion of the DART Expansion Programme."

The draft Transport Strategy for the Greater Dublin Area 2022 – 2042 has also recently been published and is currently out for public consultation. The draft strategy identifies 'battery-electric carriages' as a major forthcoming scheme in the Public Fleet expansion.

The BEMU project is in accordance with all existing and emerging policies and objectives of the Transport Strategy for the Greater Dublin Area.

6.3 Regional Policy

6.3.1 Eastern & Midland Regional Assembly, Regional Spatial & Economic Strategy 2019-2031

A Regional Spatial and Economic Strategy (RSES) is a strategic plan which identifies regional assets, opportunities and pressures and provides appropriate policy responses in the form of Regional Policy Objectives. At this strategic level it provides a framework for investment to better manage spatial planning and economic development throughout the Region.

The RSES sets out sixteen Regional Strategic Outcomes, three of which are relevant to the BEMU project:

"Sustainable Settlement Patterns:

Better manage the sustainable and compact growth of Dublin as a city of international scale and develop Athlone, Dundalk, Drogheda and a number of key complementary growth settlements of sufficient scale to be drivers of regional growth. (NSO 1, 7, 10)"

The BEMU project will assist in the development of urban settlements along the east coast rail network, and also Drogheda as a destination in which to live and work in.

"Compact Growth and Urban Regeneration

Promote the regeneration of our cities, towns and villages by making better use of under-used land and buildings within the existing built-up urban footprint and to drive the delivery of quality housing and employment choice for the Region's citizens. (NSO 1)"

The BEMU project will encourage the development of underutilised zoned lands along the east coast rail network via provision of a more efficient public transport route.

"Integrated Transport and Land Use

Promote best use of Transport Infrastructure, existing and planned, and promote sustainable and active modes of travel to ensure the proper integration of transportation and land use planning. (NSO 2, 6, 8,9)"

The BEMU project will assist in achieving a more balanced approach to the integration of transportation and development, both in terms of employment and residential locations. It will make locations along the east coast rail network more favourable for both employers and residents.

The 'DART Expansion' – which includes the introduction of the BEMU fleet - is heavily referenced and supported in the document, including in relation to the development of the Dublin Metropolitan Area, and Drogheda.

Regional Policy Objective 5.2 states:

"Support the delivery of key sustainable transport projects including Metrolink, DART and LUAS expansion programmes, BusConnects and the Greater Dublin Metropolitan Cycle Network and ensure that future development maximises the efficiency and protects the strategic capacity of the metropolitan area transport network, existing and planned."

Regional Policy Objective 8.8: supports delivery of the rail projects set out in Table 8.2, subject to the outcome of appropriate environmental assessment and the planning process.

One of the projects set out in Table 8.2 is:

"DART Expansion Programme – new infrastructure and electrification of existing lines, including provision of electrified services to Drogheda or further north on the Northern Line, Celbridge – Hazelhatch or further south on the Kildare Line, Maynooth and M3 Parkway on the Maynooth/Sligo Line, while continuing to provide DART services on the South-Eastern Line as far south as Greystones."

6.4 Louth County Development Plan 2021-2027

The Louth County Development Plan 2021-2027 was adopted on 30th September 2021 and came into effect on 11th November 2021. The Plan 2021-2027 has superseded the Drogheda Borough Council Development Plan 2011-2017 and the North Drogheda and Environs Local Area Plan.

A key priority of the plan is to promote the continued sustainable and compact growth of the town as a regional driver of city scale with a target population of 50,000 by 2031. This will be supported by

objectives to regenerate the town centre, promote compact growth in the town's hinterlands and enhance the role of Drogheda as a self-sustaining strategic employment centre on the Dublin-Belfast Economic Corridor.

The Plan states the following in relation to Drogheda:

"The goal of achieving compact growth will require improved accessibility, sustainable mobility and the requisite infrastructure to enable Drogheda to grow as a Regional Growth Centre (RGC). The town will benefit from the extension of the DART service and improvements will be required to MacBride station relating to accessibility."

The plan recognises that the "DART Expansion Programme", and consequently the BEMU fleet introduction, is an important growth enabler for Drogheda as it would improve the connectivity to Dublin due to the increased frequency of services, making the town more accessible and attractive for economic investment and employment generating development.

The following policies and objectives in the plan are relevant:

"SS13: To support investment in public and sustainable transport infrastructure and services in Drogheda including the progression of the DART Expansion Programme which includes the electrification of the rail line and the extension of DART services to Drogheda

MOV 2: To facilitate the integration of land use with sustainable transportation infrastructure in accordance with the requirements of RPO 8.1 in the RSES by supporting the creation of a critical mass of population and employment related development that would maximise investment in public transport infrastructure and create compact, sustainable settlements.

MOV 7: To support a modal shift away from the private car to more sustainable forms of transport, such as public transport, cycling and walking and the attainment of any national targets relating to modal change published during the life of this Plan.

MOV 9: To support investment in sustainable transport infrastructure that will make walking, cycling or public transport more attractive and appealing, and facilitates accessibility for all, regardless of age, physical mobility, or social disadvantage.

MOV 12: To support the DART Expansion Programme including new infrastructure and the electrification of existing lines along the northern rail line to Drogheda."

The proposed development supports the overall vision in the Plan, particularly in relation to the development of Drogheda as a Regional Growth Centre.

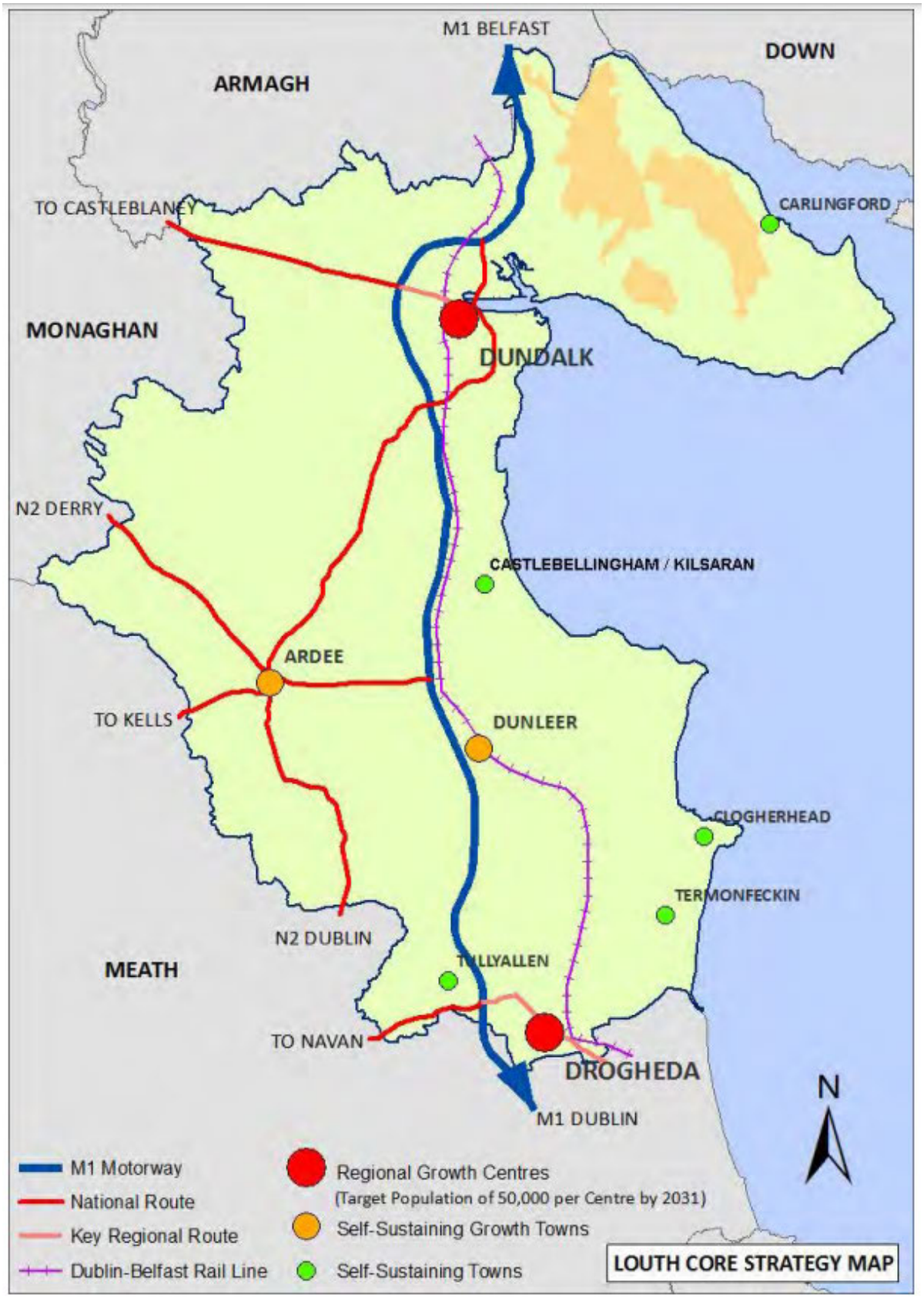


Figure 6-2: Louth Core Strategy Map Source: Louth County Development Plan 2021- 2027

Zoning Objectives

The proposed development is located within an area which is zoned as J1: Transportation Development Hub. Lands to the immediate west are zoned A1: Existing Residential. Lands to the north of Marsh Road are zoned D1: Regeneration.

The proposed development is considered to be in accordance with the relevant zoning objective.

Protected Structures

There are a number of protected structures in or adjoining Drogheda MacBride Station, including the Boyne Viaduct. Any works associated with the proposed development that may affect protected structures have been carefully assessed, details of which are provided in the supplementary Heritage Impact Assessment Report (HIAR) included with this application and summarised in Section 8.1 below.

Flooding

In accordance with the Strategic Flood Risk Assessment (SFRA) for the Louth County Development Plan 2021 – 2027, *where development is proposed within an area of potential flood risk (Flood Zone A or B), a flood risk assessment of appropriate scale will be required and this assessment must take into account climate change and associated impacts.*

Of note from the SFRA in respect of this area, is the following:

RPO–Regeneration of lands at McBride Station *– The predicted Flood Zone A & B extents encroaches on the land between the River Boyne and the Marsh Road zoned for future employment use. the extent of the flooding is limited to the lands north of Marsh Road and does not extend to the remaining land zoned adjacent to McBride Station for future employment and residential use south of Marsh Road. An open space area has been zoned to maintain the floodplain along the Silverstream watercourse.*

Although the majority of the proposed substation area is at low risk of fluvial flooding (i.e., Flood Zone C), the substation area is at moderate to high risk (Flood Zones A or B) of tidal flooding. A Flood Risk Assessment has been carried out to support this application and will be summarised in Section 7.3 of this report.

7. ENVIRONMENTAL ASSESSMENTS

7.1 Environmental Impact Assessment

The prescribed classes of development and thresholds that trigger a mandatory EIA are set out in Schedule 5 of the Planning and Development Regulations 2001, as amended. A review of the project types listed in the aforementioned Schedule 5, as amended, has been carried out. The proposed development is a type set out in Part 2 Class 10 (c) of Schedule 5 but it does not exceed the relevant quantity, area or other limit specified in that part. Therefore, it is a sub-threshold development and has been screened for EIA as described below.

Arup has prepared an EIA Screening Report on behalf of IÉ to assist in determining whether an EIA is required for the proposed development. The information provided in this report provides details on the characteristics of the proposed development and its likely significant effects (if any) on the environment. It also provides the relevant details under each of the criteria set out in Schedule 7A of the Planning and Development Regulations 2001, as amended. This information will assist the competent authority, Louth County Council to undertake the EIA screening as required under Section 103 of the Planning and Development Regulations 2001, as amended.

Based on the information provided in this report, it is the opinion of Arup that there is no real likelihood of significant effects on the environment arising from the proposed development and that an EIA is not required.

The final determination on EIA Screening will be made by the competent authority, Louth County Council.

7.2 Appropriate Assessment Screening and Natura Impact Assessment

An Appropriate Assessment (AA) is required if significant effects on European sites arising from a proposed development cannot be ruled out at the screening stage, either alone or in combination with other plans or projects. It is the responsibility of the competent authority to make a decision as to whether or not the proposed development is likely to have significant effects on European sites, either individually or in combination with other plans or projects. As set out in the AA Screening Report provided by Scott Cawley Ltd. (provided in supporting materials for this application), an Appropriate Assessment of the proposed development is required as it cannot be concluded, on the basis of objective information, that the proposed development, either individually or in combination with other plans or projects, will not have a significant effect on the following European sites: River Boyne and River Blackwater SAC, Boyne Coast and Estuary SAC, Boyne Estuary SPA, River Nanny Estuary and Shore SPA, Dundalk Bay SPA, Stabannan- Braganstown SPA, Skerries Islands SPA, and Rockabill SPA.

As such, a Natura Impact Statement (NIS) was prepared by Scott Cawley Ltd. in support of this application. The purpose of the NIS is to provide an examination, analysis and evaluation of the potential impacts of the proposed development on the above mentioned European sites and to present findings and conclusions with respect to the proposed development in light of the best scientific knowledge in the field. The NIS will inform and assist the competent authority, Louth County Council, in carrying out its Appropriate Assessment as to whether or not the proposed development will adversely affect the integrity of the European sites, either alone or in combination with other plans and projects, taking into account their conservation objectives.

It has been objectively concluded by Scott Cawley Ltd. that the proposed development will not adversely affect (either directly or indirectly) the integrity of any European site, either alone or in combination with other plans or projects.

Both the AA Screening Report and NIS are provided as part of the supporting materials for this planning application.

7.3 Flood Risk Assessment

A Flood Risk Assessment (FRA) has been carried out as part of this Planning Application for the proposed BEMU substation at Marsh Road car park and charging facilities at Drogheda MacBride Station.

Although the majority of the proposed substation area is at low risk of fluvial flooding (i.e., Flood Zone C), the substation area is at moderate to high risk (Flood Zones A or B) of tidal flooding. To ensure the substation remains safe and operational during and after a flood event, the finished floor levels will be raised above the 1 in 200-year tidal flood level with a 300mm freeboard allowance. The substation and all proposed works are outside the 1 in 100-year fluvial flood extents and as such, raising of development levels will not have an impact on fluvial flooding elsewhere.

Pedestrian access is considered at low risk during a tidal event, due to access provision from the existing stairs on the south end of the car park. Safe access and egress for vehicles will occur when high tide recedes, which is anticipated to be within one hour.

With above considered, a Flood Emergency Plan will be developed for the substation location. The plan will detail triggers for activation, including receipt of a timely flood warning, and a plan will set out arrangements for access and egress, both for pedestrians, vehicles, and emergency services ahead of a flood event.

In conclusion, the FRA has demonstrated that the risks relating to flooding to the proposed development are moderate but can be managed and therefore comply with Department of Environment, Heritage and Local Government and OPW and Louth County Council planning guidance.

8. OTHER MATERIAL CONSIDERATIONS

8.1 Heritage and Archaeological Impacts

There are no recorded archaeological sites located with the proposed development site and the only example within a study area extending for 500m from its boundary comprises a Mound located approximately 390m to the southwest. It is, therefore, concluded that the proposed development will result in no predicted impacts on the known archaeological resource. While the archaeological potential of the location is considered to be low, the possibility for the presence of sub-surface archaeological features cannot be discounted and will require mitigation. Appropriate measures are included within the Construction Environmental Management Plan (CEMP), which accompanies this planning application, to ensure that any unexpected discoveries are treated appropriately by the nominated contractor.

An Archaeological and Architectural Heritage Impact Assessment has been prepared for the proposed development and is included as part of this planning package. The report examines the property and history of Drogheda Railway Station and environs and seeks to identify the importance of the buildings in architectural heritage terms and the impact of the proposals on the structures within and around the station complex. The assessment found no significant impacts are predicted during the construction or operational phases of the proposed development.

8.2 Landscape and Visual Considerations

A Landscape and Visual Impact Assessment (LVIA) was undertaken to assess the potential impacts of the proposed development. An LVIA report was produced and is included as part of this planning application. This includes a number of photomontages from viewpoint locations in the vicinity of the proposed development. These viewpoint locations were agreed in advance with Louth County Council.

The LVIA concluded that the proposed development will not give rise to significant landscape and visual impacts. The proposed overhead charging facilities are located with the existing operational station area and the structures and in-keeping with the prevailing character of the area. The proposed sub-station compound is located within an existing carpark area and set back towards the base of rising slope. Additional planting is provided on the slope to enhance screening from Carmelite Cottages.

8.3 Proposed Boyne Greenway Route from Drogheda to Mornington

Meath County Council have recently submitted an application to An Bord Pleanála for permission to carry out works relating to the construction of a Boyne Greenway walking and cycling route east of Drogheda Town to Mornington Village. The initial section of the proposed Greenway from Ship Street/railway viaduct to the Drogheda Wastewater Treatment Plant on Marsh Road comprises of a shared pedestrian/cycle facility, 4m wide, on a flexible pavement segregated by a kerb from the adjacent carriageway of Marsh Road (R150) for approximately 1km. The greenway will be constructed by using an existing disused verge area on the north side of the Marsh Road (R150).

The proposed greenway has been considered carefully in the layout and access design of the BEMU project, particularly in relation to works occurring within IÉ's carpark at Marsh Rd. Currently this IÉ owned carpark, which acts as an overflow for the main railway station carpark, is significantly

underutilised. It is not considered a valuable public asset in terms of vehicle parking for this area of Drogheda and is not currently identified as an essential element of the Boyne Greenway project. Nonetheless, any loss of carparking will be insignificant and of a temporary nature for the duration of the BEMU operations prior to electrification of the full line. Therefore, neither proposals are expected to impact negatively upon each other.

Integration of active travel and railway networks remains a priority for IÉ, and continued engagement between all stakeholders will ensure sustained synergy on both projects. As both the DART+ CN and the Boyne Greenway projects progress, ongoing discussions will be pursued to collaborate proactively on sustainable solutions.

9. SUMMARY AND CONCLUSION

The BEMU project is being proposed as an interim capacity increase measure, ahead of the full electrification of the railway proposed under the DART+ Coastal North project. As previously identified, the BEMU project will allow the enhancement of the capacity and service on the network, ahead of the proposed implementation of the DART+ Coastal North project.

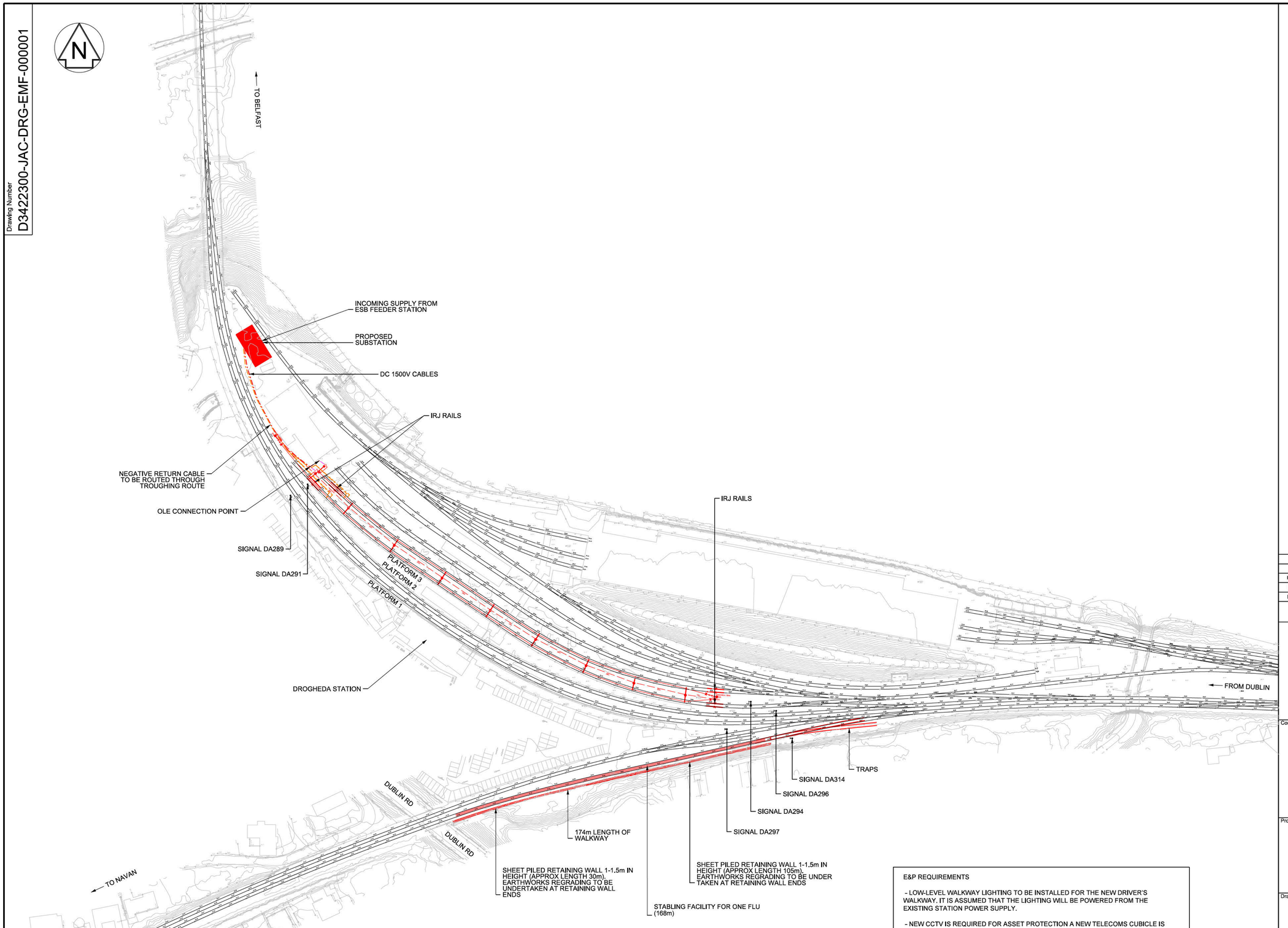
The proposed development will have a long term positive effect on the population in Drogheda. The proposal not only provides additional rail services from Drogheda to Dublin for those existing residents, but will also encourage sustainable, compact, integrated land use patterns within urban areas. Regional and intercity connectivity will be greatly improved, enhancing accessibility, and easing existing pressures from increasing demand.

The BEMU project introduces a rail transport mode which is cleaner, less dependent on oil, and more energy efficient. It will allow for efficient transportation along the east coast of Ireland, and encourage greater use of public transportation, reducing the dependency on car-based commuting. It encourages *Compact Growth*, *Sustainable Mobility* and provides a *Transition to a Low Carbon and Climate Resilient Society*.

As detailed in the previous sections, careful consideration has been given to the location of the required infrastructure and compliance of proposed works with national, regional and local policy. The proposal has also been assessed for compatibility with existing and future development proposals. Finally, all technical and environmental matters associated with the proposed development have been thoroughly evaluated and deemed acceptable. In particular, any concerns which may have arisen relating to car parking provision, flooding, heritage and visual impacts have been mitigated.

In summary, this application has been designed and informed by specialist assessments relating to the site and surrounds, pre-application consultation, the objectives of the relevant national, regional and local policy, as well as ongoing stakeholder engagement. Planning permission should therefore be granted accordingly.

Drawing Number
D3422300-JAC-DRG-EMF-000001



E&P REQUIREMENTS

- LOW-LEVEL WALKWAY LIGHTING TO BE INSTALLED FOR THE NEW DRIVER'S WALKWAY. IT IS ASSUMED THAT THE LIGHTING WILL BE POWERED FROM THE EXISTING STATION POWER SUPPLY.

- NEW CCTV IS REQUIRED FOR ASSET PROTECTION A NEW TELECOMS CUBICLE IS REQUIRED IN THE STABLING SITE TO SERVICE THE CAMERAS. ANY POWER REQUIREMENTS SHALL BE SERVICED FROM THE STATION SUPPLY.

DRAWING TO BE READ IN COLOUR

OPTION 1A
GENERAL ARRANGEMENT
SCALE 1:1000

EXISTING
PROPOSED
MODIFIED
REMOVED

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SCALE 1 : 1000

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- TWO TRACK CANTILEVER
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- FA — FIXED ANCHOR
- EW — EARTH WIRE
- SSA — SELF SUPPORTING ANCHOR
- XXm — SPAN
- INSULATOR
- SWITCH

Rev	Date	Description of Revisions	Drawn	Chkd	Appr
P01	29/10/20	ISSUED FOR INFORMATION	[redacted]		
P02	27/11/20	NAVAN STABLING OPTION ADDED			

Status: Issued for information
Suitability:

Iarnród Éireann Infrastructure

Contractor(s): Jacobs

Project: BEMU INFRASTRUCTURE STUDY

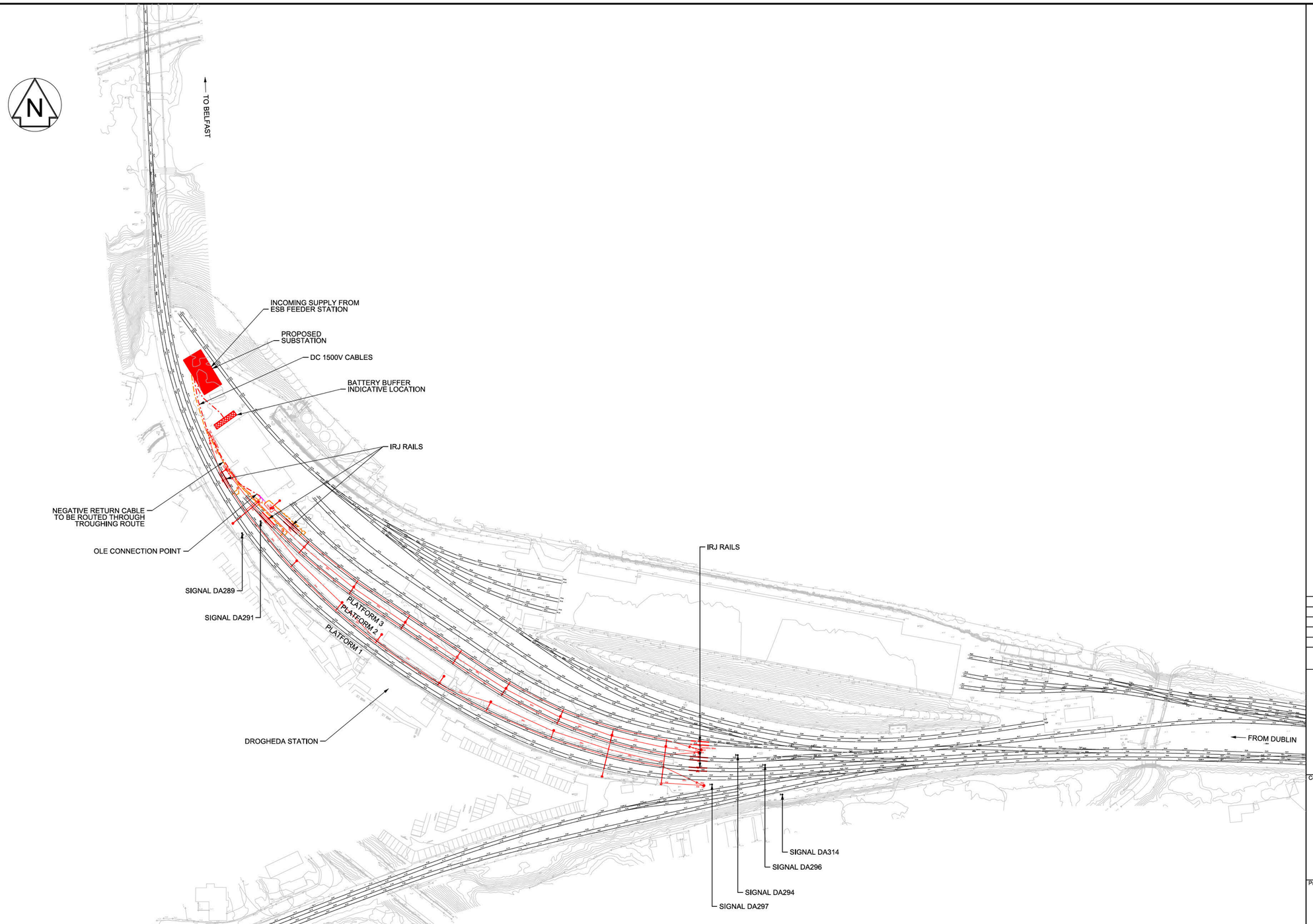
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Project: BEMU INFRASTRUCTURE STUDY

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OPTION 1B
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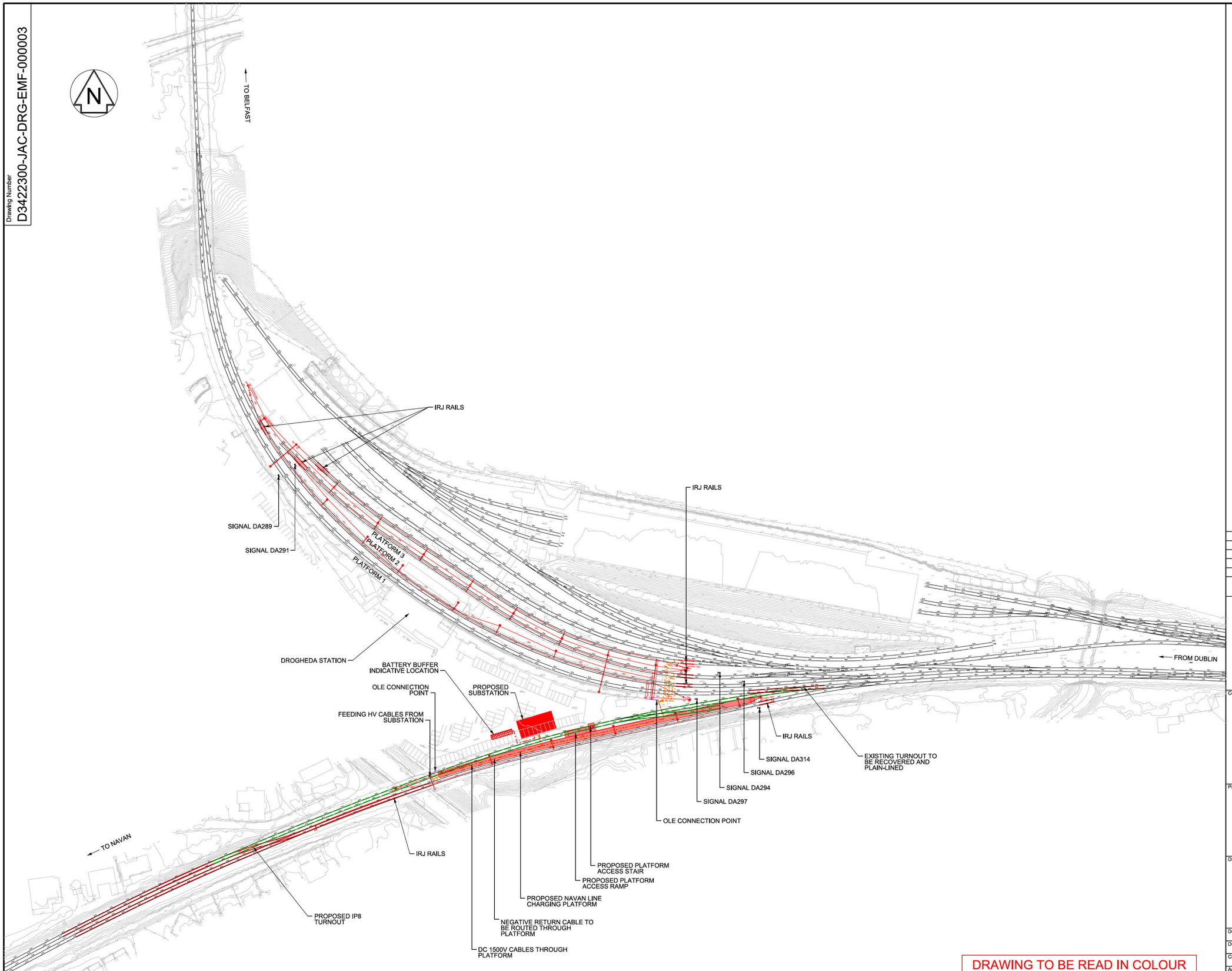
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P01	29/10/20		[redacted]		

Status: Issued for information
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Contractor(s): Jacobs

Project: BEMU INFRASTRUCTURE STUDY

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BEMU E&P Options Study

D3422300-JAC-REP-ELP-000001 | P01

29 October 2020

Iarnród Éireann

Client Reference



Project:	**BEMU Option Section Study**		
Client:	**Iarnrod Eireann**	**Project Number:**	**D3422300**
Document Title:	BEMU E&P Options Study		
Doc. No:	D3422300-JAC-REP-ELP-000001		

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Appendix A. Datasheets
Appendix B. Power Calculations
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Abbreviations

AC- Alternating Current

BEMU- Battery Electrical Multiple Units

DART- Dublin Area Rapid Transport

DC- Direct Current

DNO- Distributed Network Operator

ECR- Electrical Control Room

ECS- Empty Coaching Stock

ECO- Electrical Control Operator

EN- European Standard

EMU- Electric Multiple Unit

ESB- Electrical Supply Board

FLU- Full Length Unit

GA- General Arrangement

GRP- Glass Reinforced Plastic

HLU- Half Length Unit

HV- High Voltage

LV- Low Voltage

MIC- Maximum Import Capacity

OLE- Overhead Line Electrification

PV- Photo Voltaic

RRV- Road Rail Vehicle

RTU- Remote Terminal Unit

SCADA- Supervisory Control and Data Acquisition

SF6- Sulfur Hexafluoride

tph- Trains per Hours

UPS- Uninterruptable Power Supply

Introduction

The purpose of this report is to provide a number of comprehensive electrical design options for the charging of Battery Electrical Multiple Units (BEMU) on the Northern Line of the DART network at Drogheda Station and Depot.

The basis of this report builds on the feasibility study, carried out by Jacobs on behalf of NTA, and associated client scoping document '7498 DART+ Studies and Cost Estimate associated with the BEMU operating infrastructure on the DART Coastal Line' which outlines Irish Rails operational and rolling stock requirements.

The options are based on providing Irish Rail a frequency of six BEMU trains per hour (tph) departing Drogheda with a turnaround time of 12 minutes. The battery capacity of a Full-Length Unit (FLU) required to make the return journey between Drogheda and Malahide is 632.8kWh. This report defines the infrastructure requirements and limitations of each option concerning grid connections and space constraints. Electrical infrastructure options consider the traction substation location, equipment sizes, the proposed charging point locations, and cable routes. The electrical options have been reviewed within this report and a preferred option has been identified and recommended within the multi-discipline report.

A major deciding factor concerning the new BEMU definition is to ensure passive provision for future expansion and integration of the electrified DART system from Malahide. Thus, the battery charging infrastructure is supplied at 1500V DC via OLE infrastructure.

1.1 Option Overview

The proposals as outlined in the option study introduce charging infrastructure which varies dependent on the operational requirements.

Option 1a proposes to run BEMU OLE charging through platform 3 and siding road 4 of Drogheda station and depot. The OLE will serve as the charging points for the BEMU trains.

Option 1b builds on the proposals of Option 1a with an additional charging lane on platform 2 at Drogheda station to have 3 No charging points for BEMU trains.

Option 2b introduces OLE charging infrastructure on platform 2 & 3 and siding road 4 of Drogheda station and depot as well as an additional charging point located on the Navan lines south of the station car park. The interventions associated with Option 2b include converting the double Navan lines to a single track and adding a new platform in to allow operational running from the new charging lane.

Each option has developed with considerations of operational flexibility, performance, feasibility and cost.

A key aspect of charging the BEMU trains at Drogheda station requires the provision of a new traction substation which will provide the 1500V DC supply to the charging lane. Several locations were considered as potential substation location. The locations explored are provided in the table below:

Substation	Description	Grid reference	Advantages	Disadvantages
Location A	North depot, adjacent to fuel tanks	113953, 432838	Ease of grid connection and ease of ESB access	Earthworks, location on a major slope. The land would need to be built up or a platform would be required. Cable route across the siding.
Location B	North depot between mainline & stabling road	113927, 432842	Feeder cables connect directly from Substation to OLE switches. Ease of access for ESB via subway stairs.	Building atop of the subways open void, grid connection on through Irish Rail land. Substation curtailed between two rails.
Location C	Station Carpark	114050, 432609	Irish Rail owns the land, transport of equipment to the substation	Reduces car park spaces, potential difficulty in ESB providing grid connection.
Location D	Land adjacent to the maintenance shed	114093, 432700	No land constraints	Access issues for ESB, crossing depot tracks, ESB and IR cable route would need to cross-track (via existing footbridge)
Location E	McBride's Pitch and Putt	114040, 432761	Ease of grid connection and ease access for ESB.	Potential land take issues, civils works Length of cable route to charging infrastructure.

Table 1: Traction Substation location options

For the purpose of this option study, Option A, D & E have not been taken forward as preferred locations for the proposed traction substation as they present potential difficulties for routing the HV and DC cables to and from the substation or require substantial earthworks.

2. Option 1a- Charging on Platform 3

Option 1a offers the simplest proposal with the introduction of a single charging location on platform 3, with an additional charging location on the depot siding road 4 which is positioned directly north of platform 3. This option facilitates the ability to have a maximum of 4 trains charging per hour, with the provision of a single train being able to charge at any time. Control of the feeders will be automatic via the electrical interlocking integral to the switchgear. The ECO will be able to override the control if required. The control of the switchgear will be able to prioritise charging of platform 3 during operation running of the BEMU's, thus the train will only charge on the depot road when no trains are charging on platform 3.

To charge one train at any time the proposed traction substation requires to provide 632.8kWh of energy to the BEMU's batteries in 12 minutes. Therefore, the MIC of the new traction substation is a minimum of 3.16MVA.

For details of power calculations, refer to Appendix B.

Various locations were considered for Substation location as shown in the table below:

Substation	Description	Grid reference	Advantages	Disadvantages
Location A	North depot, adjacent to fuel tanks	113953, 432838	Ease of grid connection and ease of ESB access	Earthworks, location on a major slope. The land would need to be built up or a platform would be required. Cable route across the siding.
Location B	North depot between mainline & stabling road	113927, 432842	Feeder cables connect directly from Substation to OLE switches. Ease of access for ESB via subway stairs.	Building atop of the subways open void, grid connection on through Irish Rail land. Substation curtailed between two rails.
Location C	Station Carpark	114050, 432609	N/A for this option	N/A for this option
Location D	Land adjacent to the maintenance shed	114093, 432700	No land constraints	Access issues for ESB, crossing depot tracks, ESB and IR cable route would need to cross-track (via existing footbridge)
Location E	McBride's Pitch and Putt	114040, 432761	Ease of grid connection and ease access for ESB.	Potential land take issues, civils works Length of cable route to charging infrastructure.

Table 2: Option1a Substation Location red text indicates the preference

As the charging roads are adjacent to the Drogheda depot for Option 1a, substation location B has been proposed as the recommended option, shown in Figure 1:

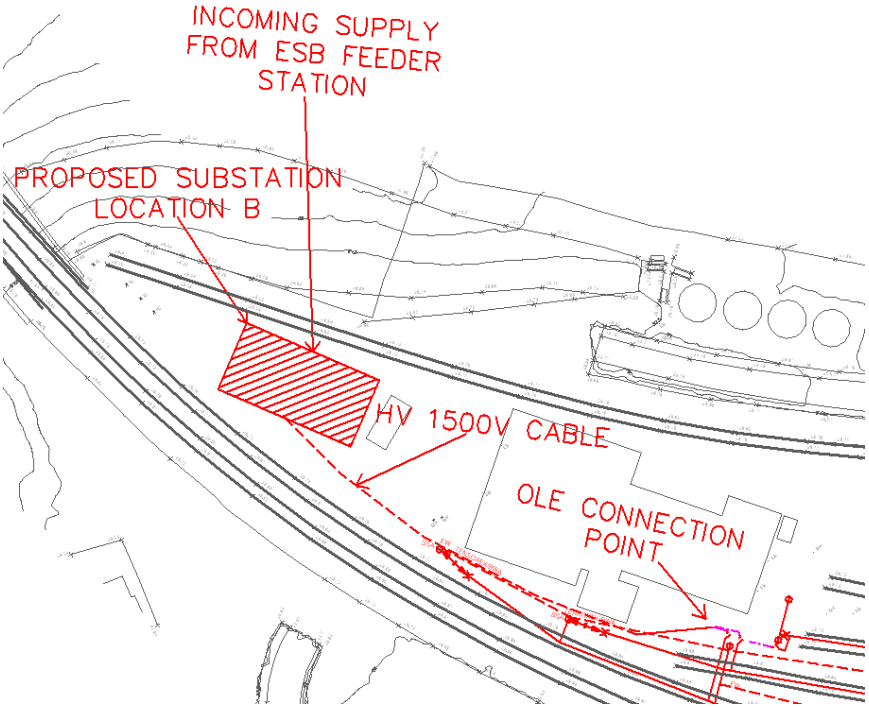


Figure 1: Cable route from traction substation to the charging points for Option 1a

The electrical schematic below and subsequent table shows the equipment required within the substation:

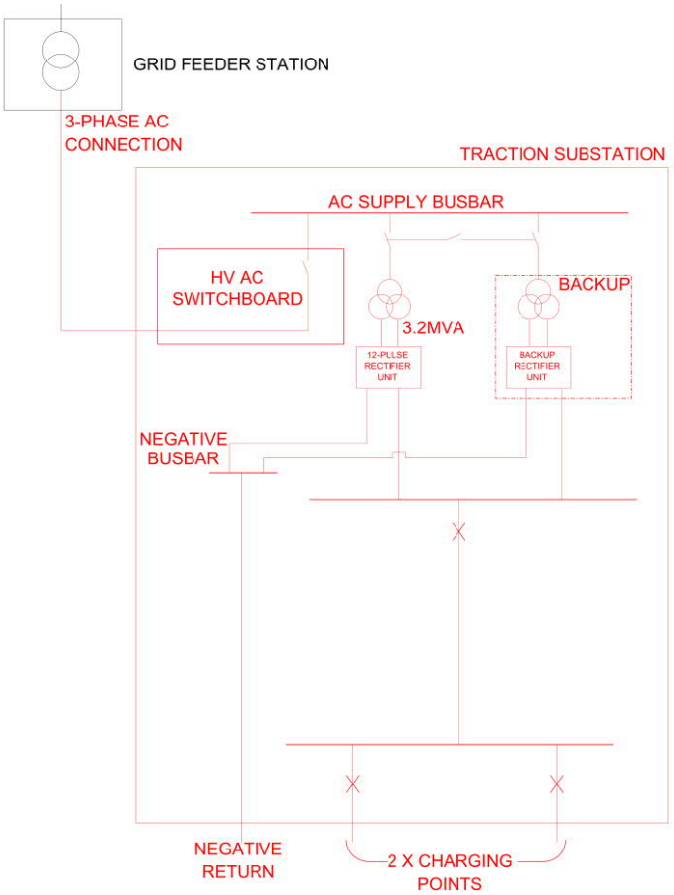


Figure 2: Electrical schematic for Option 1a

Equipment	Rating	Quantity	Example Supplier
Grid Connection	MIC 3.2MVA	1	ESB
Positive DC Cable	500mm^2 (1500V DC)	4 (Length as required)	Caledonian Cables
Negative DC Cable	240mm^2 (1500V DC)	4 (Length as required)	Caledonian Cables
HV AC Switchboard	320A @10kV AC	1	Schneider Electric
Transformer	3.2MVA	2	ABB
12-Pulse Rectifier	2.1kA	2	ABB
DC Circuit Breakers for feeder	2.1kA @ 1500V DC	2 + spare	Schneider Electric
DC Circuit Breaker for rectifier protection	2.1kA @ 1500v DC	1	Schneider Electric

Table 3: Option1a Substation Location

There is an existing ESB feeder station approximately 150m north of the depot which forms part of a 10kV ring. It has been confirmed through liaison with ESB, that the feeder station is called Mornington Road, and it is feasible that is can supply a 3.2MVA connection without major grid reinforcement.

The substation will have two transformer and rectifier units to fulfil the requirements of network redundancy and continuous supply under a connection loss or maintenance of the main unit. It should be noted that the minimum transformer size required is a 3.2MVA. As 3.2MVA is a non-standard size for a transformer, either a bespoke solution would be required or a 3.75MVA transformer to be considered going forward. Note a bespoke solution is likely to incur a greater cost and longer lead times.

The selection and specification of the transformer and rectifier unit shall be matched to complement each other in their operation to help minimise potential losses and to ensure system compatibility.

HV and LV Switchgear shall be selected and rated to disconnect appropriately under fault conditions to protect life, livestock and equipment from damage. All protection shall meet the required rating, overcurrent, earth fault, and disconnection time parameters.

DC positive feeder cables shall be routed out of the substation and will connect onto the OLE switching infrastructure to energise the battery trains via the rolling stocks pantographs. The circuit is completed by the DC negative bonding cable connecting to the rail, via the wheels of the rolling stock, and negative busbar in the substation. Cable routes for the positive and negative cables shall be combined in either surface laid troughing, elevated troughing or J hangers. Two pairs of IRJs, are required at the end of each the charging road to provide a DC return path back to the substation. Refer to the track section of report for details of IRJs.

To facilitate this capacity for charging the battery trains, an OLE system utilising a double contact wire style will be required through the length of platform 3 and depot siding road 4. Refer to OLE section of report for details. Figure 3 below shows an overview of the length of the contact wire required throughout platform 3 road and depot siding road 4.

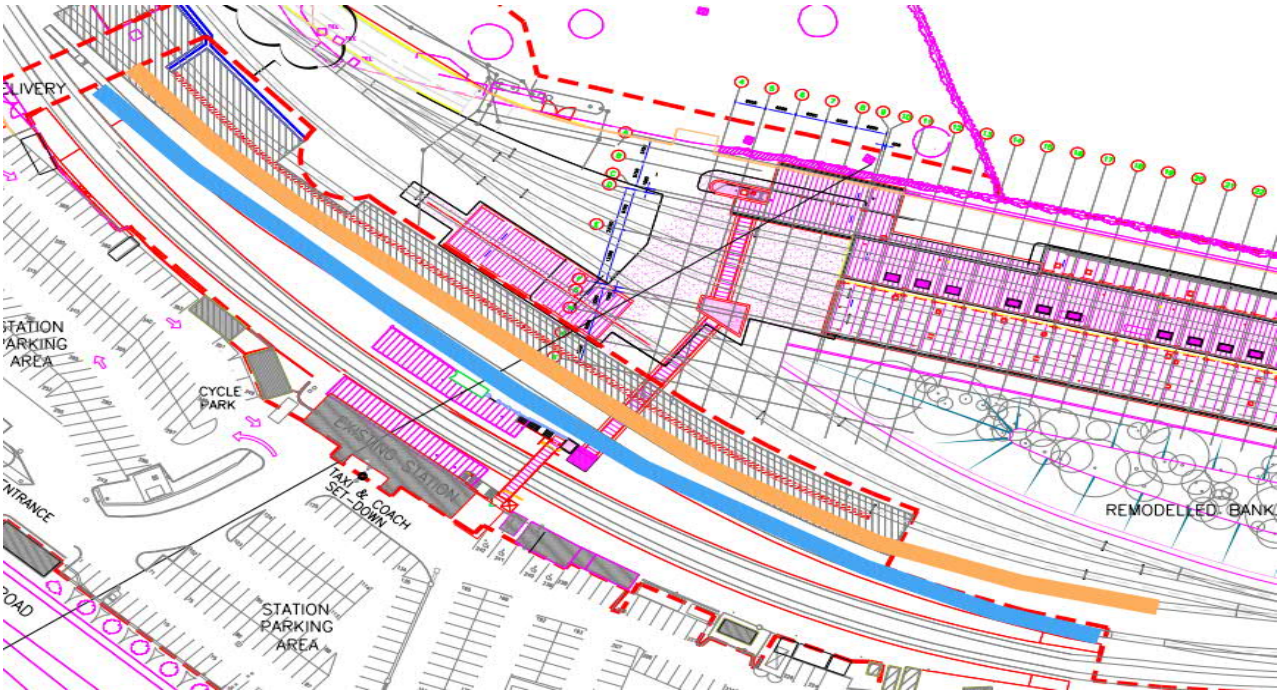


Figure 3: Option 1a Charging on Platform 3 (Highlighted in blue) with charging infrastructure on depot siding road 4 (Highlighted in orange).

The benefits of Option 1a from an E&P perspective has a reduced maximum electrical load when compared to other options, which equates to reduced demand on the local grid and reduced size of equipment required. The reduction in load demand ultimately results in a cheaper solution. Despite this, it operationally restricts the number of trains which can operate to four per hour.

3. Option 1b- Charging on Platform 2 & 3

Option 1b introduces charging infrastructure on platforms 2 and 3 through Drogheda Station. As detailed in the operational requirements it is also necessary to have Empty Coaching Stock (ECS) charging on depot siding road 4 to depart for passenger running at Laytown Station. The additional operational requirement of the ECS movements means a possible maximum of 3 BEMU trains charging simultaneously. Option 1b requires a minimum MIC from ESB of 9.48MVA.

With the introduction of the charging infrastructure on platform 2, the preferred location of the traction substation as outlined in table 2 also applies to Option 1b.

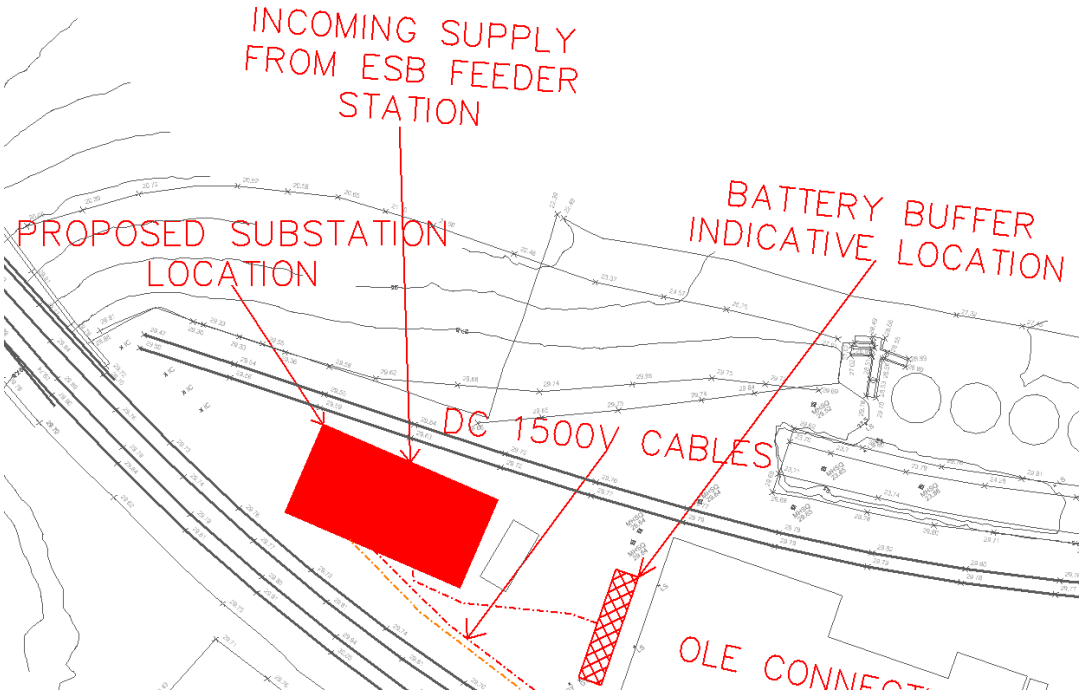


Figure 4: Proposed traction substation location for Option 1b

Option 1b requires the same amount of main traction substation equipment as specified in table 2, however, ratings of equipment are greater due to the number of trains charging simultaneously. Table 4 below provides a high-level breakdown of the primary equipment required.

Equipment	Rating	Quantity	Example Supplier
Grid Connection	MIC 9.48MVA	1 No	ESB
Positive DC Cable	500mm^2 (1500V DC)	6 (Length as required)	Caledonian Cables
Negative DC Cable	240mm^2 (1500V DC)	6 (Length as required)	Caledonian Cables
HV AC Switchboard	948A @10kV AC	1 No	Schneider Electric
Transformer	10MVA	2 No	ABB
12-Pulse Rectifier	6.4kA	2 No	ABB
DC Circuit Breaker for rectifier protection	6.4kA @ 1500V DC	1 No	Schneider Electric
DC Circuit Breakers for feeder	2.1kA @ 1500V DC	3 No + spare	Schneider Electric

Table 4: Option 1b Traction substation primary equipment breakdown

Figure 5 below provides a high-level view of the traction substation arrangement for Option 1b. Note, battery buffer omitted for clarity this can be seen in figure 14.

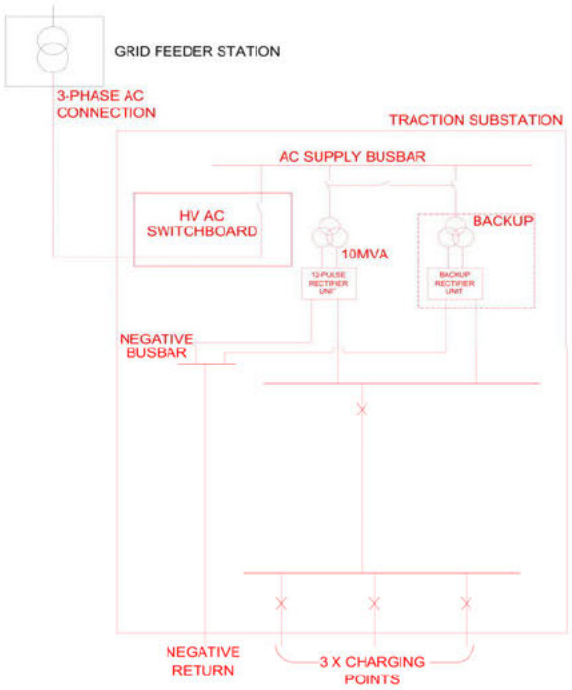


Figure 5: Traction substation schematic for Option 1b

Through consultations with ESB, the limitations of the current grid infrastructure, at Mornington Road close to Drogheda Station, would not be able to sufficiently supply three BEMUs simultaneously without grid upgrades. To reduce the demand on the local grid network and to still provide operational flexibility, a sequential control

system may be implemented to control the amount of BEMU trains charging at any time. The sequential control will be provided via the DC switchgear located in the traction substation.

Alternatively, a battery buffer system could be implemented to reduce demand and smooth instantaneous peaks. Using the proposed operational timetable requirements over an hour the demand with and without battery buffer has been modelled for Option 1b as shown in figure 6:

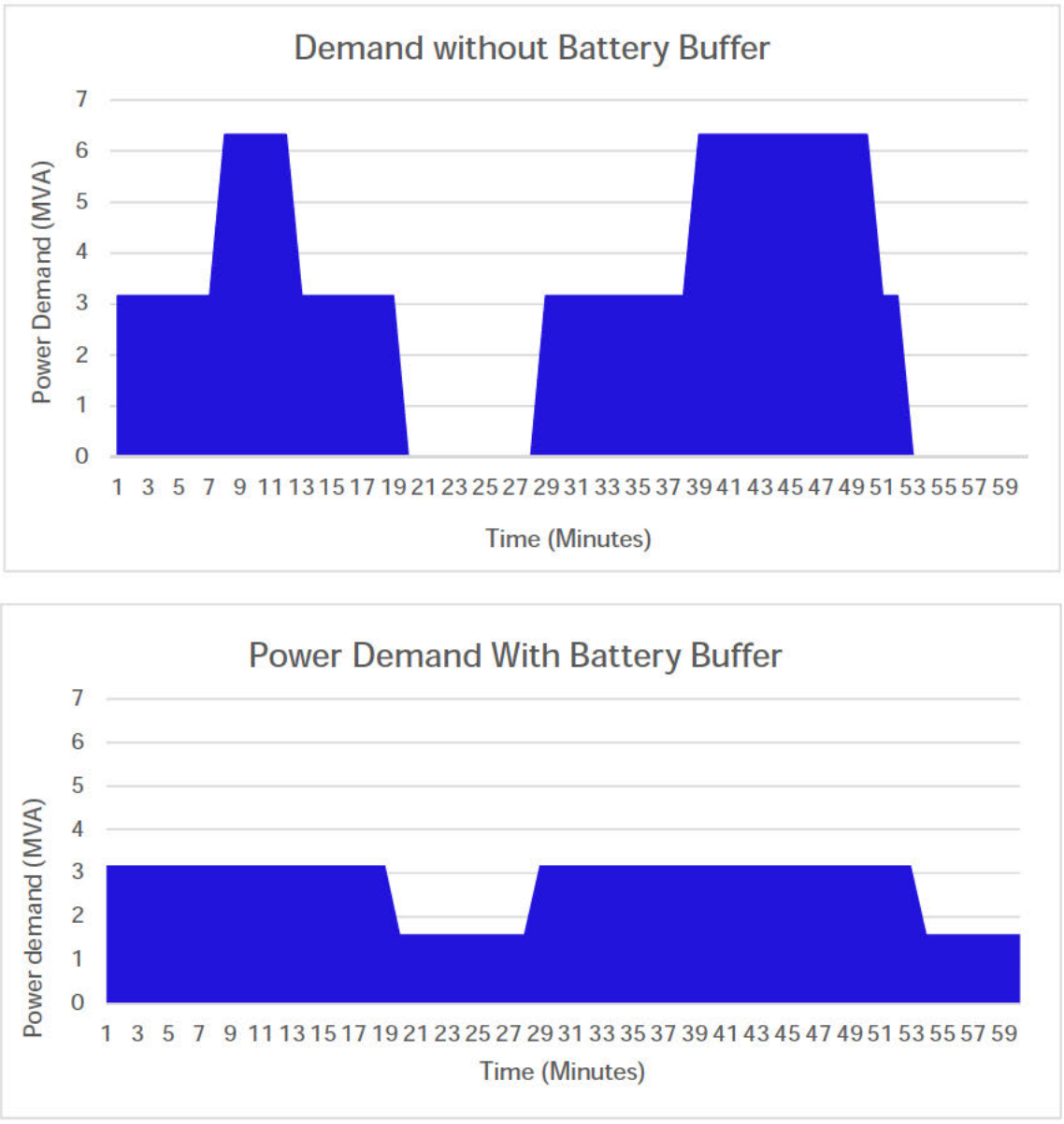


Figure 6: effect of battery buffer on power demand for option 1b

The substation will have 2 No specified transformer and rectifier units to fulfil the requirements of network redundancy and continuous supply under a fault condition or maintenance of the main unit. It should be noted that the minimum transformer size required is a 9.48MVA. As 9.48MVA is a non-standard size for a transformer, either a bespoke solution would be required or a 10MVA transformer to be considered going forward. Note a bespoke solution is likely to incur a greater cost and longer lead times.

The selection and specification of the transformer and rectifier unit shall be matched to complement each other in their operation to help minimise potential losses and to ensure system compatibility.

HV and LV Switchgear shall be selected and rated to disconnect appropriately under fault conditions to protect life, livestock and equipment from damage. All protection shall meet the required rating, overcurrent, earth fault, and disconnection time parameters.

DC positive feeder cables shall be routed out of the substation will connect onto the OLE switching infrastructure to energise the battery trains via the rolling stocks pantographs. The circuit is completed by the DC negative bonding cable connecting the rail, via the wheels of the rolling stock, and negative busbar in the substation. Cable routes for the positive and negative cables shall be combined in either surface laid troughing, elevated troughing or J hangers. Two pairs of IRJs, are required at the end of each the charging road to provide a DC return path back to the substation. Refer to the track section of report for details of IRJs.

The key advantage of Option 1b is that it provides greater operational flexibility when compared with Option 1a, with the capabilities of running 6tph out of the station and depot.

The disadvantages of Option 1b are the same as those covered in Option 1a. Despite this, Option 1b has a further disadvantage as a result of the increased demand for charging multiple BMEU trains simultaneously. The increase in electrical demand will trigger the need for ESB to provide resilience on their network, growing the project's operational and capital cost for the procurement, maintenance, and running of the traction substation. Refer to costing section in the main report for further details.

4. Option 2b- Charging on Navan Lines and Platform 2 & 3

Option 2b proposes the introduction of charging infrastructure on the Navan line as well as charging infrastructure on platforms 2 & 3 and siding road 4. Based on the information provided by Irish Rail, the Navan lines are not frequently used, introducing the possibility of installing a new platform and charging lane. The depot road charging lane will not have an operational priority for charging. Control will be implemented on the switchgear to prioritise charging of the charging platforms during the operational running of the BEMU's, thus the train will only charge on the depot roads when trains are not charging on all other platforms. As the Navan Lines are a branch line which runs west of Drogheda, the preferred substation location differs from the previous options shown in table 5 below:

Substation	Description	Grid reference	Pros	Cons
Location A	North depot, adjacent to fuel tanks	113953, 432838	Ease of grid connection and ease of ESB access	Earthworks, location on a major slope. The land would need to be built up or a platform would be required. Cable route across siding and main lines.
Location B	North depot between mainline & stabling road	113927, 432842	Ease of access for ESB via subway stairs.	Building atop of the subways open void, grid connection on through Irish Rail land. Substation curtailed between two rails. Feeder cables need to cross tracks to arrive at the charging station
Location C	Station Carpark	114050, 432609	The substation can supply all charging stations without crossing tracks, Irish Rail owns the land, transport of equipment to the substation	Reduces car park spaces, ESB difficulty, potential difficulty in ESB providing grid connection.
Location D	Land adjacent to the maintenance shed	114093, 432700	No land constraints	Access issues for ESB, crossing depot tracks, ESB and IR cable route would need to cross-track (via existing footbridge)
Location E	McBride's Pitch and Putt	114040, 432761	Ease of grid connection and ease access for ESB.	Potential land take issues, civils works Length of cable route to charging infrastructure.

Table 5: Option 2b Substation Location red text indicates a preference

The preferred location of the traction substation for the supply of the charging for Option 2b is located at the east end of Drogheda Station car park. Ultimately this location provides a direct connection between the traction substation and the charging infrastructure without crossing any tracks. The traction substation location for Option 2b can be seen in more detail in Figure 7.

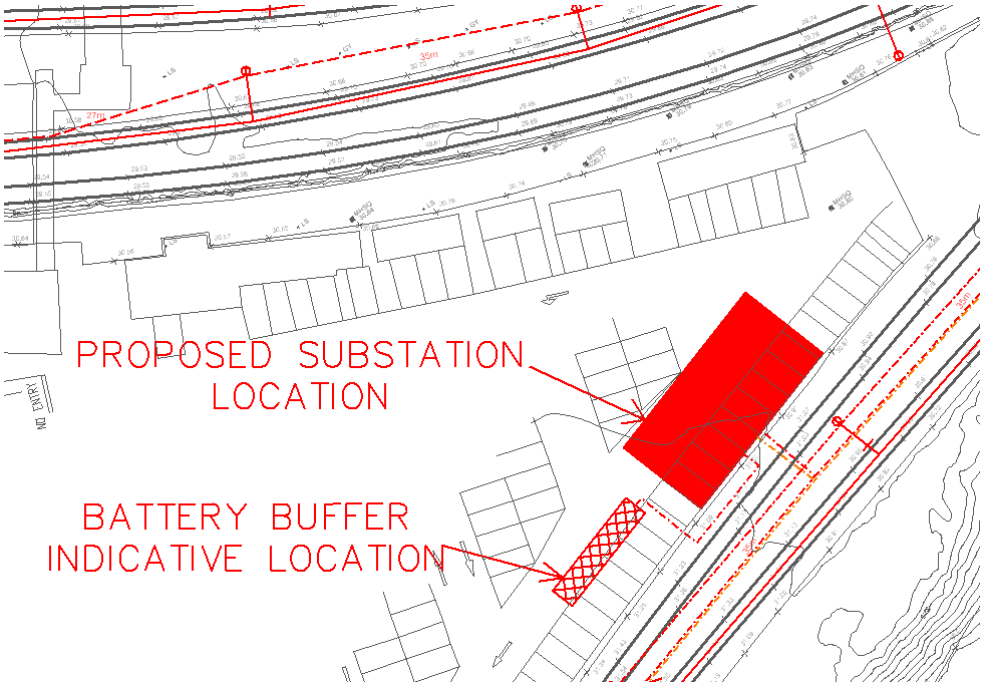
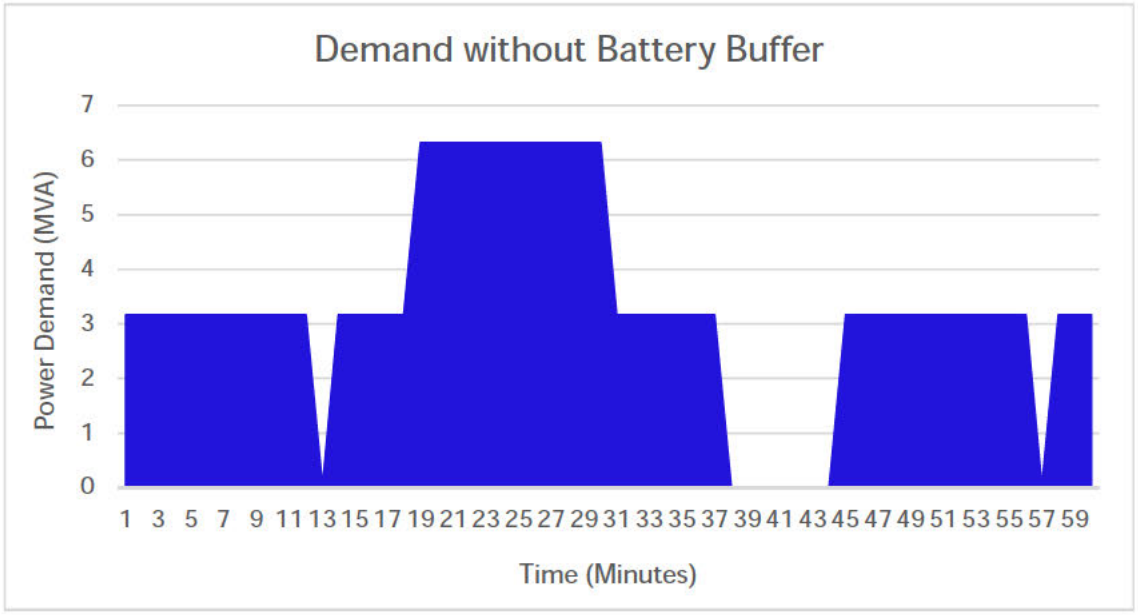


Figure 7: Preferred traction substation location for Option 2b

The feeders shall be routed through the new platform in both directions, as the OLE switch connection points are positioned at the east end of Drogheda Station, and the Navan line OLE connection point positioned at the south of the proposed platform.

The maximum number of trains that can charge simultaneously in option 2b is three, thus the MIC equates to 9.48MVA. If it is not feasible to provide this large demand without significant grid upgrade, the provision of sequential control could be applied to the DC Switchgear to limit the number of trains charging simultaneously. Control of the feeders will be automatic via the electrical interlocking integral to the switchgear to ensure as a minimum the charging roads have priority over the depot road. The ECO shall be able to override the control if required.

Alternatively, a battery buffer system could be implemented to reduce demand and smooth instantaneous peaks. Using the proposed operational timetable requirements over an hour the demand with and without battery buffer has been modelled for option 2b as shown in figure 8:



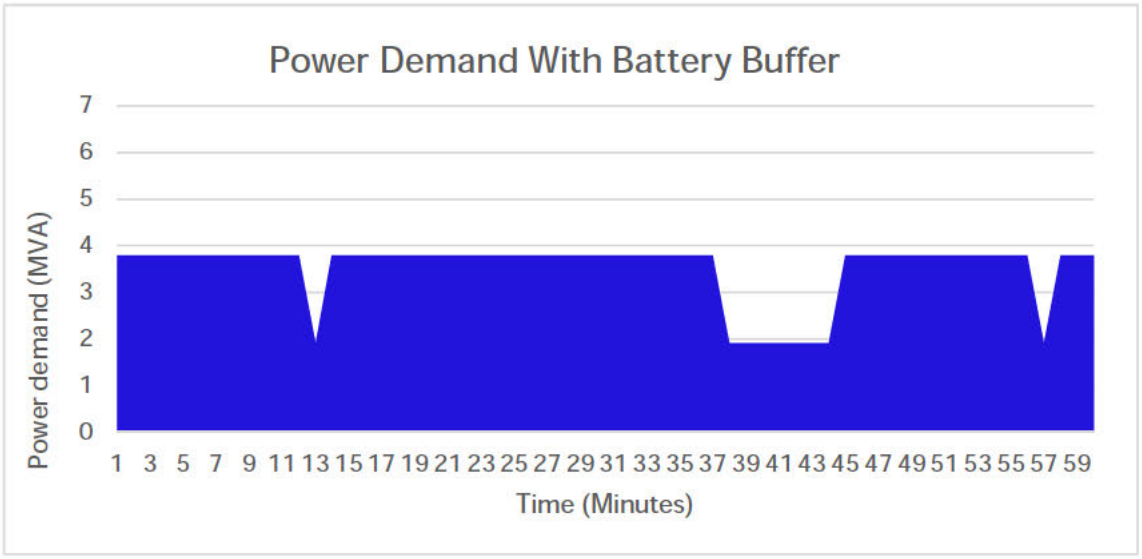


Figure 8: effect of battery buffer on power demand for option 2b

Table 6 below provides a high-level breakdown of the primary equipment for the traction substation with the additional DC circuit breaker for the feed to the Navan lines.

Equipment	Rating	Quantity	Example Supplier
Grid Connection	MIC 9.48MVA	1 No	ESB
Positive DC Cable	500mm^2 (1500V DC)	8 (Length as required)	Caledonian Cables
Negative DC Cable	240mm^2 (1500V DC)	8 (Length as required)	Caledonian Cables
HV AC Switchboard	948A @10kV AC	1 No	Schneider Electric
Transformer	10MVA	2 No	ABB
12-Pulse Rectifier	6.4kA	2 No	ABB
DC Circuit Breaker for rectifier protection	6.4kA @ 1500V DC	1 No	Schneider Electric
DC Circuit Breakers for feeder	2.1kA @ 1500V DC	4 No + spare	Schneider Electric

Table 6: Option 2b Traction substation primary equipment breakdown

Figure 9 below provides a high-level view of the traction substation arrangement for Option 2b. Note, battery buffer omitted for clarity this can be seen in figure 14.

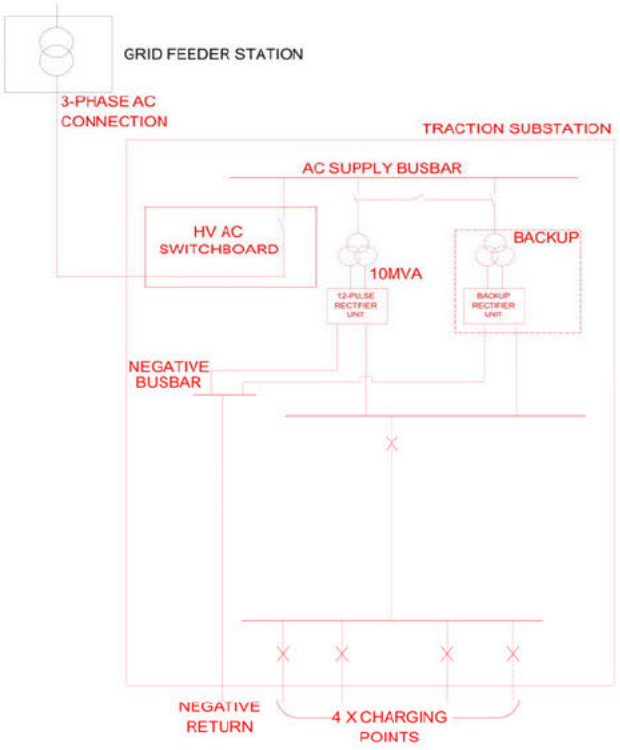


Figure 9: Traction substation schematic for Option 2b

The substation will have 2 No specified transformer and rectifier units to fulfil the requirements of network redundancy and continuous supply under a connection loss or maintenance of the main unit. It should be noted that the minimum transformer size required is a 9.48MVA based on a unity power factor. As 9.48MVA is a non-standard size for a transformer, either a bespoke solution would be required or a 10MVA transformer to be considered going forward. Note a bespoke solution is likely to incur a greater cost and longer lead times.

The selection and specification of the transformer and rectifier unit shall be matched to complement each other in their operation to help minimise potential losses and to ensure system compatibility.

HV and LV Switchgear shall be selected and rated to disconnect appropriately under fault conditions to protect life, livestock and equipment from damage. All protection shall meet the required rating, overcurrent, earth fault, and disconnection time parameters.

DC positive feeder cables shall be routed out of the substation will connect onto the OLE switching infrastructure to energise the battery trains via the rolling stocks pantographs. The circuit is completed by the DC negative bonding cable connecting the rail, via the wheels of the rolling stock, and negative busbar in the substation. Cable routes for the positive and negative cables shall be combined in either surface laid troughing, elevated troughing or J hangers. Two pairs of IRJs, are required at the end of each the charging road to provide a DC return path back to the substation. Refer to the track section of report for details of IRJs.

The inherent disadvantage associated with Option 2b is due to the increased electrical demand of charging multiple BEMUs simultaneously. The increase in electrical demand will trigger the need for ESB to provide resilience on their network, growing the project's operational and capital cost for the procurement, maintenance, and running of the traction substation. Refer to section 5.1.1 of report for more details. Furthermore, the preferred location of the substation is currently positioned within the station car park and therefore the parking capacity will be reduced. The proposed substation location is positioned south of Drogheda station and the closest known grid connection is located on the north side of the station. This could potentially cause difficulties for routing the HV connection to the substation and thus increasing cost for the connection.

5. E&P Infrastructure

Major components of the electrical infrastructure to be considered include the procurement of the new traction substation to supply the charging points outlined by the options situated at either or both Drogheda station and depot for the BEMUs.

The GA drawings D3422300-JAC-DRG-EMF-000001, 000002 & 000003 highlight the sites of the proposed electrical infrastructure including substation, charging points, supply connections, and cable management routes.

5.1.1 ESB Grid Connection

A key aspect of the operational fulfilment of BEMU charging infrastructure at Drogheda Station and depot is the procurement of an appropriately sized supply from ESB. Electrical load specifications as detailed under the charging options were formulated and derived from the rolling stock and operational requirements as a result amount of units charging simultaneously. The load data enables the appropriate sizing of the substation and equipment therein. The BEMU kWh loads were confirmed through liaison with Irish Rail and the rolling stock team.

The ESB Grid connection into the new traction substation provides the biggest project risk concerning the E&P works as the potential price range can vary from little to astronomical depending on the reinforcements required on ESB's Network. it follows that the larger the capacity required the greater the reinforcement and thus the cost of connection.

The worst-case MIC breakdown for each option is as follows:

- Option 1a- 3.16MVA
- Option 1b 9.48MVA
- Option 2b 9.48MVA

During liaison with ESB, it was intimated they could facilitate the 3.16MVA option with minimal interventions from the existing 10kV ring feeder at Mornington Road. Therefore, alternative solutions to reduce and smooth the instantaneous peaks have been considered for Options 1b and 2b.

5.1.2 Traction Substation Design

Based on details provided by the client and through desktop studies, three indicative locations for the new substation have been selected denoted as A, B & C.

Location A is situated on the north side of Drogheda/Depot, adjacent to the diesel storage tanks and south of the Mornington Road ESB feeder station by approximately 150m. Location A is located on an embankment and will require a new platform or major earthworks to be viable.

The second proposed substation site is also situated north of the station; however, location B is positioned between the main lines and depot stabling lines on the site of the redundant locomotive turntable. Location A and B offer direct routing between the ESB feeder station and the proposed substation sites. Figure 10 below shows the first 2 locations selected.

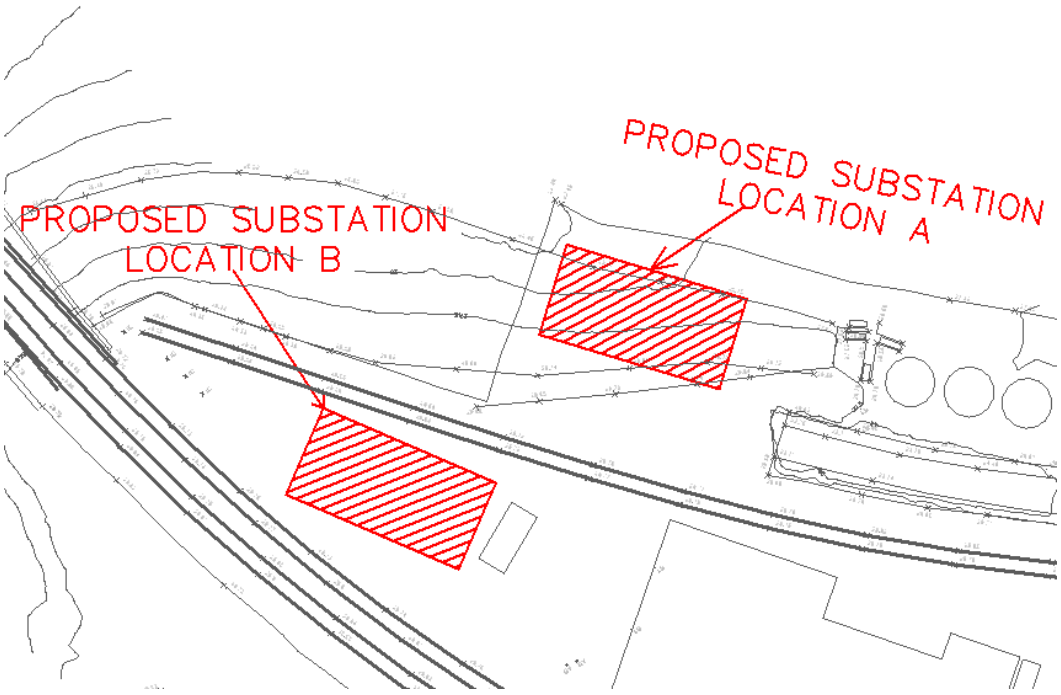


Figure 10: Drogheda station & depot – Proposed new substation locations A & B

The third proposed substation, seen in Figure 11 shown below, location C is situated at the east end of Drogheda station car park. Note that this location is only to be considered with option 2b with charging on the Navan lines.



Figure 11: Drogheda station & depot – Proposed new substation location option C

Location B & C offer distinct advantages depending on the requirements of charging lanes. If Option 1a or 1b is taken forward, then location B is the preferred substation location. As location B provides a direct route to the charging infrastructure. There several options for routing the ESB feeder connection including:

- A route around the back of the buffer stop of the siding,
- Via the underpass stairs, or
- Over the siding in a utility crossing.

One of the key constraints of location B is that an access agreement would have to be met between the utility provider (ESB) and Irish Rail to allow ESB to maintain their equipment and monitor meters.

If Option 2b is to be progressed, then location C is preferred for the substation location. Having a substation at the east of the station car park would provide a direct connection to all charging points, see Figure 11. The inherent disadvantages of situating the substation within the station car park is that it reduces customer parking spaces while creating a more complex route for ESB to supply the substation. The more complexities associated with ESB providing a connection, the greater the potential costs associated with the option.

Additional sites for the new substation have also been explored, one being the storage shed to the north of the depot. Irish Rail have prevented the repurposing of this building as it remains operational. The shed is also a heritage building and client confirmed that they had no interests to convert the storage shed into a new substation.

A further site considered for substation location identified is opposite the parking spaces in Drogheda depot within the grounds of the McBride Pitch and Putt Club. The information has been provided which suggests that the Pitch and Putt Club grounds is owned by Irish Rail and therefore could pose a potential location for a new traction substation.

To provide a robust, simple, and sustainable substation housing, considerations should be made with regards to the use of a brick-built housing, steel metallic housing, or the use of more composite materials such as GRP. The deciding factor for the material of the building will ultimately be down to the life span of the building. Therefore, a brick enclosure would be recommended due to its longevity.

The new traction system is to be earth free to provide prevention and mitigation of any DC stray currents that may be present. To ensure the system remains earth free, a traction return path for the negative DC feed, back to the negative busbar via the rails shall be provided. A buffer zone is to be implemented for the traction return to ensure the return path is maintained within the charging area and substation. Insulating pads to be considered between rails and sleepers at the subsequent stage. The Negative bar will be tied to the substation Earth bar, this should be the only connection and a device (e.g. a diode) should be installed to prevent reverse current. Voltage limiting devices and surge protection can be supplied to limit large transient voltages being transferred into the system. Their application is to be investigated further at the subsequent design stage.

The substation earth farm is to be connected to the AC equipment in the substation to ensure that transferred fault levels are limited and step and touch potentials are managed. A soil resistivity study is to be carried out at the subsequent project stage to assess the rise of earth potential that will be seen during a fault. The earthing of the substation is to comply with EN 50522.

5.1.3 Battery Buffer

A battery buffer solution ultimately reduces the demand and smooths the large instantaneous peaks that occur as a result of charging the BEMUs. The battery buffer works in parallel with the grid to charge the BEMU units. Due to the bespoke nature of the Battery Buffer, interpretation has been made from details provided from potential manufacturers and online resources, the full working parameters of the battery buffer system will be clarified at subsequent design stage, if applicable to the client's preferred option.

The battery buffer shall operate in parallel with the main ESB grid connection, so the load taken by the charging points is shared between the batteries and the grid connection. Without the battery buffer, the ‘worst-case’ instantaneous peak load will be taken from the network. With the inclusion of the battery buffer, the peak demand of the charging points is smoothed which assists the energy supplier to provide a reliable and constant supply without causing potential strain on the network and associated equipment.

The battery buffer solution while applicable to all options, it is deemed essential for the Options where several trains could be charging at once. As such, Option 1b and 2b have been modelled over an hour period based on their operational timetable devised for this study. Data presented in the graphs below show the effects of introducing a battery buffer into Option 2b:

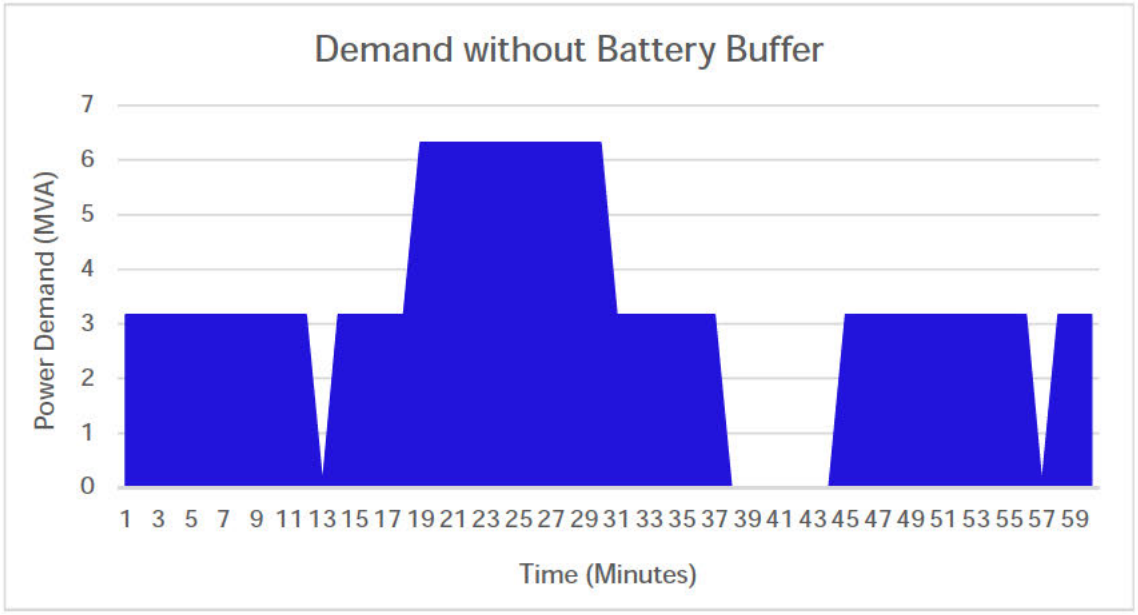


Figure 12: Electrical grid demand without the use of a battery buffer

It can be seen from the data presented in Figure 12 that the maximum demand as seen on the ESB grid is equal to approximately 6.32MVA under the conditions of two trains being charged at the same time. Note that based on the operational timetable the train arrival and turnaround time of 12 minutes there is not an instance of 3 trains charging at one time for both options 1b and 2b. The 3 trains charging simultaneously only applies where trains are delayed.

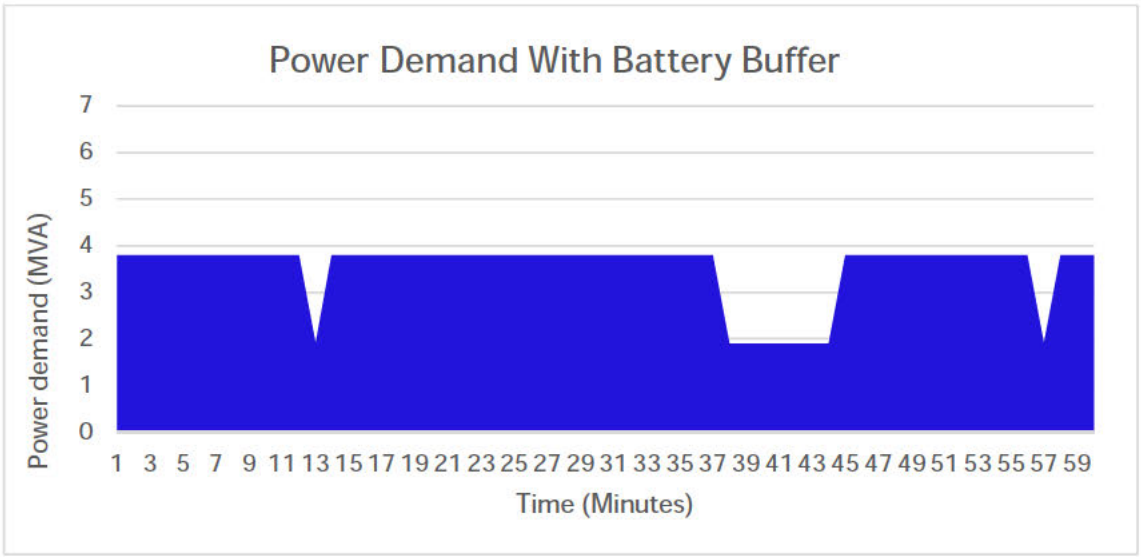


Figure 13: Electrical grid demand with the use of a battery buffer

Figure 13 shows the effect of the introduction of the battery buffer, reducing the instantaneous peak, and smoothing the overall power demand.

After liaison with potential manufacturers, it is clear that this technology is currently used to bolster the grid network. Therefore, as the BEMU are supplied at 1500V dc, an ac conversion would be required for this system; simplifying the solution.

Figure 14 below shows the feeding arrangement with the inclusion of the battery buffer and the outgoing charging points.

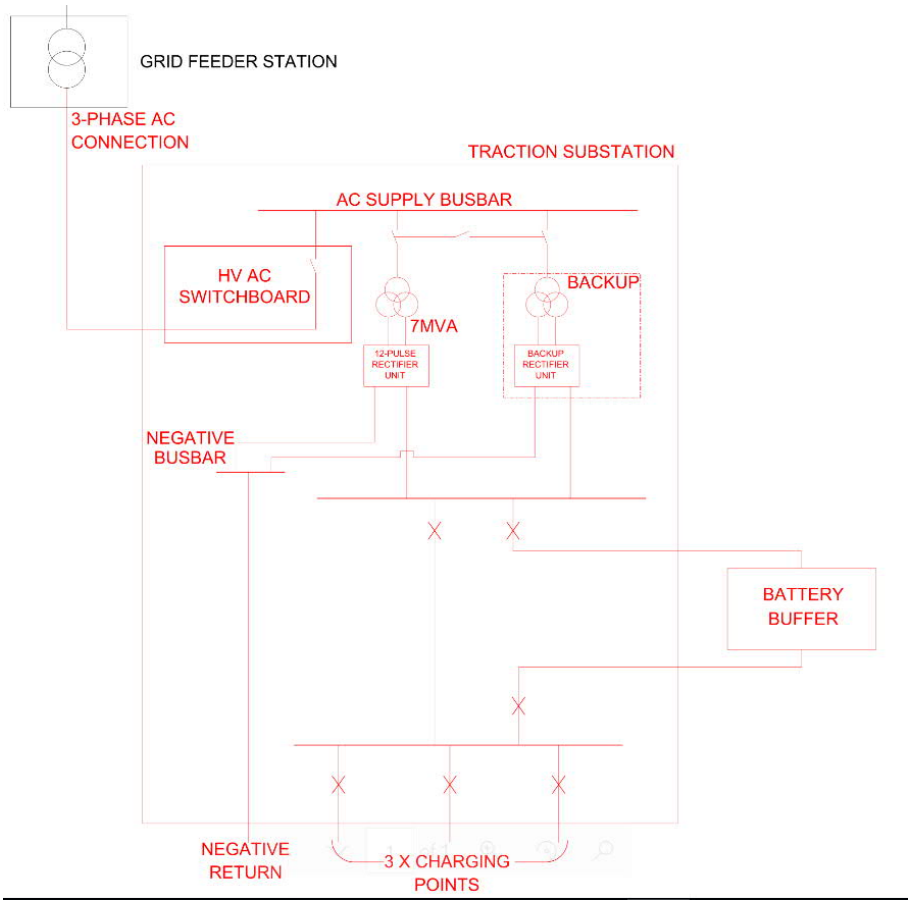


Figure 14: Traction substation with Battery buffer in feeding arrangement

The parallel link between the transformer rectifier unit and the charging points offer greater system redundancy if the maximum MIC is sought from ESB. In the event of a failure of the battery buffer, the ESB grid is to sustain the full load. The battery buffer will be a containerised solution with its built-in domestics and environmental controls to ensure the batteries work efficiently as possible.

In reference to the location of the battery buffer, where feasible the battery buffer should be located adjacent to or within proximity to the traction substation, reducing the voltage drop in cable route in and out of the substation.

One of the fundamental drawbacks of the battery buffer is the associated cost and its physical footprint. To be able to provide a significant benefit to the charging system, the battery buffer building would need to be 13m(l)x 2.5m(w)x 3m(h) and weigh 32,725kg based on details of a Samsung TB-45-2,466 battery unit, datasheet in Appendix A. The cost of the system is approximately [redacted]r kWh (example used equates to 2466kWh) and the batteries associated maintenance burden have the approximate life span of between 8-10 years.

5.1.4 HV AC Switchboard

On the AC side of the transformer, HV protection will be required to protect the primary side of the transformer and incoming ESB supply. Air/vacuum circuit breakers, relays, voltage transformers, current transformers and Instrument transformers will be integrated to achieve this protection.

5.1.5 Transformer

The transformers specified are dependent on the MIC required for the charging option selected and the voltage supplied by ESB. Due to the proximity of the Mornington Road feeder station, the connection is assumed to be a 10kV 3 phase AC, which will need to be converted into a single-phase 1500V DC supply. To provide mitigation for any transformer rectifier losses, the transformers proposed for each option should be sized larger than the peak load.

Although considerations have been made with regards to the procurement and specification of a battery buffer, the load details outlined for the specification and selection of the transformer rectifier units and any subsequent equipment have been made using worst-case instantaneous peaks.

As the charging of the BEMUs is operationally critical for the trains running between Malahide and Drogheda, a backup transformer rectifier unit is proposed for the traction substation to provide system redundancy in the event of a failure or planned maintenance. The back-up supply should be sized as equal to the primary system to be able to sustain full load conditions.

Individual details of the transformers proposed for each option and their requirements and load information can be found in sections 1 to 3.

5.1.6 Rectifier Unit

The local power grid connection shall provide an AC supply, which requires converting to DC supply to charge the battery trains. The conversion is achieved by a 12-pulse rectifier that provides supply filtering and smoothing.

Given the output voltage of 1500V DC from the power requirements of the BEMU charging points under the varying options, the output current seen by the rectifier unit equals approximately 2.1kA for Option 1a and 6.4kA for Option 1b and 2b.

The positive outgoing side of the rectifier unit will be connected to the positive 1500V DC busbar which will be protected by a high-speed circuit breaker with protection relay incorporated rated as required. The negative DC side of the rectifier will be connected to the negative return bar which forms a part of the negative DC return circuit.

The specification of the rectifier unit should be selected and proposed in conjunction with the selection of the transformer unit required. The units should operate in conjunction to ensure the operation is efficient and limit losses. The selection of the rectifier units should be considered in more detail at the subsequent design stage with further considerations into power factor, harmonics, and other potential disturbances associated with AC-DC rectification and power electronics.

5.1.7 DC Circuit Breakers

High-speed circuit breakers are required for electrical protection of the system and life. The breakers will be required to be able to handle instantaneous peaks without tripping or failing and trip within specific disconnection time under fault conditions.

The type of protective devices specified shall be selected by the load characteristics, supply type, fault conditions, etc. The circuit breakers arc suppression shall also be of either air or vacuum type. SF6 circuit breakers are undesirable and under electrical stresses produce toxic gases that, under failure or puncture, could result in the expulsion of those gases.

Based on similar outgoing feeding arrangements utilised on other DART traction substations, the DC circuit breakers should include thermal protection, overcurrent instantaneous & time protection, over-voltage protection, and a form of control. These elements combine to provide system protection to the critical systems upstream and downstream equipment.

The outgoing DC feeders need to withstand and be protected against a continuous load of 2.1kA at 1500V DC.

5.1.8 Construction & Maintainability

One of the key factors to consider in the constructability of the BEMU charging infrastructure concerning the construction of the traction substation and associated equipment is the space constraints within the station and depot (as it needs to remain operational for diesel units) and the constricted access caused by the number of the running lines and sidings.

Considerations have been made concerning the transport of equipment to the site and the ability to construct the substation elements at each potential site. Rail and road access have been examined. Drogheda depot has 2 access roads:

- McGraths Lane at the east end and
- An underbridge at the west end via the station car park.

The advantage of the two access roads includes an alternative route if one is blocked. A potential issue with the use of the access roads at Drogheda depot is that they seem narrow and therefore it may not be practical to utilise the roads. An alternative to transporting equipment to the site by train stock. Plant such as RRVs or Kirow cranes could be utilised to transport equipment to the site and to lift the components into place. A disadvantage of utilising on-track plant Is that an engineering possession may be required and as such would need to be planned to limit the disruption to the normal operation of trains.

Regular cyclical maintenance of the proposed substation and associated equipment is required to ensure all equipment is operational working as normal. A minimum of annual maintenance of the electrical power system equipment to ensure equipment's health and to replace any components which may be nearing their life expectancy. All electrical equipment shall be specified with a minimum life expectancy of 25 years, except for battery units. Any batteries specified within the system require an increased maintenance regime of a minimum of 6 monthly inspections and have a lower life in comparison to other system components.

6. E&P Systems interfaces

6.1.1 Earthing & Bonding of existing infrastructure

Earthing & bonding is a fundamental electrical safety element within the operational or working areas of the railway. At this stage, the level of detail concerning earthing and bonding is not significant. All exposed metallic and conductive parts within the OLE fall zone shall be bonded back to the LV main earth. The station bonding shall protect the public from touch potentials. The station bonding shall not be bonded to the proposed traction system, as DC traction is an earth free system. The earthing associated with the DC return and traction substation earthing has been covered in section 5.1.2.

As there will be traction electrical systems within the confines of the station and depot where there is human interaction, earthing and bonding shall be implemented to provide a safe earth path back to the station LV main earth bar, thus preventing touch potentials. All metallic and conductive parts shall have defined earth paths to ensure that all electrical housings or equipment have a potential not greater than the values specified in IEC 60364. As the traction system is earth free the segregation between the traction return and LV earthing is paramount to prevent DC stray currents.

Further details of the requirements for traction bonding and equipotential bonding for conductive parts affected can be found doc: inI-ETR-4009 - Principles of Traction Bonding. Earthing and Bonding work to be designed to adhere with, EN 50122-1 and EN 50522. An earthing and bonding strategy and design should be considered in more detail at the subsequent design stage.

6.1.2 EMC

As a result of the traction systems utilised for the charging of the BEMUs, Electromagnetic Interference may affect other electrical systems or networks that are in proximity. As far as reasonably practicable HV cables shall be segregated from others by 1m. Where data and communications cables cannot be sufficiently segregated, metallic barriers can be used to prevent interference where armour or shielding cannot be enforced. Positive and negative DC cable shall as far a reasonably possible be routed together, as the negative cancels the positive cables electromagnetic field.

At the subsequent design stage, an EMC strategy to be compiled to align with EMC guidelines stated in EN 50121, EN 61000, and IRS-203-B.

6.1.3 SCADA

To provide an element of control and monitoring to the critical systems in the traction substation and supply, a SCADA system is to be integrated to provide data and control to Connolly ECR (Electrical Control Room). The existing ECR currently oversees the overhead electrification operating to the south and will require the facility to remotely control the proposed substation and associated lineside switches. To implement the SCADA system the Substation will require to house a Remote Terminal Unit (RTU) within a marshalling cubicle which will transmit status information via a telecoms link to the master station cubicle within Connolly ECR. The information transmitted shall be replicated on a visual display which will allow the ECO (Electrical Control Operator) to monitor any alarms and remotely control the substation.

The types of alarms that may be used for the monitoring of the Substation include the following:

- Fire alarm
- Main supply on
- Main supply off
- Back up supply on
- Back up supply off
- Main/back up transformer fault
- Main/back up rectifier fault
- Battery system down

- Battery room air conditioning off
- Breaker 'XYZ' operated
- Common Plant Alarm

Further design of the SCADA system and alarms should be implemented and considered in greater detail at the subsequent design stage.

6.1.4 OLE Motorised Switches

To be able to provide control and isolation over the supply to the contact system, several motorised OLE switches (MOS) will be fitted which can automatically disconnect the supply from the contact system. The motorised switches can be either operated remotely by the ECR or manually by a trained operative. The OLE motorised switches require a LV supply. Refer to the OLE design section of the report for more details.

The point of supply for the motorised switches can be taken from multiple locations including the local station supply, LV depot supply or derived from the local signalling power supply which has the potential benefit of redundancy via battery back and/or generator. The supply used will be investigated further at the subsequent design stage.

7. Future Considerations

Future considerations investigate further sustainability, cost-benefit, practicality, and safety that could be introduced in the charging system.

To further reduce the carbon footprint and alleviate demand on the grid, renewable energy sources could be used to bolster the ESB supply. PV solar cells and/or wind turbines could be introduced to provide power to the charging infrastructure. The renewable supplies will be integrated into the proposed feeding arrangement to support the ESB supply.

The advantages of using PV cells/wind turbines as a secondary energy source is the potential cost saving over the life period of the infrastructure and clean energy through renewable means. The disadvantages to the renewable energy sources are the requirement for additional land take for the installation, the cost of the infrastructure initially, and the intermittent effect of renewable energy sources. The McBride pitch and putt may be the ideal location for mounting this equipment.

Another sustainable design option to be explored is the use of combined troughing and walking routes where necessary. Combined cable troughing and walking routes offer a robust, sustainable, and safe design solution for sites that have limited space. A combined troughing and walking route introduces a lightweight, low maintenance, easily accessible cable management system that offers the same routing capabilities as 2 No C1/43 concrete troughs. The finished walking surface provides a safe route for maintainers and other personnel to access lineside equipment.

Operator and Maintainer safety is a paramount aspect in the design the use of non-conductive materials provides additional safety benefits. Materials such as brick and GRP can be used in place of steel or other conductive materials for electrical housings and civils infrastructure. The nature of non-conductive electrical housings ensures that fault currents are not transferred onto the housing and therefore removes touch potential risk. Materials such as GRP have similar mechanical properties as steel with an increased tensile strength but with the added benefit of being non-conductive. A disadvantage of GRP is that it suffers from poor stiffness and rigidity. Rigidity will need to be factored in when looking at the mechanical protection it provides especially where subject to the elements.

8. Schedule of interfaces

The E&P interfaces with other disciplines are summarised in the table below:

Interfacing Element	Interface
Civils	. New substation structures and foundation design; . Electrical immunisation of the conductive parts nearby to the charging points; . Procurement of new cable routes throughout the site;
Track	. Position of IRJs to provide a direct path for the DC return current; . Electrical immunisation of the conductive parts nearby to the charging points; . Provision of track connections and bonds for negative return circuit;
Signalling	. Position of IRJs to provide a direct path for the DC return current;
OLE	. Interface with the positive connection points to and from the contact wires;
Telecoms	. Interface with Telecoms for communication link for SCADA and alarms to Connolly ECR;
Environmental	. Environmental interface for any relative ecology data associated with the site any specific considerations regarding the location of the new substation;
Ops & Timetable	. Information regarding the movement of trains and the number of trains to be charging;
Rolling Stock	. Battery capacity and pantograph details as specified from the rolling stock and operational requirements;
Utilities services (ESB)	. Procurement of a new supply connection to the existing HV electrical network;
UK & Ireland Railway Heritage	. Details or information regarding any historical aspects or heritage aspects at Drogheda station that may be affected by the introduction of the charging system;

Table 7: E&P interface table

9. Conclusion and recommendations

E&P works are defined by the power capacity required from the ESB grid connection and the substation location. The MIC and preferred substation location provided for each option is a follow: -

- Option 1a- MIC is 3.16MVA and substation location B
- Option 1b- MIC is 9.48MVA and substation location B
- Option 2b- MIC is 9.48MVA and substation location C

To reduce the overall power capacity, it is recommended that the Battery Buffer system is considered for charging trains in option 1b and 2b, to smooth the high instantaneous peaks seen during these scenarios. It should be noted that option 1a provides the most viable option with reference to ESB connection, without requirements for resilience upgrades.

10. Standards

Below is a non-exhaustive list of standards used while compiling the E&P report:

EN 50522 - Earthing of power installations exceeding 1 kV a.c.;

EN 50122-1 - Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Protective provisions against electric shock;

EN 50121 - Railway applications. Electromagnetic compatibility;

EN 61000 - Electromagnetic compatibility (EMC);

IRS-203-B - EMC Co-ordination;

Appendix A. Datasheets

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Sécheron SA
Commercial contact: [redacted]

To: Jacobs UK
To the attention [redacted]

We thank you for your inquiry and are pleased to tender in accordance with the general conditions of Sécheron SA

Project Name	Equipment Description	Price in EUR
Europe Battery Train Charging	**1500 Vdc DC Traction Power Substation Equipment** - Equipment fully manufactured, assembled and tested by Sécheron in compliance with IEC/EN	Refer to §2

1. COMMERCIAL CONDITIONS

Offer validity	Budget Quote – not valid for order placement
Price	All prices are fixed in EUROS (EUR), Delivery FCA Prague, Czech Republic, excluding VAT – According to Incoterms® 2020
Payment conditions	To be discussed
Payment terms	To be discussed
Delivery time	6 months for FAT of the 1st batch upon acknowledgment of the purchase order. Detailed schedule to be agreed between parties.
Guarantee	12 months upon installation completion date but not later than 18 months after the FAT.

[redacted]

Sécheron SA

[redacted]

2. Price Breakdown

Pos	Material description	Qty	Unit Price EUR	Total Price EUR
10	**ESTRA-MBS-HD 8000A DC Switchgear:** - UR80M-82s withdrawable HSCB - MIU10 Current Transducer - VM Voltage Transducer - SEPCOS protection relay + SEPCOS display - Surge arrester 2000Vdc	1	[redacted]	
Total Price				

3. Deviations & Clarifications

a. The price provided is for budget purpose only, a firm quotation will be provided when a detailed specification is provided.

4. Rates for Associated Services

A) Workshop services:

Sécheron Prague workshop service description	Daily rate EUR
Daily rate for additional Factory Acceptance Tests (FAT for the 1st batch is free of charge)	[redacted]
8 hours daily rate for training with a Secheron technical expert: - Operation and maintenance training of the equipment (Max 6 pers.),	

Travel, accommodation and meals costs as well as pocket money of the Purchaser and/or the Final Customer and/or their representatives during inspection/FAT are not included in the price.

B) Onsite services:

Onsite services description	Daily rate EUR
8 hours daily rate of 1 Sécheron field engineer (Onsite travel time from hotel to site): - Rate for normal day (Monday to Friday / from 7.00 am to 8.00 pm) - Supervision of installation, - Test & Commissioning, - Training for maintenance and operation of equipment of group of 4-6 people. *(Hotel, meals and local transportation included)*	[redacted]
Rental of a DC contactor for short-circuit test	

Extra costs of 50% for onsite services during:

- Nights (from 8.00 pm to 7.00 am)
- Week-end
- Bank holidays

Not included:
Flight tickets are not included. The price of roundtrip flight tickets + 10% will be charged to the purchaser.
All prices are net, without any duty or tax.

General conditions of contract for the supply of plant and machinery

1. General

1.1 The contract shall be deemed to have been entered into upon receipt of supplier's written acknowledgement stating its acceptance of the order. Tenders which do not stipulate an acceptance period shall not be binding.

1.2 These general conditions of supply shall be binding if declared applicable in the tender or in the order acknowledgement. Any conditions stipulated by the customer which are in contradiction to these general conditions of supply shall only be valid if expressly acknowledged by the supplier in writing.

1.3 All agreements and legally relevant declarations of the parties to the contract must be in writing in order to be valid.

1.4 Should a provision of these general conditions of supply prove to be wholly or partly invalid, the parties to the contract shall jointly seek an arrangement having a legal and economic effect which will be as similar as possible to the invalid provision.

2. Scope of supplies and services

The supplies and services are exhaustively specified in the order acknowledgement and in appendices thereto, the supplier shall be entitled to make any changes which lead to improvements provided such changes do not result in a price increase.

3. Technical documents

3.1 Unless otherwise agreed upon, brochures and catalogues are not binding. Data provided for in technical documents are only binding in so far as having been expressly stipulated as such

3.2 Each party to the contract retains all rights to technical documents provided to the other. The party receiving such documents recognizes these rights and shall - without previous written consent of the other party - not make these documents available to any third party, either in whole or in part, not use them for purposes other than those for which they were handed over.

4. Regulations In force in the country of destination and safety devices

4.1 The customer shall, at the latest when placing the order, draw the attention of the supplier to the standards and regulations applicable to the execution of the supplies and services, to the operation of the plant as well as to the health and safety of personnel.

4.2 Unless otherwise agreed upon, the supplies and services shall comply with those standards and regulations at the place of business of the customer about which the supplier has been informed under Clause 4.1. additional or other safety devices shall be supplied to the extent as having been expressly agreed upon.

5. Prices

5.1 Unless otherwise agreed upon, all prices shall be deemed to be net ex-works, excluding packing, in freely available Swiss francs without any deduction whatsoever. Any and all additional charges, such as, but not limited to, freight charges, insurance premiums, fees for export, transit, import and other permits, as well as for certifications, shall be borne by the customer Likewise, the customer shall bear any and all taxes, fees, levies, customs duties and the like which are levied out of or in connection with the contract, or shall refund them to the supplier against adequate evidence in case the supplier is liable for them.

5.2 The supplier reserves the right to adjust the prices in case the wage rates or the raw material prices vary between the submission of the tender and the contractually agreed performance. In such case the adjustment shall be made according to the attached price adjustment clause. In addition, an appropriate price adjustment shall apply in case the delivery time has been subsequently extended due to any reason stated in Clause 8.3, or the nature or the scope of the agreed supplies or services has changed, or the material or the execution has undergone changes because any documents furnished by the customer were not in conformity with the actual circumstances, or were incomplete.

6. Terms of payment

6.1 Payments shall be made by the customer at supplier's domicile according to the agreed terms of payment, without any deduction for cash discount, expenses, taxes, levies, fees, duties, and the like. Unless otherwise agreed upon. The price shall be paid in the following instalments:

- one third as advance payment within one month after receipt of the order acknowledgment by the customer,
- one third on expiry of two thirds of the agreed delivery time,
- the remainder within one month after supplier's advice that the supplies are ready for dispatch.

Payment shall be deemed to be effected as far as Swiss francs have been made freely available to the supplier at supplier's domicile. In case payment by bills of exchange is agreed, the customer shall pay the cost of discounting of such bills, bill of exchange taxes and collection charges.

6.2 The dates of payment shall also be observed if transport, delivery, erection, commissioning or taking over of the supplies or services is delayed or prevented due to reasons beyond supplier's control, or if unimportant parts are missing, or if post-delivery work is to be carried out without the supplies being prevented from use.

6.3 If the advance payment or the contractually agreed securities are not provided in accordance with the terms of the contract, the supplier shall be entitled to adhere to or to terminate the contract, and shall in both cases be entitled to claim damages, If the customer is in delay with a further payment, or if the supplier is seriously

concerned that it will not receive payments in total or in due time because of circumstances having taken place since entering into the contract, the supplier, without being limited in its rights provided by law, shall be entitled to refuse the further performance of the contract and to retain the supplies ready for dispatch until new terms of payment and delivery will have been agreed and until the supplier will have received satisfactory securities. If such an agreement cannot be reached within a reasonable time, or in case the supplier does not receive adequate securities, the supplier shall be entitled to terminate the contract and to claim damages.

6.4 It the customer delays in the agreed terms of payment, it shall be liable, without reminder, for interest with effect from the date on which the payment was due ate rate depending on the terms prevailing at the customer's domicile, but not less than 4 per cent over the current discount rate of the Swiss National Bank.

7. Reservation of title

The supplier shall remain the owner of all supplies until having received the full payments in accordance with the contract. The customer shall cooperate in any measures necessary for the protection of supplier's title. In particular upon entering into the contract it authorizes the supplier to enter or notify the reservation of title in the required form in public registers, books or similar records, alt in accordance with relevant national laws, and to fulfil all corresponding formalities, at customer's cost.

During the period of the reservation of title, the customer shall, at its own cost, maintain the supplies and insure them for the benefit of the supplier against theft, breakdown, fire, water and other risks. It shall further take all measures to ensure that the supplier's title is in no way prejudiced

8. Delivery time

8.1 The delivery time shall start as soon as the contract is entered into, all official formalities such as, but not limited to, import, export, transit and payment permits have been completed, payments due with the order have been made, and any agreed securities given and the main technical points settled. The delivery time shall be deemed to be observed if by that time the supplier has sent a notice to the customer informing that the supplies are ready for dispatch.

8.2 Compliance with fine delivery time is conditional upon customer's fulfilling of its contractual obligations.

8.3 The delivery time is reasonably extended:

a) it the information required by the supplier for performance of the contract is not received in time, or if the customer subsequently changes it thereby causing a delay in the delivery of the supplies or services; b) if hindrances occur which the supplier

cannot prevent despite using the required care, regardless of whether they affect the supplier or the customer or a third party Such hindrances include, but shall not be limited to, epidemics, mobilization, war, revolution, serious breakdown in the works, accidents, labor conflicts, late or deficient delivery by subcontractors of raw materials, semi-finished or finished products, the need to scrap important work pieces, official actions or omissions by any state authorities or public bodies, natural catastrophes; c) if the customer or a third party is behind schedule with work it has to execute, or with the performance of its contractual obligations, in particular if the customer fails to observe the terms of payment

8.4 The customer shall be entitled to claim liquidated damages for delayed delivery into far as it can be proved that the delay has been caused through the fault of the supplier and that the customer has suffered a loss as a result of such delay if substitute material can be supplied to accommodate the customer, the latter is not entitled to any damages for delay. Damages for delayed delivery shall not exceed 1/2 per cent for every full week's delay and shall in no case whatsoever altogether exceed 5 per cent of the contract price of the part of the supplies in delay. No damages at all shall be due for the first two weeks of delay. After reaching the maximum liquidated damages for delayed delivery, the customer shall grant the supplier a reasonable extension of time in writing, If such extension is not observed for reasons within supplier's control, the customer shall have the right to reject the delayed part of the supplies or services. Ifs partial acceptance is economically not justified on the part of the customer, the fatter shall be entitled to terminate the contract and to claim refund of the money already paid against return of the deliveries supplied.

8.5 In case a specific date instead of a delivery period is fixed, such date shall correspond to the last day of a delivery period, Clauses 8.1 to 8.4 apply by analogy.

8.6 Any delay of the supplies or services does not entitle the customer to any rights and claims other than those expressly stipulated in this Clause 8. This limitation does, however, not apply to unlawful intent or gross negligence on the part of the supplier, but does apply to unlawful intent or gross negligence of persons employed or appointed by the supplier to perform any of its obligations.

9. **Packing**

Packing shall be charged for separately by the supplier and shall not be returnable. However, if it is declared as supplier's property, it shall be returned by the customer, carriage paid, to the place of dispatch.

10. Passing of benefit and risk

10.1 The benefit and the risk of the supplies shall pass to the customer by the date of their leaving the works.

10.2 If dispatch is delayed at the request of the customer or due to reasons beyond supplier's control, the risk of the supplies shall pass to the customer at the time originally foreseen for their leaving the works. From this moment on, supplies shall be stored and insured on the account and at the risk of the customer.

11. Forwarding, transport and insurance

11.1 The supplier shall in time be notified of special requirements regarding forwarding, transport and insurance. The transport shall be at customer's expense and risk. Objections regarding forwarding or transport shall upon receipt of the supplies or of the shipping documents be immediately submitted by the customer to the last carrier.

11.2 The customer shall be responsible for taking insurance against risks of any kind.

12. Inspection and taking-over of the supplies and services

12.1 As far as being normal practice, the supplier shall inspect the supplies and services before dispatch. If the customer requests further testing, this has to be specially agreed upon and paid by the customer.

12.2 The customer shall inspect the supplies and services within a reasonable period and shall immediately notify the supplier in writing of any deficiencies, if the customer fails in doing so, the supplies and services shall be deemed to have been taken over.
12.3 Having been notified of the deficiencies the supplier shall as soon as possible remedy them according to Clause 12.2, and the customer shall give the supplier the possibility of doing so. After remedy of such deficiencies, a taking-over test according to Clause 12.4 will he carried out at the request of the customer or of the supplier.
12.4 Subject to Clause 12.3 the carrying out of a taking-over test as well as laying down the conditions related thereto need a special agreement. In the absence of such agreement the following shall apply:
12.5 The supplier shall advise the customer in time of the execution of the taking over test so that the customer or its representative can attend. A taking-over report shall be prepared which shall be signed by both the customer and the supplier or by their representatives. Such report shall either state that the taking-over has taken place, or that it has taken place under reservations, or that the customer has refused the acceptance, in the last two cases, the deficiencies shall be fisted individually in the report. In case of insignificant deficiencies, in particular those which do not substantially hinder the efficient functioning of the supplies or services, the customer shall not be entitled to refuse the acceptance of the supplies or services and the signature of the taking-over report. The supplier shall remedy such deficiencies without delay. In case of important deviations from the contractor of serious deficiencies the customer shall give the supplier the possibility of remedying these within a reasonable time. Thereafter a further taking-over test shall take place. If during this test important deviations from the contract or serious deficiencies appear again, the customer shall be entitled to claim either a price reduction or an indemnity or other compensations from the supplier, provided this has been agreed before. It, however, the deviations and deficiencies appearing during such test are of such importance that they cannot be remedied within a reasonable time and provided the supplies and services cannot be used for their specified purpose, or such use is considerably impaired, then the customer shall be entitled to refuse acceptance of the defective part or, if partial acceptance is economically not justified for it, to terminate the contract. In such case the supplier can only be held liable to reimburse the sums which have been paid to it for the parts affected by the termination.
12.6 Taking-over shall also be deemed completed
- if the taking-over test cannot be carried out on the date provided for due to reasons beyond supplier's control:
- if the customer refuses the acceptance without being entitled to do so
- if the customer refuses to sign the taking-over report prepared in accordance with clause 12.4;
- as soon as the customer uses the supplies or services.
12.7 Deficiencies of any kind in supplies or services shall not entitle the customer to any rights and claims other than those expressly stipulated in Clauses 12.4 and 13 (guarantee, liability for defects).

13. Guarantee, liability for defects

13.1 Guarantee period The guarantee period is 12 months, or 6 months in case of 24-hour operation, it starts when the supplies leave the works or at the taking-over of the supplies and services should such taking-over have been agreed upon before, or, if the supplier undertakes the erection, upon completion thereof. If dispatch or taking-over or erection are delayed due to reasons beyond supplier's control, the guarantee period shall end not later than 18 months after supplier's notification that the supplies are ready for dispatch. For replaced or repaired parts the guarantee period starts anew and lasts 6 months after replacement or completion of the repair or taking-over, but not longer than the expiry of a period being double to the guarantee period stipulated in the preceding paragraph The guarantee expires prematurely if the customer or a third party under-takes inappropriate modifications or repairs or if the customer, in case of a defect, does not immediately take appropriate steps to mitigate the damage and give the supplier the possibility of remedying such defect.
13.2 Liability for defects in material, design and workmanship
Upon written request of the customer, the supplier undertakes at its choice to repair or replace as quickly as possible any parts of the supplies which, before the expiry of the guarantee period, are proved to be defective due to bad material, faulty design or poor workmanship. Replaced parts shall become supplier's property. The supplier shall bear the costs of remedying the detective parts in its works. If the repair cannot be carried out in supplier's works, the customer shall bear the related costs to the extent exceeding the customary costs of transport, personnel, travelling, living, dismantling and reassembly of the defective part
13.3 Liability for express warranties Express warranties are only those which have been expressly specified as such in the order acknowledgment or in the specifications. An express warranty is valid until the expiry of the guarantee period at the latest. If a taking-over test has been agreed, the warranty shall be deemed to have been fulfilled as soon as the test results prove the relevant quality or capacity. If the express warranties are not or only partially achieved, the customer may first of all require the supplier to carry out the improvements immediately. The customer shall give the supplier the necessary time and possibility of doing so. If such improvements fail completely or in part, the customer may claim such compensation as has been agreed before for such case, or, if such an agreement has not been made, a reasonable reduction of price, if, however, the detects are of such importance that they cannot be remedied within a reasonable time and provided the supplies and services cannot be used for their specified purpose, or if such use is considerably impaired, then the customer shall be entitled to refuse acceptance of the defective part or, if partial acceptance is economically not justified for it, to terminate the contract. In such case the supplier can only be held liable for reimbursing the sums which have been paid to it for the parts affected by the termination.
13.4 Exclusions from the liability for defects
Excluded from supplier's guarantee and liability for defects are all deficiencies which cannot be proved to have their origin in bad material, faulty design or poor workmanship, e.g. those resulting from normal wear, improper maintenance, failure to observe the operating instructions, excessive loading, use of any unsuitable material, influence of chemical or electrolytic action, building or erection work not undertaken by the supplier, or resulting from other reasons beyond supplier's control.
13.5 Supplies and services of subcontractors
For supplies and services of subcontractors requested by the customer, the supplier assumes guarantee and liability for defects only to the extent of such subcontractors' guarantee and liability obligations.
13.6 Exclusivity of guarantee claims
With respect to any defective material, design or workmanship as well as to any failure to fulfill express warranties, the customer shall not be entitled to any rights and claims other than those expressly stipulated in Clauses 13.1 to 13.5.
13.7 Liability for additional obligations
The supplier is only liable to the extent of unlawful intent or gross negligence as far as claims arising out of faulty advice and the like or out of breach of any additional obligations are concerned,

14. Non-performance, bad performance and their consequences

14.1 In all cases of bad performance or non-performance not expressly covered by these general conditions of supply in particular if the suppler, without valid reasons, starts execution of the supplies and services so late that punctual completion is unlikely to be foreseen, calf an execution contrary to the terms of the contract can be clearly foreseen due to supplier's fault, or if the supplies and services have been executed contrary to the terms of the contract due to supplies fault-, then the customer shall be entitled to grant a reasonable additional period for the supplies or services affected thereby by simultaneously warning to terminate the contract in case of non-compliance. If such additional period lapses duo to supplier's fault, the customer shall be entitled to terminate the contract with respect to the supplies or services executed, or certain to be executed, contrary to the terms of the contract, and to claim a refund of the payments already made for such supplies or services 14.2 In such case Clause 16 shall apply with regard to any claims for damages on the part of the customer and with regard to the exclusion of any further liability, and any claim for damages shall be limited to 10 per cent of the contract price for the supplies and services affected by the termination .

15. Termination of the contract by the supplier

The contract shall be adapted appropriately, if unforeseen events considerably change the economic affect or the content of the supplies or services or considerably affect the activities of the supplier, or if performance subsequently becomes impossible. Insofar as such adaptation is economically not justifiable, the supplier shall be entitled terminate the contractor the parts affected thereby. If the supplier wishes to terminate the contract it shall – after having recognized the consequences of the event - immediately inform the customer: this applies even if an extension of the delivery time has been agreed before. In case of termination of the contract the supplier shall be entitled to the payment of those parts of the supplies and services which have already been carried out. Claims for damages on the part of the customer because of such termination are excluded.

16. Exclusion of further liability

Any rights and claims on the part of the customer other than those expressly stipulated in these general conditions of supply are excluded, irrespective on what ground they are based; this in particular refers to claims for damages, reduction of price or termination attire contract unless expressly stipulated therein. In no case whatsoever shall the customer be entitled to claim damages other than compensation for costs of remedying defects in the supplies. This in particular refers, but shall not be limited, to loss of production, loss of use, loss of orders, loss of profit and other direct or indirect or consequential damages. These exclusions, however, do not apply to unlawful intent or gross negligence on the part of the supplier, outdo apply to unlawful intent or gross negligence of persons employed or appointed by the supplier to perform any of its obligations.

17. Right of recourse of the supplier

If, through actions or omissions of the customer or of persons employed or appointed by it to perform any of its obligations, personal injury or damage to the property of third parties occurs and if a claim is made against the supplier, then the latter shall be entitled to take recourse against the customer

18. Erection

If the supplier undertakes the erection other supervision of the erection, the General Conditions of Erection of the supplier shall apply

19. Jurisdiction and applicable law

19.1 The place of jurisdiction for both the customer and the supplier shall be at the registered office of the supplier. The supplier shall, however, be entitled to sue the customer at the latter's registered address.
19.2 The contract shall be governed by Swiss law.

Sécheron



/// TRACTION POWER SYSTEMS

ESTRA-MBS-HD

High-speed circuit breaker panels
Heavy Duty (EN/IEC standards)

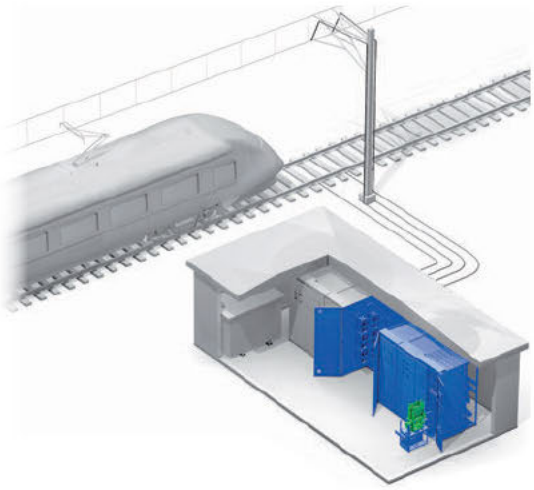


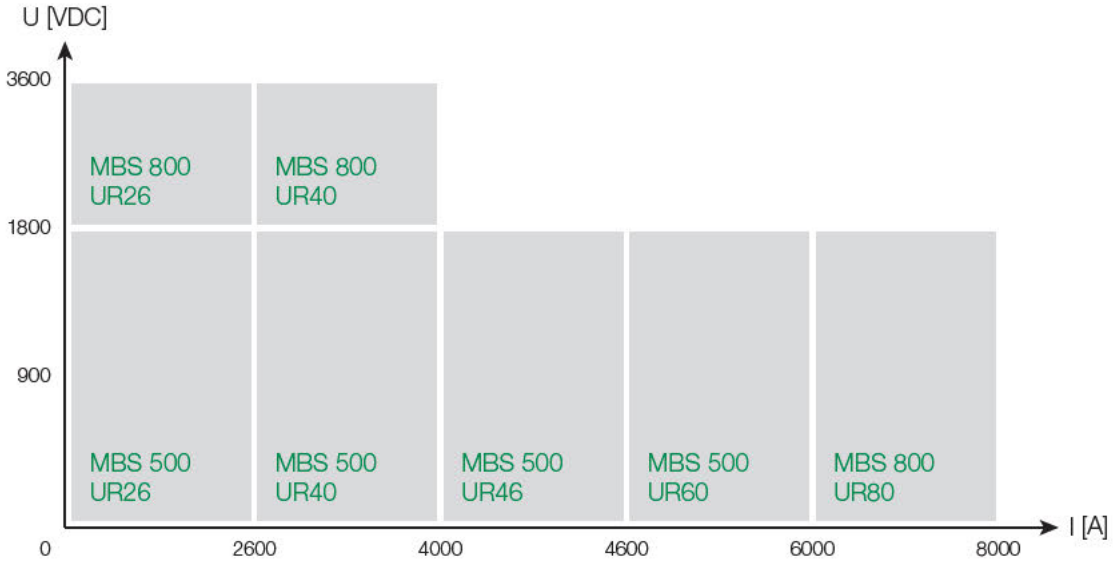
GENERAL INFORMATION

With a complete range of equipment and a leading expertise in DC traction power substations, Sécheron SA is a world leader and major partner for electrification of DC traction networks.

Covering all activities from calculation, network design and engineering, up to the production of the DC Systems, Sécheron SA can offer customers and partners tailor made solutions based on a modular concept and standard products.

Our equipment is developed on world leading technology and proven worldwide design and acceptance. In-house technology covers all key devices applied in the DC Systems (Rectifiers, DC HSCB, Disconnect Switches, Protection Relays, Measuring Amplifiers, etc.).





MAIN BENEFITS

- Heavy Duty performances.
- Limited maintenance with easy access to all parts.
- Very compact with minimum depth.
- Possibility to install cubicles directly against a wall.
- Front access to all equipment.
- Fully type tested according to EN 50123-6/A1:2015.
- Extended modular line-up.

HSCB DC SWITCHGEAR: DESCRIPTION

DC traction networks require safe power distribution and reliable control systems.

The MBS breaker panel is based on Sécheron traction DC protection experience and proven technology components are applied for all major functions in this cubicle.

The DC switchgear serves as the control and protection equipment for the DC power distribution.

The DC breaker panel type MBS is a modular concept cubicle which integrates different functions and equipment in three compartments:

- Rear high-voltage busbar compartment
- Protection and control system
- High-speed circuit breaker trolley



MBS Feeder Panel

/// REAR HIGH-VOLTAGE BUSBAR COMPARTMENT

The high-voltage compartment is at the rear of the cubicle. It contains the main busbar, cable connections, voltage and current measuring and, where applicable, disconnector switches.

/// PROTECTION AND CONTROL SYSTEM

The protection and control system is located at the front of the cubicle. This low-voltage compartment contains low-voltage components and ensures the protection through the SEPCOS, protection and control relay.

/// HIGH-SPEED CIRCUIT BREAKER TROLLEY

The high-speed circuit breaker (Sécheron UR series) is mounted on a removable four-wheeled trolley which can be easily withdrawn from the cubicle. The trolley also contains the line test device equipment. The HSCB is connected to the auxiliary circuits thanks to an unpluggable multiple connector and the breaker is connected to the high-voltage busbars by power finger connectors. All trolleys are exchangeable by one of the same type and are easy to manoeuvre.



MBS Feeder Trolley

The withdrawable high-speed circuit breaker trolley has four positions:

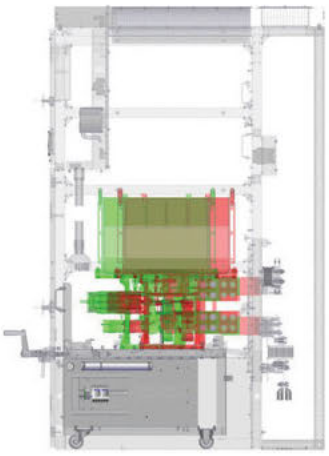
- Service position
- Test position
- Disconnected position
- Removed position

When the trolley is in service position, the front high-voltage door is locked and it is not possible to access the trolley. When high-voltage is applied to the breaker, it must be open before the trolley can be moved from service to test position.

The trolley is moved from one position to another either manually by an external handle or electrically via the SEPCOS touch screen display. In this way, user's security is ensured. Trolleys can be encoded to ensure that they cannot be exchanged for a trolley of another type.

Active equipment is located on the trolley.

The **motorized trolley** is an available option that allows the trolley to be disconnected remotely, thus replacing the line isolating disconnecting switch. Motor is embedded on the trolley.



Service and test positions

HSCB DC SWITCHGEAR: CHARACTERISTICS

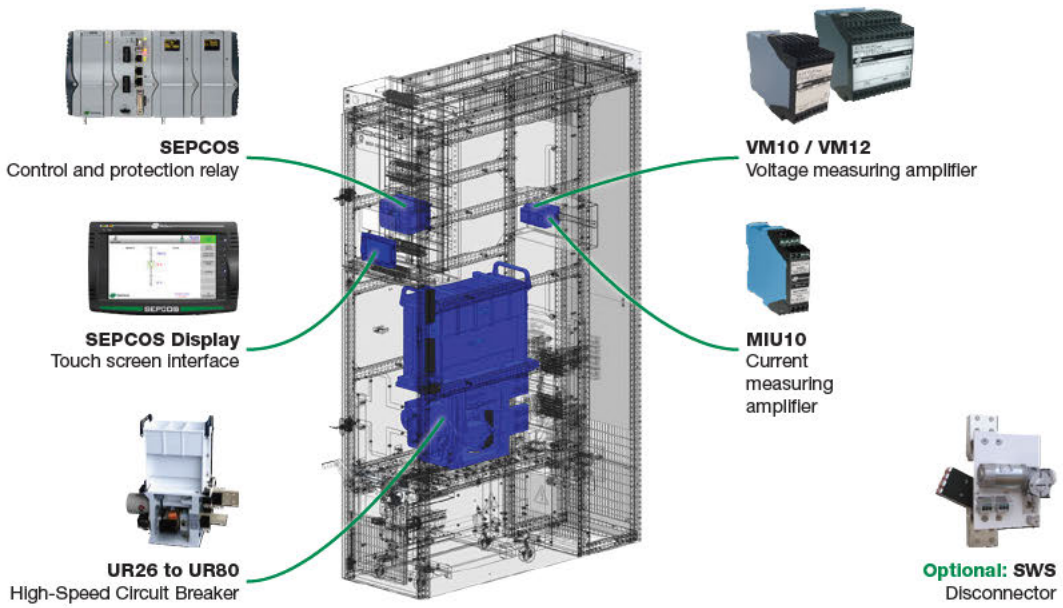
CUBICLE TYPE	Symbol	Unit	MBS 800				
			MBS 500				
Rated service current	I_{Ne}	[A]	2600	4000	6000	8000	4000
Rated voltage	U_{Ne}	[VDC]	900/1800	900/1800	900/1800	900/1800	3600
Circuit breaker type	-	-	UR26	UR36/40	UR46/60	UR80	UR40
Power frequency withstand voltage - Active part to earth (50 Hz, 1 min)	-	[kV]	5.5/9.2	5.5/9.2	5.5/9.2	5.5/9.2	18.5
Main busbar	I_e	[kA]	Up to 11				
Busbar rating - Connection	-	[A]	2500	4000	6000	8000	4000
Rated short-circuit current – T_{Nc} 100 ms (900 VDC) – T_{Nc} 31.5 ms (1800 VDC) – T_{Nc} 31.5 ms (3600 VDC)	$I_{Nss}/\hat{I}_{Nss}$	[kA]	 125/178 63/90 -	 125/178 80/113 -	 125/178 80/113 -	 134/190 - -	 - - 40/57
Protection degree	-	-	IP20 or IP42				
Ambient temperature range	T	[°C]	-5 to +40				
Typical weight	-	[kg]	500	550	650	700	700
Dimensions (W x D x H)	-	[mm]	500 or 800* x 1400 x 2400				

** UR80 and UR40 (3 kV) fit only in 800 mm MBS.*

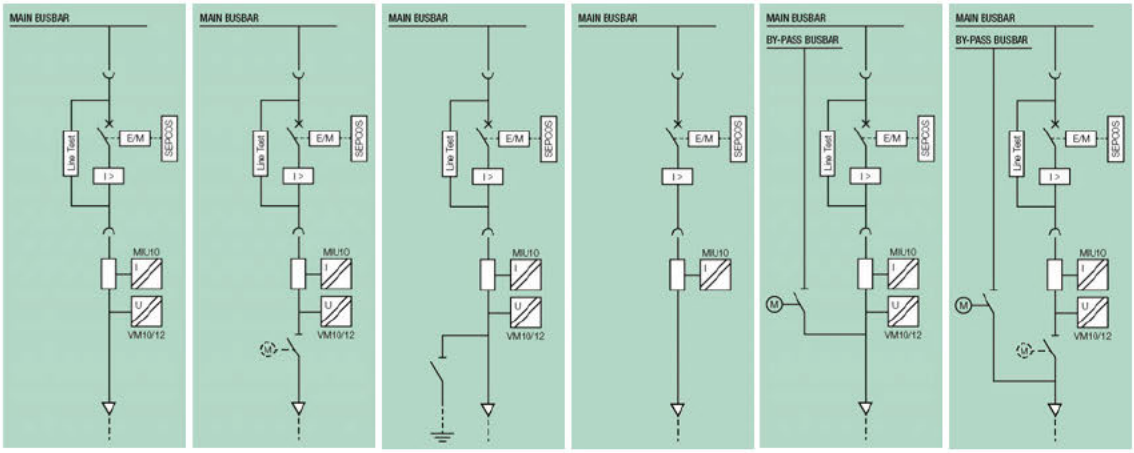
For further characteristics: Please refer to the data sheet for the individual circuit-breaker type.
Designed according to standard specifications EN 50123 and IEC 61992.

HSCB DC SWITCHGEAR: COMPOSITION

Key components of the switchgear are designed and manufactured by Sécheron and are fully compatible.



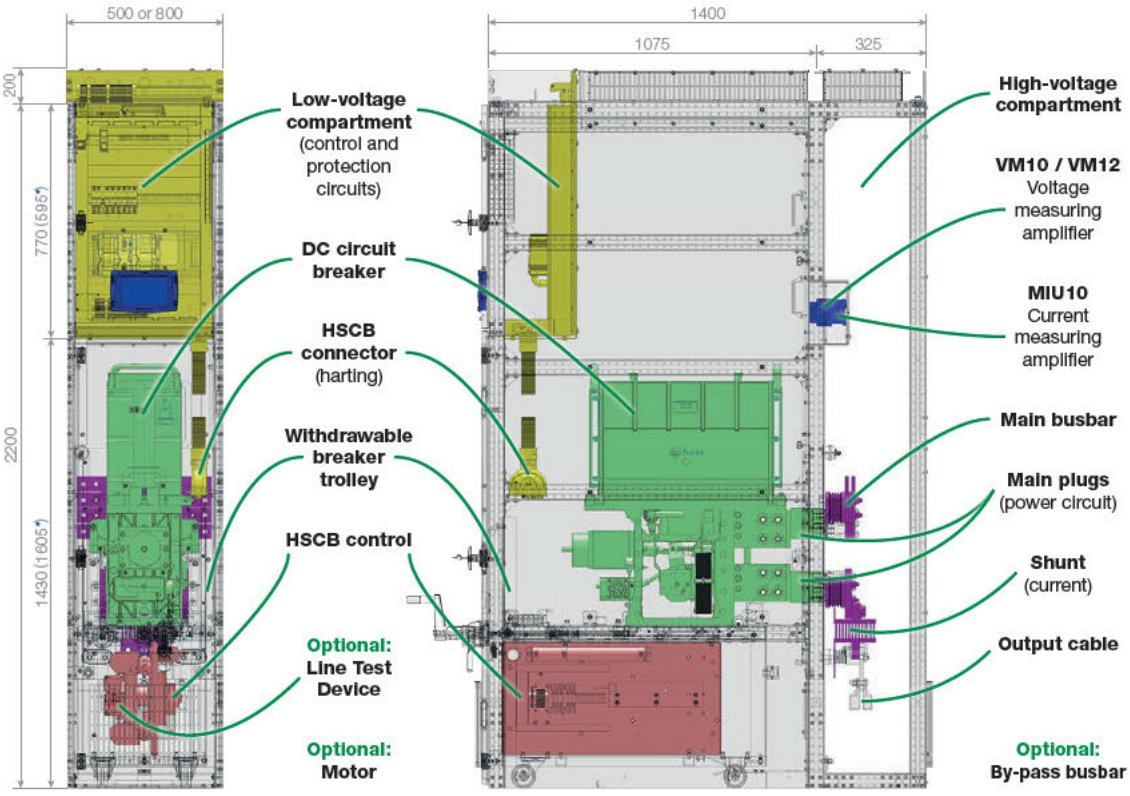
HSCB DC SWITCHGEAR: APPLICATIONS



Line feeder | **Line feeder with isolating switch** | **Line feeder with earthing switch** | **Rectifier breaker** | **Line feeder with by-pass** | **Line feeder with by-pass and isolating switch**

Installation of lightning arrester for outgoing feeder is available upon request.

HSCB DC SWITCHGEAR: MAIN DIMENSIONS



** For 3600 VDC cubicle.*

DISCONNECTING DC SWITCHGEAR

Disconnector cubicles are applied for incoming DS, negative DS or coupling DS.

The system contains two compartments:

- High-voltage compartment
- Low-voltage compartment

Each compartment has a separate front door and can be mounted against the wall. Cable connection is possible from the bottom or top. Disconnectors are rated 2000 A, 4000 A, 6300 A and 8000 A.

/// INCOMING DS CUBICLE

Incoming DS cubicles isolate the positive high-voltage output transformer/rectifier group from the feeder DC distribution bus. Disconnectors may have single or double poles. Double poles are used to disconnect the positive and the negative pole simultaneously. Operation may be motorized or manual. There are four different sizes: 500 mm, 800 mm, 1200 mm or 1600 mm. Incoming DS cubicles may contain up to 4 disconnectors.

/// NEGATIVE DS CUBICLE

Negative DS cubicles isolate the negative pole of the rectifier groups from the return current of the network (rail). Operation may be motorized or manual. There are four different sizes: 500 mm, 800 mm, 1200 mm or 1600 mm. Negative DS cubicles may contain up to 4 disconnectors.

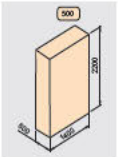
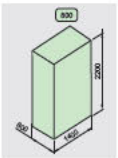
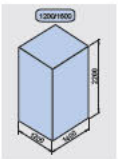
/// COUPLING DS CUBICLE

Coupling DS cubicles subdivide the DC switchboard into separate busbar sections. Operation may be motorized or manual, size is 500 mm.



Disconnecting Switch cubicle

Below are the different configurations according to the cubicle dimensions and types:

	Incoming DS cubicle					Negative DS cubicle			Coupling DS cubicle		
	2000 A - 1 pole	4000 A - 1 pole	6000 A - 1 pole	2000 A - 2 poles	4000 A - 2 poles	2000 A - 1 pole	4000 A - 1 pole	6000 A - 1 pole	2000 A - 1 pole	4000 A - 1 pole	6000 A - 1 pole
	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	1	1	2	2	2	1	1	1
	4	4	4	2	2	4	4	4	2	2	2



Disconnecting Switch SWS



Disconnecting Switch SWS

CONTROL AND PROTECTION RELAY

SEPCOS is a protection and control unit that is applied to the outgoing feeder or the incoming HSCB cubicles in the DC traction substation.

/// MAIN FEATURES

- Modular PLC concept, PLC programming, IEC 61131 normalized programming.
- Fully approved in railway substation environment IEC 60255-22.
- High noise immunity thanks to sampling rate at 40 microseconds and 16 bits A-D converter.

/// PROTECTION FUNCTIONS

- All typical protection functions (e.g. DDL +/-, Imax +/-, etc.).

/// CONTROL FUNCTIONS

- HSCB ON/OFF control with electric or magnetic holding.
- Intertripping, automatic reclosing, anti-pumping, line test function.
- External synchronization of the PLC, measurement supervisor control.

/// OPEN TO ALL CUSTOMER NETWORKS AND PROTOCOLS

- TCP/IP: Modbus-TCP.
- Specific TCP/IP based power distribution protocols: IEC 60870-5-104, IEC 61850, DNP 3.0.
- Fieldbus: Modbus-RTU, Profibus-DP.



SEPCOS in a low-voltage compartment

1 SEPCOS may be controlled and parametrized through a user-friendly 7" color touch screen Display located on the front door of the cubicle.

2 All functions are available through a web-server (S-Web), including visualization of trends.





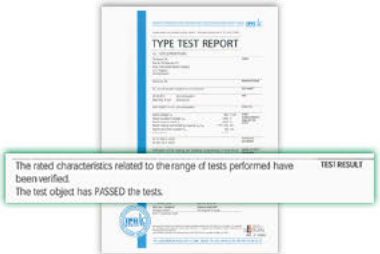
STANDARDS

According to standards IEC 61992-2:2006, EN 50123-2:2003 and IEC 60980 (Seismic tests).
Approved type test reports available.

Main features	MBS 500		MBS 800	
Rated voltage	900 VDC	1800 VDC	900 VDC	3600 VDC
Rated service current	6000 A	6000 A	8000 A	4000 A
Rated making & breaking capacity	125/177 kA	80/113 kA	134/190 kA	40/57 kA
Rated track time constant	100 ms	31.5 ms	100 ms	31.5 ms
Duty classes	f, e, d	f, e, d	f, e, d	f, e, d
Degree of protection	IP42	IP42	IP42	IP42

INTERNAL ARC TEST

Main features	MBS 500
Rated voltage	900 VDC
Rated insulation voltage	1800 V
Prospective current under arcing conditions	50/71 kA
Permissible arc duration	250 ms
Degree of protection	IP42



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Datasheet
TheBattery™ - Samsung Solution

Technical Specifications

Battery type	Multiple Samsung SDI batteries using Li-ion NMC chemistry
Power Conversion System	One or multiple Energy Storage Inverters (ESI) of max. 300 kVA each (under optimum grid and temperature conditions). Features: modularity, redundancy, high efficiency, wide range, minimal low-load losses; reduction by smart control switching off unused inverters
Energy Storage Inverter Efficiency	97,2% max.
Transformer	External transformer or optional internal LV/MV transformer
Required Connection	3P + N 230/400Vac, TN-C/TN-S; compliant with EN 50160:2010 */ MV option upon request
Connection Auxiliary Power	3P + N 63A 230/400Vac; compliant with EN 50160:2010 Optional: internal auxiliary power feed
Frequency	50 Hz; compliant with EN 50160:2010
Earthing	From grid connection Optional: connection of an external earthing pin
System Controller and Communication	Combination of a high-end industrial controller with the RTU developed by Alfen. Various communication channels possible: local HMI, Modbus TCP/IP and Alfen's TheBatteryConnect back office platform for remote monitoring and control. Platform offers flexible and open-standard interfacing to the customer's Energy Management System.
Operational Modes of System Controller	Peak shaving, Energy trading (P/Q Control), Micro-grid, Secondary Reserve, Frequency Response Service, Black start (depending on availability of auxiliary power). Combination of black start with internal auxiliary power feed is a custom made option.
Operating Temperature Range	-20°C to + 40°C Optional: temperature range extension (-40°C)
Climatization	Air-conditioned battery compartment, forced air-cooled inverter compartment
Standards	NEN3140, NEN3840, ISO9001, ISO14001, ISO 27001, Low Voltage Directive 2014/35/EU, EMC directive 2014/30/EU, Batteries directive 2006/66/EU, HD IEC 60364: 2005, NEN 1010: 2015, IEC 61439-2: 2011, EN-IEC 62477-1, EN 61000-6-2:2005, EN 61000-64:2007+A1:2011, IEC 62619: 2017, IEC 60947, IEC 61439, IEC 62271-100, IEC 62271-102, IEC 62271-103, IEC 62271-200. Road and sea transport ADR class 9, UN 3536, UN 3481 (Lithium-ion Batteries in equipment)

NOTE

Other system configurations upon request.
Subject to misprints, errors and technical modifications.
Values based on standard test conditions.
* Alignment with Alfen NV required.

Technical Specifications

Noise level	50-63 dB(A) at 10 meter (20°C ambient temperature), depending on positioning
Warranties	2 year product warranty Battery capacity performance guarantee up to 10 years (depending on load profile)
Operation & Maintenance	Various Service Level Agreements available (Bronze, Silver, Gold, Platinum)
Type of enclosure	Containerized integrated solution
IP-value of enclosure	IP54
Dimensions (l x w x h)	10ft: 2.99m x 2.44m x 2.59m 20ft: 6.06m x 2.44m x 2.89m 40ft: 12.19m x 2.44m x 2.89m
System weight	4,400 - 29,700kg
System battery capacity	137 - 2,055 kWh; larger systems are possible with Alfen's modular, integrated, multiple container solution

Example configurations

Type	Battery capacity (kWh)	Power kVa (20°C)	Power kVa (40°C)	Container type (ft)	System weight (kg)
TB-10-343	343	300	250	10	6,200
TB-20-617	617	300	250	20	10,200
TB-40-754	754	900	750	40	14,300
TB-40-1,028	1,028	1,500	1,250	40	17,900
TB-40-1,165	1,165	1,200	1,000	40	18,500
TB-40-1,233	1,233	1,200	1,000	40	19,100
TB-40-1,644 (with integrated MV transformer)	1,644	1,800	1,500	40	29,700
TB-40-2,055	2,055	2,400	2,000	40	28,700
TB-45-2,466	2,466	2,400	2,000	45	32,725

NOTE

Above is an indication of the different sized systems which are possible with Alfen's TheBattery. Being a fully modular system however, the sizing of any given system can be subject to change due to the specific requirements of the project in question.



Alfen B.V.

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trified track. This implies that a standstill charging station must use one of the standard railway electrification voltages, either AC 25 kV 50Hz, or AC 15 kV 16.7 Hz. Fortunately, these high voltages imply a low charging current. For example, a BEMU that charges its batteries at 1 MW power and 25 kV only requires a charging current of 40 A. This is important, because pantographs typically have a standstill current limit that is much lower than their current limit while moving. The current-limit at standstill can be improved somewhat by using overhead conductor rail instead of normal contact wire, but is less than 150A in any case. If the current is much higher than this, the graphite in the pantograph's current collector will start to burn [5]. Using the standard electrification voltages also has another advantage, in that they are highly standardized, and therefore electrical equipment is more readily available.

4 Description of the Physical Charging Station

The physical structure of the charging station is quite simple. It consists of a short length of overhead conductor rail, approximately 20 m to 200 m in length. This length depends on the type, length, and number of battery trains that will be charging at one time. The conductor rail is supported by normal trackside posts and high voltage insulators. Insulated cables lead from the power supply to the conductor rail, with the return path from the running rails. Furrer+Frey makes 25 kV and 15 kV overhead conductor rail systems that are ideal for this purpose (figure 3).



Figure 3:
Overhead Conductor Rail at Auckland Station (Photo: Furrer+Frey).

5 Description of the Power Supply to the Charging Station

The power supply for a standstill charging station is simplified compared to a power supply for a long stretch of track. It only needs to supply one small piece of overhead conductor rail, and usually only a single train at a time. This makes the power supply relatively simple to design since it is self-contained with a predictable load. One does not have to take into account moving trains several kilometers apart going in both directions.

However, a standstill station is often located far away from existing dedicated single phase rail power supplies, so power needs to come from the local three phase grid. This creates some challenges compared to a normal OHL power supply:

- Power to the train needs to be single phase AC, not three phase AC, so three phase needs to be changed to single phase.
- The frequency may need to be changed, i.e. from 50 Hz to 16.7 Hz in the case of AC 15 kV 16,7 Hz trains.
- There may only be a 10 kV to 20 kV medium voltage three phase connection at the charging station site
- The local grid may not have enough capacity to supply the bursts of power needed as trains arrive, charge, then leave.

Each of these challenges are examined in turn.

6 Power to the train needs to be single phase, not three phase

Trains can only consume single phase AC, because they only have a single contact at the pantograph. Creating single phase power from a three-phase supply is not difficult, one can simply connect a single phase transformer between two of the phases, and the result is a single phase output [6]. The problem is that if you pull a lot of power from the grid in this way the voltage and current flow will no longer be balanced among the phases. There are at least two ways to avoid this problem:

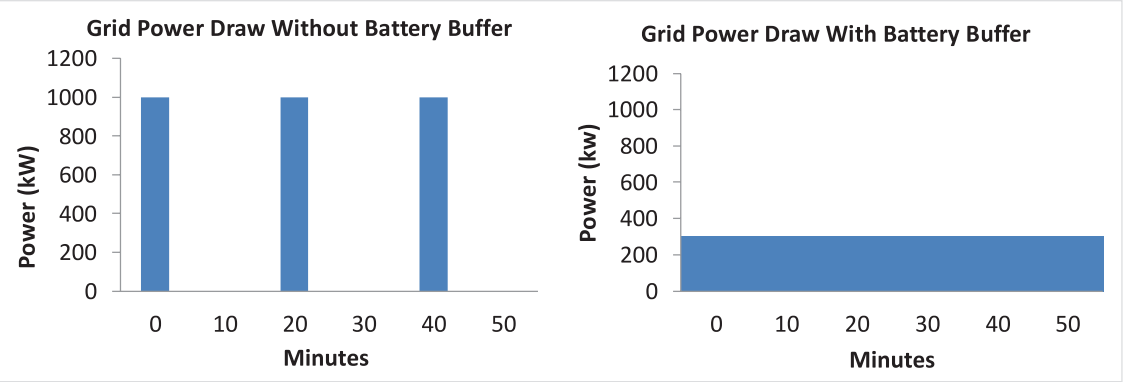


Figure 4:
Example of Peak Smoothing using a *Grid Storage Battery Buffer* (Graphics: Furrer+Frey).

- Use a *STATCOM* or *Static VAR Compensator* (SVC) load balancing system to balance the power between the phases [6]. The load balancer transfers active power between the phases to create a balanced load.
- Use a *Static Frequency Converter* (SFC) that converts three phase power to DC, then converts this DC power to single phase AC. This approach draws symmetrical power from the three-phase grid, with no load imbalance, and then supplies single phase power to the train at any frequency [7].

The frequency may need to be changed, i.e. from 50 Hz to 16.7 Hz.

In countries including Germany, Switzerland, Austria and Sweden, the standard frequency of the OLE voltage is 16.7 Hz instead of the grid 50 Hz. For maximum compatibility and greatest adherence to standards, converting to 16.7 Hz may be desirable. There is one modern way to change frequency:

- Use a Static Frequency Converter (SFC) that converts three phase power to DC, then converts this DC power to single phase AC at any frequency.

There may only be a 10 kV to 20 kV medium voltage 3-phase connection at the charging station site

Particularly in branch railway lines, the electric grid may only have *Medium Voltage* (MV) available. The amount of unbalanced power draw is not permitted in three phase grids beyond a certain maximum amount (typically 1% of the short circuit power). This is particularly difficult when the local grid is medium voltage with a low short circuit current [8]. Either an SVC or SFC can be used to draw balanced power from a MV line, eliminating this problem.

The local grid may not have enough capacity to supply the bursts of power needed as trains arrive, charge, then leave

The power demand from the local grid from battery trains can be very uneven. When the train arrives and starts charging, a high demand is suddenly requested from the grid. When the batteries are charged and/or the train departs, the demand suddenly stops. Depending on how many trains per hour need to be charged, these high demand peaks may be difficult to supply from the local grid without adding more capacity. Adding more capacity may require expensive upgrades to transmission lines and substations. To provide a "market signal" to forestall these upgrades, the grid operator often charges "peak demand" fees that make the cost of electricity much higher than if the electricity is drawn at a constant rate. The only way to avoid this is to use a *Static Frequency Converter* (SFC) with integrated grid storage battery that converts three phase power to DC, then converts this DC power to single phase AC. In this way, the maximum grid draw can be substantially reduced by 50–75%, depending on the frequency of the trains, and the large peaks in demand are leveled out (figure 4).

From the above three challenges, you can see that while a STATCOM/SVC load balancer can help to convert three phase to single phase, a more general solution is to use an SFC with optional battery to convert the three-phase power to DC, then convert it back to single phase AC. The SFC approach also has some additional benefits [8]:

- Reactive power control on the public grid side can be provided to the grid operator, improving the power quality on the grid.

Appendix B. Power Calculations

$$Power\ Required\ to\ charge\ 1\ No\ BEMU\ (8\ Car) = \ 632.8kWh$$

$$Real\ Power\ (P)\ Required\ to\ charge\ 1\ No\ BEMU\ (8\ car)\ in\ 12\ minues = \frac{632.8}{0.2} = 3.16MW$$

$$\therefore P \approx S = 3.16MVA$$

$$Real\ Power\ (P)\ Required\ to\ charge\ 3\ No\ BEMU\ (8\ car)\ in\ 12\ minues = \frac{(632.8\ \times 3)}{0.2} = 9.48MW$$

$$\therefore P \approx S = 9.48MVA$$

Appendix C. Resources used

https://new.abb.com/medium-voltage/apparatus/circuit-breakers/indoor-CB

https://www.secheron.com/products-solutions/tps/estra/hscb-panels/

https://www.secheron.com/products-solutions/tps/estra/

http://www.trojan-services.com/products/trotred/

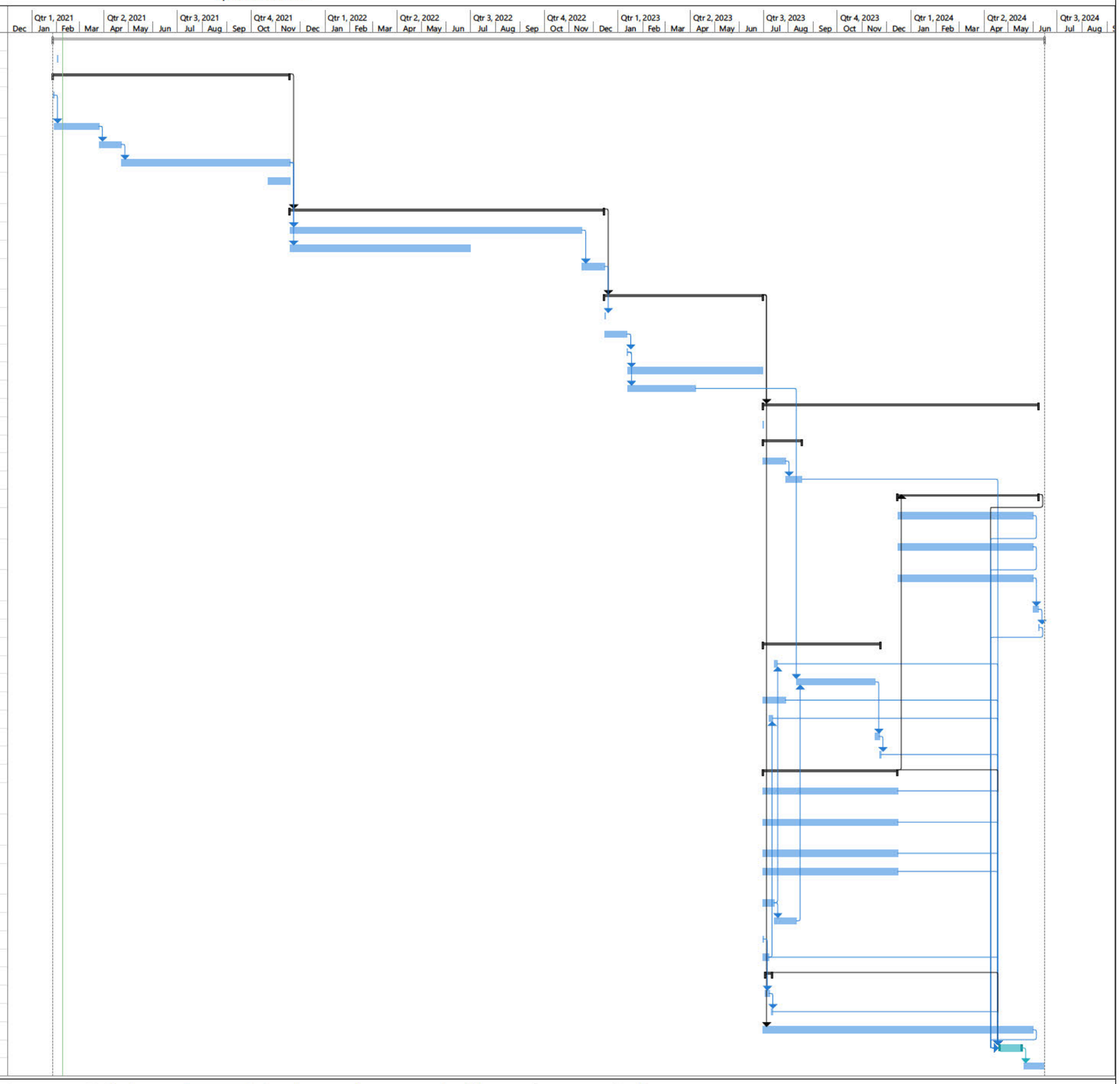
https://www.mobility.siemens.com/global/en/portfolio/rail/electrification/dc-tractionpower-supply.html

https://new.abb.com/news/detail/53409/abb-launches-dcgear-a-new-switchgear-rangefor-dc-traction-power-supply-applications

https://liveshareeu1.seismic.com/i/k7laNomGpvFkeqk4n8Vif76kMKSpLesuaPLUSSIGNoPsfXTgkPLUSSIGNrJR6ygK2oEW0W4lEvRc VoHJLhFZtfvnHw0 axvC2i3rHzE3Zy5I AR9i0NDhT705gag7jOGPLUSSIGN9BkK6kUZxwv9?enableIink=false

Option 2B Revision 5

ID	Task Name	Duration	Start	Finish
0	**Pre Construction Option 2B**	**883 days**	**Wed 27/01/21**	**Fri 14/06/24**
1	IE Board and NTA approval for MDC Award	1 day	Mon 01/02/21	Mon 01/02/21
2	**PMP 2**	**211 days**	**Wed 27/01/21**	**Wed 17/11/21**
3	Appoint MDC PMP Phase 2,3,4 prelim design, planning, Detail Design	1 day	Wed 27/01/21	Wed 27/01/21
4	Surveys	40 days	Thu 28/01/21	Wed 24/03/21
5	MDC Commencement Period Phase 2, 3 and 4	20 days	Thu 25/03/21	Wed 21/04/21
6	Preliminary Design	150 days	Thu 22/04/21	Wed 17/11/21
7	SMS 14 Process Cert E and D - Concept and Prelim design approval	20 days	Thu 21/10/21	Wed 17/11/21
8	**PMP 3**	**280 days**	**Thu 18/11/21**	**Wed 14/12/22**
9	BEMU Planning (Including RO)	260 days	Thu 18/11/21	Wed 16/11/22
10	BEMU Detail Design	160 days	Thu 18/11/21	Wed 29/06/22
11	SMS 14 Process Cert C - Approval of DD and permitt to construct	20 days	Thu 17/11/22	Wed 14/12/22
12	**PMP 4**	**141 days**	**Thu 15/12/22**	**Thu 29/06/23**
13	IE Board Approval to issue tender PMP 4b & PMP 5 and 6	1 day	Thu 15/12/22	Thu 15/12/22
14	NTA approval to issue tender	20 days	Thu 15/12/22	Wed 11/01/23
15	BEMU Construction Tender Issue	1 day	Thu 12/01/23	Thu 12/01/23
16	BEMU Construction Tender Period	120 days	Fri 13/01/23	Thu 29/06/23
17	Long lead items	60 days	Fri 13/01/23	Thu 06/04/23
18	**PMP 5 & 6**	**246 days**	**Fri 30/06/23**	**Fri 07/06/24**
19	IE Board & NTA approval to award contracts	1 day	Fri 30/06/23	Fri 30/06/23
20	**Track Schedule**	**35 days**	**Fri 30/06/23**	**Thu 17/08/23**
21	Cut out existing rail and install IRJ rail	20 days	Fri 30/06/23	Thu 27/07/23
22	Install S&C unit and asociated sluing	15 days	Fri 28/07/23	Thu 17/08/23
23	**OLE Schedule**	**126 days**	**Fri 15/12/23**	**Fri 07/06/24**
24	Install steelwork for structures on Depot road 4 (allowing for possessions)	120 days	Fri 15/12/23	Thu 30/05/24
25	Install steelwork for structures on Platform 2 (allowing for possessions)	120 days	Fri 15/12/23	Thu 30/05/24
26	Install steelwork for structures on Navan Line (allowing for possessions)	120 days	Fri 15/12/23	Thu 30/05/24
27	Run and tension wires	5 days	Fri 31/05/24	Thu 06/06/24
28	T&C	1 day	Fri 07/06/24	Fri 07/06/24
29	**E&P Schedule**	**105 days**	**Fri 30/06/23**	**Thu 23/11/23**
30	Earthing of substation	2 days	Fri 14/07/23	Mon 17/07/23
31	Fit out substation.	70 days	Fri 11/08/23	Thu 16/11/23
32	Installation of battery buffer	20 days	Fri 30/06/23	Thu 27/07/23
33	Run cables in new troughing	3 days	Fri 07/07/23	Tue 11/07/23
34	Interface with ESB.	3 days	Fri 17/11/23	Tue 21/11/23
35	T&C	2 days	Wed 22/11/23	Thu 23/11/23
36	**Civils Schedule**	**120 days**	**Fri 30/06/23**	**Thu 14/12/23**
37	Install pile foundations for depot road 4 (allowing for possessions)	120 days	Fri 30/06/23	Thu 14/12/23
38	Install foundations on Platform 2 (allowing for possessions)	120 days	Fri 30/06/23	Thu 14/12/23
39	Station Footbridge Lift (allowing for possessions)	120 days	Fri 30/06/23	Thu 14/12/23
40	Construct new platform and associated access (allowing for possessions)	120 days	Fri 30/06/23	Thu 14/12/23
41	Install foundations for new substation.	10 days	Fri 30/06/23	Thu 13/07/23
42	Construct new substation.	20 days	Fri 14/07/23	Thu 10/08/23
43	Install Signalling base	1 day	Fri 30/06/23	Fri 30/06/23
44	Construct associated cable trough route.	5 days	Fri 30/06/23	Thu 06/07/23
45	**Signalling Schedule**	**7 days**	**Mon 03/07/23**	**Tue 11/07/23**
46	Install Signalling equipment	5 days	Mon 03/07/23	Fri 07/07/23
47	T&C	2 days	Mon 10/07/23	Tue 11/07/23
48	Construction of new fan siding.	240 days	Fri 30/06/23	Thu 30/05/24
49	SMS 14 Process Cert T and B - Interim Operation	20 days	Fri 19/04/24	Fri 17/05/24
50	BEMU Commissioning	20 days	Mon 20/05/24	Fri 14/06/24



Project: Pre Construction Optio
Date: Mon 08/02/21

Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress

Risk Identification							Current Qualitative Risk Assessment								Risk Management											
Risk No (Identifier)	Risk Status	Risk Type	Scenario	Title	Risk Cause	Risk Event	Risk Effect	Likelihood Score (1 to 5)	Cost Impact Score (1 to 5)	Time Impact Score (1 to 5)	Quality Impact Score (1 to 5)	Reputation Impact Score (1 to 5)	H&S/E Impact Score (1 to 5)	Overall Risk Ranking	Risk Assessment Notes	Risk Response	Risk Owner	Risk Mitigation Action/s	Action Owner	Baseline Date for Close out of action	Target Date for Close out of action	Date Last Reviewed	Escalate Risk	Risk Trend	Risk Exposure Start Date	Risk Impact/ Expiry Date	Review Comments 21/10/2020
1	Open	Project	Scenario 1 (Current Timetable of 2tph and 3tph)	Operations	Desire to maximise BEMU train frequency on Drogheda Route	Little impact on route operations because relatively low BEMU train frequency on Drogheda Route	Minimal	1	0	0	0	0	1	1			Jacobs										
2			Scenario 1 (Current Timetable of 2tph and 3tph)	Stabling	Maynooth Depot Unavailable	We are mirroring the existing timetable so event should be manageable	minimal	3	2	2	1	2	2	6			Jacobs										
3			Scenario 1 (Current Timetable of 2tph and 3tph)	Infrastructure (Civil and E&P)	Placement of charging infrastructure around platforms.	Inadequate platform space	Increased disruption for railway assets	2	2	1	0	0	1	4			Jacobs										
4			Scenario 1 (Current Timetable of 2tph and 3tph)	Infrastructure (Civil and E&P)	Battery Power	Lack of ESB Grid Power. Charging is estimated at 3.16MVA single train charging at one time.	Inability to operate the Scenario service	3	3	3	1	1	3	9			Jacobs										
5			Scenario 1 (Current Timetable of 2tph and 3tph)	Infrastructure (Civil and E&P)	Battery Power	Trickle Charge needed overnight in Depot	Charging Stations needed in Depot	2	4	3	2	3	2	8			Jacobs										
6			Scenario 1 (Current Timetable of 2tph and 3tph)	Infrastructure (Civil and E&P)	Battery Power	Lack of available power from ESB Grid	Difficulty in providing the required electrical infrastructure to support all charging requirements in the area.	3	3	3	3	3	3	9			Jacobs										
			Scenario 1 (Current Timetable of 2tph and 3tph)	Infrastructure (Civil and E&P)	Battery Power	Platform 3 charging sec ion close to Diesel Fuel Road	Deemed unsafe to operate	3	4	3	3	3	4	12			Jacobs										
7			Scenario 1 (Current Timetable of 2tph and 3tph)	Land Planning	Unidentified land requirement	Land required	Railway Order	1	3	3	3	3	2	3			Jacobs										
8			Scenario 1 (Current Timetable of 2tph and 3tph)	Construction	Impact on Train Operations	Extended possessions	Operations Disruption	2	3	3	3	4	3	8			Jacobs										
9	Open	Strategic	Scenario 2 (TSS 1b - 5tph)	Operations	Desire to maximise BEMU train frequency on Drogheda Route	Inefficient operations with 2tph ECS	Following confirmation that main objective is to replace existing service level, latest operational paper reflects reduced concern in this area. Whilst this may s ill prove challenging, it is not considered the main priority.	4	3	2	2	2	1	12			Jacobs										
10	Open	Railway Order	Scenario 2 (TSS 1b - 5tph)	Stabling	Maynooth Depot Unavailable	Difficulty in accommodating enough vehicles at Drogheda for overnight stabling whilst supporting Scenario 2 services.	Poor operational robustness	5	4	4	3	4	2	20			Jacobs										
			Scenario 2 (TSS 1b - 5tph)	Stabling	DMUs con inue to need stabling at Drogheda Depo	No space for BEMU Stabling	Empty Coaching Stock Moves to remote locations	3	4	4	3	4	2	12			Jacobs										
11	Open	Project	Scenario 2 (TSS 1b - 5tph)	Infrastructure (Civil and E&P)	Placement of charging infrastructure around platforms.	Inadequate space	Increased disruption for railway assets	3	2	2	2	0	1	6			Jacobs										
12	Open	Main Works Contracts	Scenario 2 (TSS 1b - 5tph)	Infrastructure (Civil and E&P)	Battery Power	Power requirements for charging is estimated at 6 33 MVA for 2 trains charging at one time.	New traction substation required (Depot area). MIC needs to be confirmed with ESB.	4	4	3	2	0	2	16			Jacobs										
13	Open	Project	Scenario 2 (TSS 1b - 5tph)	Infrastructure (Civil and E&P)	Battery Power	Trickle Charge needed overnight in Depot	Charging Stations needed in Depot	3	3	3	4	4	3	12			Jacobs										
12	Open	Project	Scenario 2 (TSS 1b - 5tph)	Infrastructure (Civil and E&P)	Battery Power	Lack of available power from ESB Grid	Difficulty in providing the required electrical infrastructure to support all charging requirements in the area.	3	3	3	4	4	3	12			Jacobs										
			Scenario 2 (TSS 1b - 5tph)	Infrastructure (Civil and E&P)	Battery Power	Platform 3 charging sec ion close to Diesel Fuel Road	Deemed unsafe to operate	3	4	3	3	3	4	12			Jacobs										
13	Open	Strategic	Scenario 2 (TSS 1b - 5tph)	Land Planning	Platforms on Navan Line	Land required	Railway Order	3	3	4	4	3	3	12			Jacobs										
14	Open	Project	Scenario 2 (TSS 1b - 5tph)	Construction				1	1	1	1	1	1	1			Jacobs										
16	Open	Programme	Scenario 3 (TSS 3 - 6tph)	Operations	Desire to maximise train frequency on Drogheda Route	Difficulty in providing cost effective solution for 6tph service that does not impact operations in some way.	Following confirmation that main objective is to replace existing service level, latest operational paper reflects reduced concern in this area. Whilst this may s ill prove challenging, it is not considered the main priority.	3	4	3	4	3	1	12			Jacobs										
17	Open	Strategic	Scenario 3 (TSS 3 - 6tph)	Stabling	Desire to maximise train frequency on Drogheda Route	Difficulty in accommodating enough vehicles for overnight stabling whilst suppor ing full 6tph service.	Poor operational robustness	4	2	3	3	3	0	12			Jacobs										

Risk Identification								Current Qualitative Risk Assessment								Risk Management												
Risk No (Identifier)	Risk Status	Risk Type	Scenario	Title	Risk Cause	Risk Event	Risk Effect	Likelihood Score (1 to 5)	Cost Impact Score (1 to 5)	Time Impact Score (1 to 5)	Quality Impact Score (1 to 5)	Reputation Impact Score (1 to 5)	H&S/E Impact Score (1 to 5)	Overall Risk Ranking	Risk Assessment Notes	Risk Response	Risk Owner	Risk Mitigation Action/s	Action Owner	Baseline Date for Close out of action	Target Date for Close out of action	Date Last Reviewed	Escalate Risk	Risk Trend	Risk Exposure Start Date	Risk Impact/ Expiry Date	Review Comments 21/10/2020
18	Open	Project	Scenario 3 (TSS 3 - 6tph)	Infrastructure (Civil and E&P)	Placement of charging infrastructure around platforms.	Inadequate space	Increased disruption for railway assets	3	4	3	3	4	0	12			Jacobs											
19	Open	Project	Scenario 3 (TSS 3 - 6tph)		Battery Power	New traction substation required (Station Carpark area). Power required to charge three trains at any one time. MIC needs to be confirmed with ESB. Required MIC is 9.48 MVA for 3 trains charging at one time.	TQ-0002 issued to try and clarify/ rationalise power requirements. ESB contact is key to further progress. *Revised energy figures agreed as per TQ-0002 will help this somewhat. Also battery "buffer" charging being investigated.*	3	2	3	4	4	1	12			Jacobs											
20	Open	Project	Scenario 3 (TSS 3 - 6tph)		Battery Power	Trickle Charge needed overnight in Depot	Charging Stations needed in Depot	3	4	3	3	3	0	12			Jacobs											
21	Open	Railway Order	Scenario 3 (TSS 3 - 6tph)		Battery Power	Lack of available power from ESB Grid	Difficulty in providing the required electrical infrastructure to support all charging requirements in the area.	3	3	2	4	4	0	12			Jacobs											
22	Open	Project	Scenario 3 (TSS 3 - 6tph)	Land Planning	Platforms on Navan Line	Land required	Railway Order	3	3	3	3	4	0	12			Jacobs											

Jacobs

DESIGN HAZARD ELIMINATION AND RISK REDUCTION REGISTER

Latest Meeting Date	

Phase	
C	Construction
M	Maintain / Clean
U	Use as Workplace
D	Demolish

Project Name:	BEMU Infrastructure Study
Project Number:	D3422300-JAC-HSF-EMF-000001
Client:	Irish Rail

Update Critical Risk Table

Probability	Worst Potential Severity (WPS) of Impact	Risk Rating
1: Highly Unlikely 2: Unlikely 3: Possible 4: Likely 5: Highly Likely	1: Nil or slight injury / illness, property damage or environmental issue. 2: Minor injury / illness, property damage or environmental issue. 3: Moderate injury or illness, property damage or environmental issue. 4: Major injury or illness, property damage or environmental issue. 5: Fatal or long term disabling injury or illness. Significant property damage or environmental issue. 10. Multiple fatalities and catastrophic event	NOTE: The purpose of Risk Rating is to determine which risks are significant. It is a subjective assessment and not an absolute or precise determination



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Risk ID.	Formal Review Description	Phase	Activity	Potential Hazard	Person(s) Most at Risk	Prob	WPS	Initial Risk Rating	Discipline	Design Measures to Eliminate Hazards	Design Measures to Reduce Risk	Residual Prob	Residual WPS	Residual Risk Rating	Residual Risk Description	Included on Drawing No(s) or other doc. (give ref.)	Action By (Name or Role)	Target Date	Revised Target Date	Date Action Complete	Tracker Status	Comments	Primary Legislation
E&P01	5: Design Stage Review	M	Electrical Fault	Electric shock	Maintenance	3	4	12	Electrical	N/A	Electrical circuit protective devices to protect humans and livestock from getting an electrical shock.	3	4	12	Full calculations to be undertaken at the subsequent stage of the design. A competent contrator to install all electrical works						*OVERDUE*		
E&P02	5: Design Stage Review	U	Touch Potential	Electric shock	Public	3	4	12	Electrical	N/A	The traction return, Earthing and bonding system and protection to be designed to limit touch potentials	3	4	12	Soil resistivty testing and earthing & bonding strategy to be compiled at subsequent stage						*OVERDUE*		
E&P03	5: Design Stage Review	U	inadvertant disconnection of traction return. Defaulting to earth	DC Stray Currents	Maintenance	3	3	9	Electrical	N/A	Traction return to be designed such that the DC circuit is free of earth.	3	3	9	Traction return to be further developed at subsequent stage of design						*OVERDUE*		
E&P04	5: Design Stage Review	M	Unstable batteries in battery buffer releasing hydrogen	Explotion, fire	Maintenance	3	10	30	Electrical	N/A	Battery Buffer provided by manufacturer. Manufacturer needs to confirm that the product has the sufficiently safe and prove correct measures are in place.	3	10	30	Designer to ensure safety confirmations are in place						*OVERDUE*		
E&P05	5: Design Stage Review	U	EMC issues	EMI- noise in signalling and telecoms systems worse case it can affect pacemakers	Staff	2	4	8	Electrical	N/A	Approved equipment and manufacturers to be used to limit EMC.	2	4	8	Positive and negative cables to be routed in the same containment where possible. High voltage cable to be segrgated by 1m to other cables where possible. If armour or screening can't not be used metallic seperators to be utilised.						*OVERDUE*		
E&P06	5: Design Stage Review	U	Dewirement	Electric shock	Public	4	5	20	Electrical	N/A	Earthing and bonding and protection to be designed to ensure electrical disconnection in the event of a dewirement	4	5	20	OLE and electrical designer to examine at the subsequent design stage.						*OVERDUE*		
E&P07	5: Design Stage Review	U	HV fault	Electric Shock, power cut, black out in area	Maintenance	3	5	15	Electrical	N/A	Electrical circuit protective devices to protect humans and livestock from getting an electrical shock.	3	5	15	full calculations to be undertaken at the subsequent stage of the design. A competent contrator to install all electrical works						*OVERDUE*		
E&P08	5: Design Stage Review	U	Battery fault on train in a fuel tank area	Explosion fire	Staff	3	10	30	Non Jacobs Designer	N/A	Rolling Stock manufacturer. Manufacturer needs to confirm that the product has the sufficiently safe and prove correct measures are in place.	3	10	30	Designer to ensure safety confirmations are in place						*OVERDUE*		
E&P09	5: Design Stage Review	C	Building and equipment on top of under bridge	Collapse of bridge	Maintenance	4	5	20	Civil / Structural	N/A	If substation to be built atop of the underbridge, the civils and structural to investigate strengh at subsequent stage.	4	5	20	If substation to be built atop of the underbridge, the civils and structural to investigate strengh at subsequent stage.						*OVERDUE*		
E&P10	5: Design Stage Review	C	Burried serives	Electric shock due to cable strike	Demolition	4	4	16	Electrical	N/A	cable and buried records to be review, CAT scans to be undertaken to limit the likilhood of a cable stike	2	4	8	Hand diggs to be undertaken where there is higher risk of buried cables						*OVERDUE*		
E&P11	5: Design Stage Review	U	Power surge lightning strike	Damage to equipment, power cut	Maintenance	3	3	9	Electrical	N/A	Surge protection to be designed into the circuitry of the to limit damage to equipment	2	3	6	At subsequent stage designer to assess where it is beneficial to place lighting rods atop of the new substation building						*OVERDUE*		

Risk ID.	Formal Review Description	Phase	Activity	Potential Hazard	Person(s) Most at Risk	Prob	WPS	Initial Risk Rating	Discipline	Design Measures to Eliminate Hazards	Design Measures to Reduce Risk	Residual Prob	Residual WPS	Residual Risk Rating	Residual Risk Description	Included on Drawing No(s) or other doc. (give ref.)	Action By (Name or Role)	Target Date	Revised Target Date	Date Action Complete	Tracker Status	Comments	Primary Legislation
OLE 01	5: Design Stage Review	M	Touch Potential	Electric shock, due to OLE structures in proximity of fence and walking route	Staff	3	3	9	Electrical	NA	Suitable protection to be applied to mast to avoid touch potential or protective insulation to be provided on the fence.	2	2	4	Protective sheath will be installed on masts.To be determined at later stage.						*OVERDUE*		
OLE 02	5: Design Stage Review	U	Falling from height	Injury due to climing on OLE structures on platform area	Public	3	4	12	Electrical	NA	Anti climbing guards to be installed on all the structures.	2	2	4	Details to be determined at a later design stage.						*OVERDUE*		
OLE 03	5: Design Stage Review	M	Touch Potential to foot over bridge	OLE wire running in proximity of bridge	Public	4	2	8	Electrical	NA	Footbridge to be bonded to traction return to avoid any touch potential issues	2	1	2	Bridge bonding assessment to be carried out.						*OVERDUE*		

BIMU Infrastructure Study - Charging Station Option Selection Matrix — Rev 2 — Date: 20/10/2020

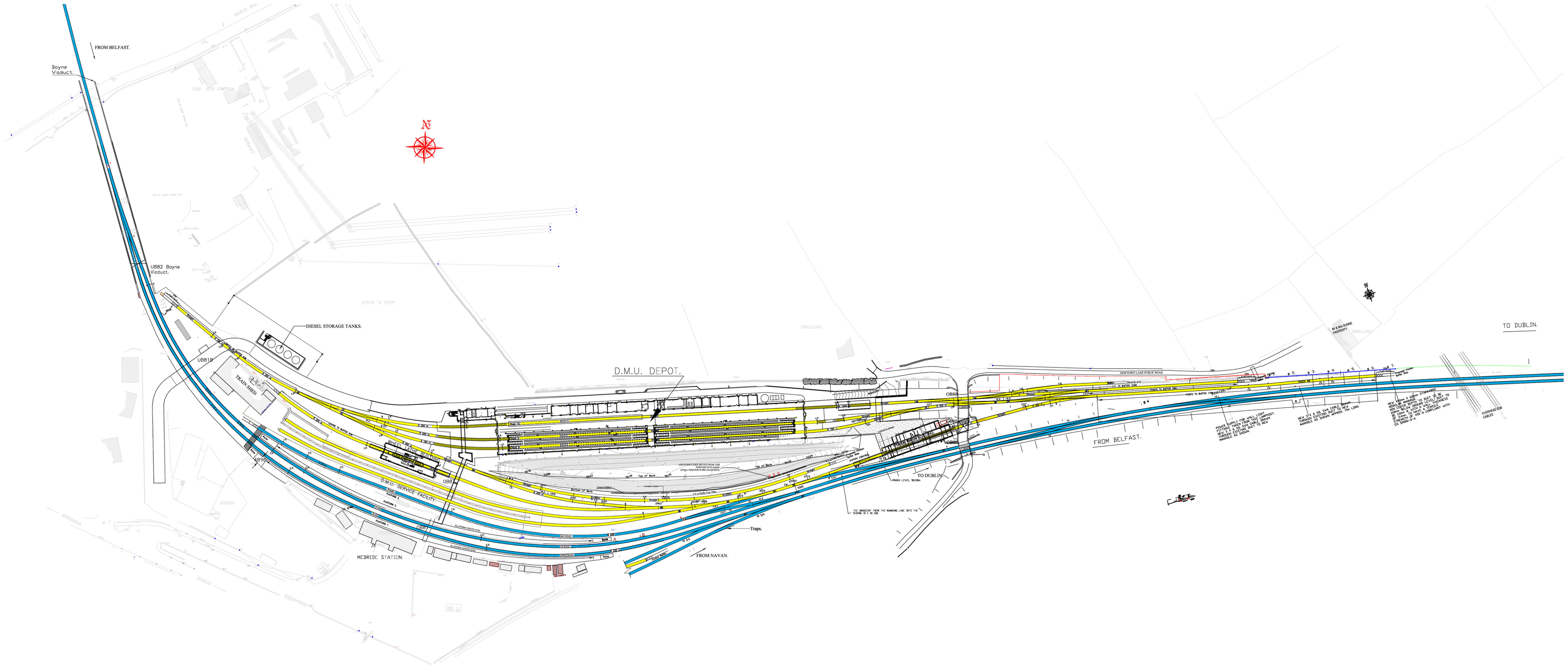
Jacobs

The colour coding indicated below has been used to assess the impact of the differing options on the study lines.

Low impact- Workable solution with no concerns
Medium impact- Some aspects need to be checked to ensure feasibility
High impact- Major concern that makes the option more difficult
Option discounted- No further progress was undertaken

				Operations																	
Scenario	Option No.	Requirement	Description	Timetable	Vehicle movements needed across main lines	Charging done on through lines	Contingency for late arrivals/ Performance	Stabling	Track	Signalling	CLI	Civils	E&P	Environmental	Planning/ Railway Order Implications	Property/Listed Structures	Cost	Assessment	Pass/Fail for carry over to CAF evaluation
2/5 BIMU DART's per hour	1a	2/5 BIMU DART's per hour in line with the current timetable	Charging station only on Platform 1 and connection of depot road 4 to a charging station for depot functionality.	2/5 DART per hour timetable can be accommodated in this option. Current timetable can use platform 1 for charging.	None - charging done at platform	No	Yes - 1 platform can accommodate 2 x 4 car vehicles. Performance should not adversely affect operations for 2/5 tph but offers little contingency using one platform.	Operational analysis indicates potential uplift from existing 5E vehicles to 6E for Shelbourne BIMU services. It is assumed these extra vehicles could be accommodated either in Drogheda station or on the Kevan Line branch without need for further stabling in the depot.	No impact - should any CLI infrastructure be placed in the R & J nos of the existing line a gauging assessment will be required to ensure clearances are met.	Minimal impact- signal sighting may require a review.	1. Electrify Platform 1 and depot road 4 with overhead contact system for charging. 2. Installation of CLI masts on platform 1 for identifying depot road 4 (exit to back structure would be utilised in this/other) 3. Supports for wire depending on curve and can be 10m span [Note for consultee team the support structures are required at 10-12m centres.]	Minimal impact to install charging points.	New traction substation required (Depot area). Power required to charge one train at anytime (Platform 1 OR Depot Road 4). MIC needs to be confirmed with ESB. Required MIC is 5.45MVA single train charging at one time.	Minimal impact to install charging points.	No Railway Order required. Standard planning application for works on IE lands only.	Minimal Impact		Simplest and cheapest option if maximum frequency required is no more than 2/5 tph.	Pass
2/5 BIMU DART's per hour	1c	2/5 BIMU DART's per hour in line with the current timetable	Charging points on Platforms 1 and 5 and connection of depot road 5 to a charging point for depot functionality. [Only 1 charging point to be operational at a time]	This option accommodates the 2/5 DART per hour timetable with the second charging platform offering operational flexibility.	None - charging done at platform	Yes - Platform 2 - blocked for part of the time depending on turnaround times.	2 platforms allow for operational contingency and flexibility. Performance should not adversely affect operations for 2/5 tph but offers greater contingency and flexibility using two service platforms.	Operational analysis indicates potential uplift from existing 5E vehicles to 6E for Shelbourne BIMU services. It is assumed these extra vehicles could be accommodated either in Drogheda station or on the Kevan Line branch without need for further stabling in the depot.	No impact - should any CLI infrastructure be placed in the R & J nos of the existing line a gauging assessment will be required to ensure clearances are met.	Minimal impact- signal sighting may require a review.	1. Electrify Platform 5. Platform 2 and depot road 4 with overhead contact system for charging. 2. Installation of CLI masts on platforms 5 and 2 for identifying depot road 4 (exit to back structure would be utilised in this/other) 3. Supports for wire depending on curve and can be 10m span [Note for consultee team the support structures are required at 10-12m centres.]	Minimal impact to install charging points.	New traction substation required (Depot area). Power required to charge one train at anytime (Platform 5 OR 2 OR Depot Road 4). MIC needs to be confirmed with ESB. Required MIC is 5.45MVA for a single train charging at one time.	Minimal - small environmental impact as works required on two platforms	No Railway Order required. Standard planning application for works on IE lands only.	Works on 2No. platforms - Increase the potential to impact upon setting of Protected Structures		This option combines Option 1a with an additional charging station on platform 2 to offer increased charging facilities. There is additional cost for the additional charging station on Platform 2 which in turn will give additional operational flexibility	Pass
2/5 BIMU DART's per hour	4	2/5 BIMU DART's per hour in line with the current timetable	Charging points on Kevan Line with train movements from existing platforms 1, 2, and 5 with the connection of depot road 4 to a charging point for depot functionality.	Assumes trains shunt from platforms to depot and back requires longer turnaround times, thereby shunt impacts on overall train capacity at Drogheda, lack of contingency for late running. So timetable would be wholly unfeasible.	Yes - two moves for two trains each to be done in 2 mins. Blocking both main lines every 5 mins	No	Time consuming double shunt over during periods of late running. Performance will affect operations	Operational analysis indicates potential uplift from existing 5E vehicles to 6E for Shelbourne BIMU services. It is assumed these extra vehicles could be accommodated either in Drogheda station or on the Kevan Line branch without need for further stabling in the depot.	No impact	New signals and associated equipment to be designed.	1. Electrify one with overhead contact system for charging. 2. Installation of CLI structures as will be co-ordinated with other disciplines to have enough space. 3. Supports for wire depending on curve and can be 10m span [Note for consultee team the support structures are required at 10-12m centres.]	Minimal impact to install charging points.	New traction substation required (Station Carpark area). MIC needs to be confirmed with ESB. Required MIC is 5.45MVA single train charging at one time. Charging also available to depot road 4 when not used for train in service.	Minimal - small environmental impact as works required on Kevan line.	No Railway Order required. Standard planning application for works on IE lands only.	Minimal Impact		Not whose operationally	Fail
5	2/5 BIMU DART's per hour in line with the current timetable	Use of charging in depot for services during the day	Assumes trains shunt from platforms to depot and back requires longer turnaround times, thereby shunt impacts on overall train capacity at Drogheda, lack of contingency for late running. So timetable would be wholly unfeasible.	Yes - two moves for two trains each to be done in 2 mins. Blocking both main lines every 5 mins	No	Time consuming double shunt over during periods of late running. Performance will affect operations	Operational analysis indicates potential uplift from existing 5E vehicles to 6E for the like BIMU services. It is assumed these extra vehicles could be accommodated either in Drogheda station or on the Kevan Line branch without need for further stabling in the depot.	No impact	Minimal impact- signal sighting may require a review.	1. Electrify one with overhead contact system for charging. 2. Installation of CLI structures as will be co-ordinated with other disciplines to have enough space. 3. Supports for wire depending on curve and can be 10m span [Note for consultee team the support structures are required at 10-12m centres.]	Minimal impact to install charging points.	New traction substation required (Depot area). MIC needs to be confirmed with ESB. Required MIC is 5.45MVA single train charging at one time.	Minimal - small environmental impact as works required on depot	No Railway Order required. Standard planning application for works on IE lands only.	Minimal Impact		Not whose operationally but also depot capacity and flexibility would be lost	Fail
6	2/5 BIMU DART's per hour in line with the current timetable	New sidings either on Dublin or Dundalk side of station and connection of depot road 6 to a charging point for depot functionality.	High on trains have no contingency for late arrival and train will block main lines as they are moved	Yes - moves for two trains each to be done in 2 mins. Blocking both main lines every 5 mins	No	No. Performance may adversely affect operations								Minimal - small environmental impact as works required at only on one end		Minimal Impact		as whose operationally but also since the sidings would likely be further away than Kevan line the main line would be blocked for longer with train movements than for the case of movements on the Kevan line	Fail
8	2/5 BIMU DART's per hour in line with the current timetable	Charging line section at Newton Bridge area and connection of depot road 4 to a charging point for depot functionality.	Potential for operations impact particularly if trains have to shunt during increased times. Unlikely to deliver a reliable timetable	None - Charging done at Newton Bridge area	No	Time consuming double shunt over during periods of late running. Performance may adversely affect operations. Also a concern with the length of space available	Operational analysis indicates potential uplift from existing 5E vehicles to 6E for the like BIMU services. It is assumed these extra vehicles could be accommodated either in Drogheda station or on the Kevan Line branch without need for further stabling in the depot.	Insufficient space on property's we charging line. If a turnout is predicted beyond the existing bridge following the main down tracks onto approx. only approx. 110-120m available between the proposed CLI and the position of a required buffer stop.	New signals and associated equipment to be designed.	Concerns for CLI gradient changes and constraints with clearances to the proximity of a bridge.	Minimal impact to install charging points.	New traction substation required. MIC needs to be confirmed with ESB. Required MIC is 5.45MVA single train charging at one time.	Minimal Impact	No Railway Order required. Standard planning application for works on IE lands only.	Minimal Impact - the required land does not appear to be to use		There is a possibility for operational impact- a residence not associated. main concern there is not enough space available in the Newton bridge area for the proposed track	Fail
TSS Scenario 1b	1b	TSS Scenario 1b (2 tph - 2 empty runners to/from Leyland)	Charging points on Platforms 1 and 5 and connection of depot road 4 to a charging point for depot functionality and to serve empty runners. [Charging for up to 3 trains simultaneously possible.]	This option accommodates TSS 1b. (The 2/5 DART per hour timetable can also be accommodated in this option with second platform offering operational flexibility.)	None - charging done at platform	Yes - Platform 2 - blocked for part of the time depending on turnaround times.	2 platforms allow for operational contingency and flexibility. Performance should not adversely affect operations for 2/5 tph but offers greater contingency and flexibility using two service platforms.	For increased service levels beyond the base level operational levels can be used to avoid the need for additional stabling in Drogheda depot. (e.g. service ramp up gradually earlier trains are run north to Drogheda and if necessary empty running from Inispruach depot is also possible)	No impact - should any CLI infrastructure be placed in the R & J nos of the existing line a gauging assessment will be required to ensure clearances are met.	Minimal impact- signal sighting may require a review.	1. Electrify Platform 5. Platform 2 and depot road 4 with overhead contact system for charging. 2. Installation of CLI masts on platforms 5 and 2 for identifying depot road 4 (exit to back structure would be utilised in this/other) 3. Supports for wire depending on curve and can be 10m span [Note for consultee team the support structures are required at 10-12m centres.]	Minimal impact to install charging points.	New traction substation required (Depot area). Power required to charge one train at three in semi-rural trains at any one time on Platforms 1 and 5 and potentially Depot Road 4). MIC needs to be confirmed with ESB. Required MIC is 8.55MVA for 3 trains charging at one time.	Minimal - small environmental impact as works required on two platforms	No Railway Order required. Standard planning application for works on IE lands only.	Works on 2No. platforms - Increase the potential to impact upon setting of Protected Structures		Simplest and cheapest option to fulfil TSS 1b title options combines Option 1a to offer increased charging facilities while potentially utilising some of the same proposed DoT infrastructure already in place for Option 1a. Depot functionality may be somewhat restricted during times when empty running is required.	Pass
	4a	TSS Scenario 1b (2 tph - 2 empty runners to/from Leyland)	Charging points on Platforms 1 and 2 and an existing Road Invert Box (but with no platform as used for empty runners only) with the connection of depot road 4 to a charging point for depot functionality.	TSS 1b can be accommodated in this option however need to have use of Kevan line as previously mentioned. Operational disadvantage to this option.	Yes - two moves for two trains each to be done in 2 mins. Blocking both main lines every 5 mins	Yes - Platform 2 - blocked for part of the time depending on turnaround times.	Through charging points to have contingency for needs to cross main lines which could the opt service.	For increased service levels beyond the base level operational levels can be used to avoid the need for additional stabling in Drogheda depot. (e.g. service ramp up gradually earlier trains are run north to Drogheda and if necessary empty running from Inispruach depot is also possible)	No impact	New signals and associated equipment to be designed.	1. Electrify whole Platform through standard Catenary/catenary wire or conductor beam. 2. For new platform installation of CLI structures as platform will be coordinated with other disciplines to have enough space. 3. Supports for wire depending on curve and can be 10m span while for conductor beam the support structures are required at 10-12m centres.	Minimal impact to install charging points.	New traction substation required (Station carpark area). Power required to charge at least two (and possibly three) trains at any one time. MIC needs to be confirmed with ESB. Charging also available to depot road 4 when not used for train in service.	Minimal - small environmental impact as works required on Kevan line	No Railway Order required. Standard planning application for works on IE lands only.	Minimal Impact		Not whose operationally due to losing entire main service line to go into service. Also still need depot road charging as shuttle up no infrastructure compared to Option 2b.	Fail
TSS Scenario 3	2a	TSS Scenario 3 (6 tph)	Charging stations on Platform 1 and 2 and connection of depot road 4 to a charging station for depot functionality. PLUS New platform and charging points on Kevan line and the connection of depot road 4 to a charging point for depot functionality as described in Option 1a.	TSS timetable can be accommodated. Clarification of future use of Kevan line required (lightly used at present)	Yes - departing trains would cross the main Dublin line. Trains departing the new platform would be timed not to conflict with trains arriving in platforms 1,2 & 5	No	Allows for up to 6tph to be accommodated. longer turnaround times and platform flexibility- allows main trains to/from Dublin Dundalk & Belfast to use platforms 1 and 2 which would remain clear. Performance should not adversely affect operations	For increased service levels beyond the base level operational levels can be used to avoid the need for additional stabling in Drogheda depot. (e.g. service ramp up gradually earlier trains are run north to Drogheda and if necessary empty running from Inispruach depot is also possible)	It is recommended that the existing trapping protection found in the existing UP between the two lines there is removed for all sub options in this Option). This is an unusual layout and relaying the traps will likely result in having to provide a platform which is wide in the road which may present stepping distance issues / non compliances.	New signals and associated equipment to be designed for the new platform.	1. Electrify whole Platform with overhead contact system for charging. 2. For new platform installation of CLI structures as platform will be coordinated with other disciplines to have enough space. 3. Supports for wire depending on curve and can be 10m span [Note for consultee team the support structures are required at 10-12m centres.]	To provide an 8 car length platform on the existing Fitting layout the platform will have to cross the existing Dublin bound crossing road in the north. The end of the platform would be beyond the west side of the bridges (and therefore whole) due to required. Thereof part would also require to be realigned to suite space for the new platform and associated cross points. Although it is likely this could be achieved with minimal loss of space.	New traction substation required (Station carpark area). Power required to charge three trains at any one time. MIC needs to be confirmed with ESB. Required MIC is 8.55MVA for 3 trains charging at one time. Charging also available to depot road 4 when not used for train in service.	Potential environmental impact as works required for new platform and charging points and new bridge all across. Potential impacts upon properties in the immediate south and to the west of the Dublin bound crossing road and to the east of the Dublin bound crossing road in terms of noise and impact on listed structures.	Railway Order maybe required should civils works be carried out on or in the vicinity of the Dublin Road overbridge. Standard planning application for works on IE lands only.		Viable operational option for 6 tph but involves considerable additional expense and increased environmental impact compared to other options.	Pass
	2b	TSS Scenario 3 (6 tph)	Charging stations on Platform 1 and 2 and connection of depot road 4 to a charging station for depot functionality. PLUS New platform and charging points on Kevan line and the connection of depot road 4 to a charging point for depot functionality as described in Option 1a.	TSS timetable can be accommodated. Clarification of future use of Kevan line required (lightly used at present)	Yes - departing trains would cross the main Dublin line. Trains departing the new platform would be timed not to conflict with trains arriving in platforms 1,2 & 5	No	Allows for up to 6tph to be accommodated. longer turnaround times and platform flexibility- allows main trains to/from Dublin Dundalk & Belfast to use platforms 1 and 2 which would remain clear. Performance should not adversely affect operations	For increased service levels beyond the base level operational levels can be used to avoid the need for additional stabling in Drogheda depot. (e.g. service ramp up gradually earlier trains are run north to Drogheda and if necessary empty running from Inispruach depot is also possible)	The existing twin track alignment at this location will be reduced to a single track alignment in order to place the proposed platform in the rail corridor with the removal of one of the tracks and the associated junction S&C (and trap). In order to tie back in to the existing twin track alignment (which we believe forms a passing loop for freight vehicles) a new turnout will be required.	New signals and associated equipment to be designed for the new platform.	1. Electrify whole Platform with overhead contact system for charging. 2. For new platform installation of CLI structures as platform will be coordinated with other disciplines to have enough space. 3. Supports for wire depending on curve and can be 10m span [Note for consultee team the support structures are required at 10-12m centres.]	If the Kevan line can be reduced to single track as a car length platform can comfortably be provided in the correct number of the second track (including utilising the existing bridge deck on the Dublin Road bridge). This option will have relatively little expense on compilation for Civils.	New traction substation required (Station carpark area). Power required to charge three trains at any one time. MIC needs to be confirmed with ESB. Required MIC is 8.55MVA for 3 trains charging at one time. Charging also available to depot road 4 when not used for train in service.	Potential environmental impact as works required for new platform and charging points. Potential impacts upon properties in the immediate south.	Standard planning application for works on IE lands only.	Potential impacts upon the setting of the Protected Structures within the Rail Station would need to be assessed.	Viable operational option for 6 tph but involves considerable additional impact compared to other options. May need min possible future plans for the line though change could be removed easily)	Pass
	3	TSS Scenario 3 (6 tph)	Charging stations on Platform 5 and 2. PLUS Converting the existing depot line 4 to mainline operations with a platform now existing depot line 5.	TSS timetable can be accommodated. Additional platform advantageous in allowing trains to/from/control away from through main lines platforms 1 and 2	Yes - arrivals from Dublin cross the Up line arrivals would be timed not to conflict with departures from platforms 1, 2 & 5	No	This option can facilitate 6tph trains to/from/control away from the main line. Performance may adversely affect operations within the depot.	As this option opts into available depot space to relocate rail roads, further stabling lens/common length, preferentially and likely to need, over-run assets to accommodate.	The existing depot road control to the station will be connected to existing operations. The adjacent depot road will be removed and a new platform installed in its stead. New S&C is proposed which segregates the newly connected track from the remaining depot tracks through a connect with the Platform 5 road. Relocating of fuel road to elsewhere within depot likely to be very difficult.	Existing depot signalling infrastructure to be assessed for compatibility upgrade to main line infrastructure.	1. Electrify whole Platform with overhead contact system for charging. 2. For new platform installation of CLI structures as platform will be coordinated with other disciplines to have enough space. 3. Supports for wire depending on curve and can be 10m span [Note for consultee team the support structures are required at 10-12m centres.]	A new platform will be provided utilising the depot fuelling road nearest the station. The other fuelling road will be left in situ as the existing shunt neck or mainline platform construction (road, structure or T&T) will be erected over this track (but in the existing line). This will allow the depot to revert to produce any relatively short 2-3 hours if required. A connecting lift and stairs to the existing bridge deck will then be accommodated close anywhere access to this platform.	New traction substation required. Power required to charge up to three trains at any one time. MIC needs to be confirmed with ESB. Required MIC is 5.45MVA for 1 train charging at one time. Charging also available to depot road 4 when not used for train in service.	Potential for disruption to contaminated waste/materials needs to be taken into consideration for relocation of fuelling route.	No Railway Order required. Standard planning application for works on IE lands only.	Minimal Impact		This option would incorporate a platform between the up two depot roads or over the current depot road No.5 to offer passenger facilities. However the relocation of the refuelling roads 4 and 5 would have to be considered to maintain depot operations. It would appear to be very difficult to identify a suitable location within the depot to do this.	Pass

	7	TS3 Scenario 1: [if tpht] [Actually applies to all 5 scenarios]	Potential charging at other stops, [Flash charging] and connection of depot road-E to a charging point for depot functionality.	Minimal operational impact	None - charging done at platform	No	Yes. Performance should not adversely affect operations							Moderate environmental impact on particularly/all or numerous locations		Moderate - High possibility of taking land at each station	High impact due to requirement of multiple charging stations		Fail
	8	TS3 Scenario 1: [if tpht] [Actually applies to all 5 scenarios]	Section of standard OLE under w3m operation as approach to station and connection of depot road-E to a charging point for depot functionality.	Minimal operational impact - timetables for 3/5 DART per hour and TS3/4/TS03 can be delivered	None - charging done approaching station	Yes - approaching station	Yes - and minimum turnaround times can be less than 12 minutes. Performance should not adversely affect operations	For increased service levels beyond the base level operational tools can be used to avoid the need for additional stabling in Drogheda depot. (e.g. service ramps, gradually earlier trains are run north to Drogheda and if necessary empty running from Connolly depot is also possible)	No impact	Minimal impact signal sighting may require a review	Impact on install and design since 12km of OLE along the length of the proposed route in both directions. The distance has been worked out as follows: The turnout on the leaving roadroad line is allowed to be 1:500 if for 40 n then dropping to 1:200 if continuous. To obtain a quick answer, let us assume that the new centre which could be near Naul, or conclusively (which may make it more standard). The grade is taken at 1:500, i.e. OLE + x = 1:200. The power class of a 50kV OLE is likely to be normal. (2 MW) (less than normal operation does from rail because of the proximity of the battery). That makes 2 x OLE of 2 have a power demand of 4.4 MW. The MW is most likely to equal the capacity of fast time to recover at 4 minutes this project. If you need fast value at a rapids and one stable is, notes. Use means that there is 4.2 MW - 2.8 MW = 2.1 MW available for charging. The 11 mega movement implies 840 (440) needs to be stored. It is 40MJ OLE at Drogheda. Fast charge time is 30/1500 / 2 (0.02 MW x 0.5 h = 1.0 mins) x 2 mins in each direction. Looking at Daly motion times means that the rates aren't here to run them around, but rate is off (conservative which is around 1.5m). Final assumption, work done can then be small.	Impact on design and install OLE the rotations along the rotation well as additional substations along the line	Would require at least one additional traction substation (on top of the one in Drogheda) additional MVA required to be fed by separate 2-3 supply. Benefit being that the Substation() would be strategically placed in sub future electrification. MIC needs to be confirmed with DIL. Traction modelling required.	Moderate impact due to works occurring over a much bigger area than for other options.	Safety Order maybe required due to works related to construction and maintenance across works. Standard planning application for works on E lands only.	Probably low impact but stands of isolated/un locations etc. required to confirm.	[redacted]	Main concerns - length of OLE which would be required, limited losses of capability of batteries being charged as train is still running on approach to station. requires increase in capability over existing DART system. High cost associated to install OLE infrastructure, environmental impact additional land required for traction substations (and motion rest) impact operation should not be affected and significant cost for installation. Although there are significant disadvantages across other options in terms of cost and environmental impact because this option is much further reaching it would form the first leg of future electrification and in that sense would not a standalone cost. For that reason this is still considered a valid option.	Pass


FROM BELFAST.
Boyne Viaduct.
UB82 Boyne Viaduct.
DIESEL STORAGE TANKS.
UB81R
TRAIN SHED
D.M.U. DEPOT.
WHEEL LATHE BUILDING
D.M.U. SERVICE FACILITY.
OB81
OB82
MCBRIDE STATION.
Traps.
FROM NAVAN.
TO DUBLIN.
FROM BELFAST.
TO DUBLIN.
NEWTOWN LANE PUBLIC ROAD
M & Mrs DUNNE PROPERTY.
DWELLING
POINTS TO BUTLER STN
POINTS TO BUTLER STN
TRACK 1
TRACK 2
TRACK 3
TRACK 4
TRACK 5
TRACK 6
TRACK 7
TRACK 8
TRACK 9
TRACK 10
TRACK 11
TRACK 12
TRACK 13
TRACK 14
TRACK 15
TRACK 16
TRACK 17
TRACK 18
TRACK 19
TRACK 20
TRACK

Jacobs

BEMU Infrastructure Study - CAF Option Selection Matrix Rev 1 Date: 23/10/2020

Notes:
The below CAF criteria has been colour coded against the individual option driven from the project requirements to incorporate infrastructure in order to charge new BEMU rolling stock.
The operational aspect is not included within the CAF matrix below as only options that are considered operationally and technically feasible have been carried forward from the initial sift.
The criteria for MCA from the "COMMON APPRAISAL FRAMEWORK FOR TRANSPORT PROJECTS AND PROGRAMMES" is included below for reference.

The colour coding indicates the following:
Low Impact: Workable solution with no concerns
Medium Impact: Some aspects need to be checked to ensure feasibility
High Impact: Major concern that makes the option more difficult
N/A Criteria not applicable for that given option.

Scenario	Requirement	Option No.	Scenario	Description	Economy	Safety	Integration	Environment	Accessibility and Social Inclusion	Physical Activity (where applicable)	Assessment	Preferred Option
2/3 BEMU DARTs per hour	2/3 BEMU DARTs per hour in line with the current timetable	1a	2/3 BEMU DARTs per hour in line with the current timetable	**Charging station only on Platform 3 and conversion of depot road 4 to a charging station for depot functionality.**	Small cost - installation on one platform and depot road and a traction substation	New OLE infrastructure to be designed, constructed and maintained to IE standards.	N/A	The project by defenition will reduce the environmental impact which occurs whilst operating diesel trains. This option has minimal environmental impact during operation and construction.	New installations will be immediately adjoining existing station providing equivalent accessibility.	N/A	This option fulfils the Base 2/3 tph scenario with some operational redundancy offered by Depot 4 charging capability as back up. It has the least cost and smallest environmental impact.	Yes
	2/3 BEMU DARTs per hour in line with the current timetable	1c	2/3 BEMU DARTs per hour in line with the current timetable	**Charging points on Platforms 2 and 3 and conversion of depot road 4 to a charging point for depot functionality. [Charging available for 1 train at a time].**	Small to moderate cost - installation on two platforms, depot road and a traction substation	New OLE infrastructure to be designed, constructed and maintained to IE standards.	N/A	The project by defenition will reduce the environmental impact which occurs whilst operating diesel trains. This option has minimal environmental impact during operation and construction.	New installations will be immediately adjoining existing station providing equivalent accessibility.	N/A	This option fulfils the Base 2/3 tph scenario with additional operational redundancy offered by Platform 2 charging capability as back up. It has the some additional cost and environmental impact compared to Option 1a.	No (however this option could be considered instead of Option 1a if the additional operational flexibilty was consdided to outweigh the additional cost)
TSS Scenario 1b	TSS Scenario 1b (3 tph + 2 empty runners to/from Laytown)	1b	TSS Scenario 1b (3 tph + 2 empty runners to/from Laytown)	**Charging points on Platforms 2 and 3 and conversion of depot road 4 to a charging point for depot functionality and to serve empty runners. [Charging available for 3 trains at a time].**	Moderate cost - installation on two platforms depot road and a traction substation with charging capability for 3 trains at a time.	New OLE infrastructure to be designed, constructed and maintained to IE standards.	N/A	The project by defenition will reduce the environmental impact which occurs whilst operating diesel trains. This option has minimal environmental impact during operation and construction.	New installations will be immediately adjoining existing station providing equivalent accessibility.	N/A	This option fulfils the TSS 1b scenario (3tph +2 empty runners) utilising Depot 4 charging capability for both depot and in service functionality. There is some redundancy available with 3 charging statons and likely only needing 2 at a time. It has the least cost and smallest environmental impact for this scenario. If additional operational redundancy is required Option 2 (a or b - Navan branch line charging) would be required.	Yes
TSS Scenario 3	TSS Scenario 3 (6 tph)	2a	TSS Scenario 3 (6 tph)	**Charging stations on Platform 3 and 2 and conversion of depot road 4 to a charging station for depot functionality. PLUS New platform and charging station on Navan line branch and the conversion of depot road 4 to a charging point for depot functionality.**	High Cost - New Platform, new bridge, additional land purchase, additional work in car park, construction disruption costs, signalling infrastructure, charging points and traction substation.	New infrastructure to be designed, constructed and maintained to IE standards. CCTV, fencing and lighting to be installed on new platform infrastructure.	N/A	The project by defenition will reduce the environmental impact which occurs whilst operating diesel trains. However in this case there is increased potential environmental impact as works required for new platform and charging points and new bridge structure. Potential impacts upon properties to the immediate south and to the west of the Dublin road (including access issues and impact on listed structure)	Although a new platform would be built to the latest accessibility standards, the Navan Line branch is more remote from the main station making access a little more onerous.	N/A	This option fulfils the TSS 3 (6tph) scenario with additional operational redundancy offered by Depot Road 4 charging capability as back up. However it has significant additional cost and environmental impact compared to Option 2b.	No (however this option could be considered instead of Option 2b if the additional operational flexibilty was consdided to outweigh the additional cost)
	TSS Scenario 3 (6 tph)	2b	TSS Scenario 3 (6 tph)	**Charging stations on Platform 3 and 2 and conversion of depot road 4 to a charging station for depot functionality. PLUS New platform and charging station on Navan line branch. In this case platform to be located on top of existing track (north side) thus single tracking section through here.**	Moderate Cost - New Platform, relatively minor track changes, signalling infrastructure, charging points and traction substation.	New infrastructure to be designed, constructed and maintained to IE standards. CCTV, fencing and lighting to be installed on new platform infrastructure.	N/A	Potential environmental impact as works required for new platform and charging points. Potential impacts upon properties to the immediate south.	Although a new platform would be built to the latest accessibility standards, the Navan Line branch is more remote from the main station making access a little more onerous.	N/A	This option fulfils the TSS 3 (6tph) scenario with additional operational redundancy offered by Depot Road 4 charging capability as back up. It fulfils the operational requirements yet has significantly reduced cost and environmental impact compared to Option 2a.	Yes
	TSS Scenario 3 (6 tph)	3	TSS Scenario 3 (6 tph)	**Charging stations on Platform 3 and 2. PLUS Converting the existing depot line 4 to mainline operations with a platform over existing depot line 5.**	High Cost - New Platform, signalling infrastructure, charging points and traction substation. Relocation of fuelling depot roads 4 and 5m (if possible) in order to maintain diesel fueling would be costly and very difficult to achieve.	New infrastructure to be designed, constructed and maintained to IE standards. CCTV, fencing and lighting to be installed on new platform infrastructure.	N/A	The project by defenition will reduce the environmental impact which occurs whilst operating diesel trains. However potential for disruption to contaminated waste/materials needs to be taken into consideration for relocation of fuelling roads.	New platform to include lift/ramp facilities for AFA requirements.	N/A	This option could potentially fulfil the TSS 3 (6tph) scenario however would require significant reworking of the depot to reinstate depot roads 4 and 5 elsewhere on a very constrained site (if possible). This would require significant additional cost, environmental impact and operational disruption. It would have little operational redundancy. It has significant disadvantages compared to Option 2b (and 2a).	No
	TSS Scenario 3 (6 tph) [Actually applies to all 3 scenarios]	8	All Scenarios	**Section of standard OLE under wire operation on approach to station and conversion of depot road 4 to a charging point for depot functionality.**	Elevated cost for installation of significant section of OLE although this would then be a saving when full electrification takes place.	New OLE infrastructure to be designed, constructed and maintained to IE standards.	N/A	The project by defenition will reduce the environmental impact which occurs whilst operating diesel trains. This option has minimal environmental impact during operation, however, construction may require land purchase to install new sub stations and haul roads along the route.	Installations would be to existing infraststructue and stations so accessibility will depend on existing situation.	N/A	This option is different to the others in the sense that it involves a much larger installation (approximately 7km of dual electrification) compared to the other options which are for Drogheda station and depot only. Therefore it has a much larger cost and environmental impact so in the context of this exercise it is not preferred.	No (although could be considered if the additional cost now was merited due to future cost saving for the full electrification project.)

Excerpt from CAF Guidelines

Table 9: Project Appraisal Criteria

Economy	The impacts of a transport investment on economic growth and competitiveness are assessed under the economic impact and economic efficiency criteria.
Safety	Safety is concerned with the impact of the investment on the number of transport related accidents.
Integration	Integration considers the extent to which the project being evaluated promotes integration of transport networks and is compatible with Government policies, including national spatial and planning policy.
Environment	Environment embraces a range of impacts, such as emissions to air, noise, and ecological and architectural impacts.
Accessibility and Social Inclusion	Accessibility and social inclusion embraces the notion that some priority should be given to benefits that accrue to those suffering from social deprivation, geographic isolation and mobility and sensory deprivation.
Physical Activity (where applicable)	This relates to the health benefits derived from using different transport modes

Iarnród Éireann
Irish Rail

Request For Information

Date: 03/09/2020	**RFI No:** IE-BEMU-SET-RFI-0001

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0001	Doc Title:	
Other Ref:		Response required by:	10 Sept 2020

RFI Title: Electrical interface with BEMU vehicles for charging

Contractors request for information:

We are aware that there is a tender process taking place for the new DART fleet including BEMUs. The electrical interface with the BEMU vehicles for charging that should be allowed for to give optimized solutions in the BEMU Infrastructure Study will be set to a significant extent by the technical clarifications made to the bidders and their emerging responses.

Therefore, as far as is possible within the tendering process, please can you supply the following information:

1. Confirmation of any changes to line current limits from I-ETR-4020, for a unit drawing current while static, as supplied to the bidders for the new fleet. [Why needed: This confirms the infrastructure constraint statically.]
2. Confirmation of any changes to line current limits from I-ETR-4020, for a unit drawing current while in motion, as supplied to the bidders for the new fleet. [Why needed: This confirms the infrastructure constraint dynamically.]
3. The assumed maximum charging current that will be drawn by the unit while stationary and the number of pantographs to assume this is distributed across, given the responses of the bidders for the new fleet. [Why needed: This confirms the actual anticipated maximum current demand on the charging infrastructure, per unit and per pantograph.]
4. The assumed charging time needed at Drogheda consistent with the current in 3, given the responses of the bidders for the new fleet. [Why needed: This can be used as part of the determination of the duty cycle of the charging system, along with 5.]
5. The assumed total charging energy to be supplied by the infrastructure at Drogheda for each service, given the responses of the bidders for the new fleet. [Why needed: This can be used as part of the determination of the duty cycle of the charging system, along with 4.]
6. The assumed charging arrangement(s) to allow for on the infrastructure side, eg normal overhead wire for a normal pantograph or some other method of charging such as needing a copper bar, given the responses of the bidders for the new fleet. [Why needed: To determine the mechanical interface to allow for in the charging system.]

RFI Originator:	Type Name Here	Date	
Signed:			
CRE / PM:	Type Name Here	Date	
Signed:			

Reply or Confirmation of Action taken			
1. To my knowledge there is no current limit for a unit drawing current while static in I-ETR-4020. There are temperature limits in this standard and there were no changes supplied to bidders for the new fleet in this regard. 2. The limits supplied to bidders for drawing current while in motion are as follows: a. Continuous current – 1336A, b. Maximum available current – 3000A for duration of 60 seconds 3. Please refer to response to TQ0007 (IE-BEMU-SET-TQ-0002) 4. Please refer to response to TQ0007 (IE-BEMU-SET-TQ-0002) 5. Please refer to response to TQ0007 (IE-BEMU-SET-TQ-0002) 6. As part of the tender, it is the responsibility of the Manufacturer to state the basic details of the charging infrastructure that needs to be provided in order to charge the vehicles, including the power to be supplied, and the arrangement of the shore-side conductor wire(s) or bar(s) or other apparatus required to interface with the pantograph(s) or the alternative roof-mounted arrangement on the BEMUs.			
Authorised: Iarnrod Eireann	Type Name Here	Date	Initial response: 09 September 2020 Updated response: 29 September 2020
Signed:			
Accepted: Jacobs	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 08/09/2020	**RFI No:** IE-BEMU-SET-RFI-0002

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0002	Doc Title:	
Other Ref:		Response required by:	10 Sept 2020
RFI Title: Electrical interface with BEMU vehicles for charging			
Contractors request for information:			

1. Can you confirm if a potential option for BEMU operation is to have a newly installed platform on one or both of the existing Navan branch lines at Drogheda?
2. If so, do IE have a view on the most appropriate location for platform(s)?

RFI Originator:	[redacted]	Date	4/9/20
Signed:			
CRE / PM:	[redacted]	Date	7/9/20
Signed:			

Reply or Confirmation of Action taken			
1. Yes, a potential option is to install a new platform on the Navan branch. This may appear in Scenario 3 of the TSS (alternative TSS) when it is published. 2. The preferred location would likely be where IÉ own the most property i.e. the northern side of the Navan branch. However, all options should be assessed. Part of the assessment should include the accessibility of trains to the location(s).			
Authorised: Iarnrod Eireann	Type Name Here	Date	11 September 2020
Signed:			
Accepted: Jacobs	Type Name Here	Date	
Signed:			

Request For Information

Date: 14/09/2020	**RFI No:** IE-BEMU-SET-RFI-0003

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0003	Doc Title:	
Other Ref:		Response required by:	21/09/2020

RFI Title: Train Shed

Contractors request for information:

With reference to reviewing records and examining aerial photos it seems like the Train Shed to the North of Drogheda depot may be redundant. Please can Irish Rail confirm whether the building is disused and whether it can be repurposed to house the new traction/charging substation equipment? This location would be ideal for a charging substation due to the proximity to the platform lines. Aerial photo provided below:



RFI Originator:	[redacted]	Date	14/9/20
Signed:			
CRE / PM:	[redacted]	Date	15/9/20
Signed:			
Reply or Confirmation of Action taken			
The area highlighted comprises the main warehouse for storage of 29000 DMU spare parts at Drogheda and is strategically located beside the depot. The 29000s will continue to be maintained at this depot in conjunction with BEMUs (which will require additional storage), for the initial number of years until full electrification is in place. Therefore, it would not be an option to remove this as a warehouse facility for the depot use.			
Authorised: Iarnrod Eireann	Type Name Here	Date	16 September 2020
Signed:			
Accepted:	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 16/09/2020	**RFI No:** IE-BEMU-SET-RFI-0004

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0004	Doc Title:	
Other Ref:		Response required by:	23/09/2020

RFI Title: ESB Communication protocol

Contractors request for information:

Please can Irish rail confirm the communication protocol with ESB. The BEMU project will require a new traction substation to electrify the charging station infrastructure. Thus, Jacobs needs to discuss the power requirements with energy supplier to ensure the proposals presented are feasible. This communication would be best served as a direct channel between Jacobs and ESB. Please inform Jacobs if there are other protocols in place for liaising with the ESB.

The information that requires discussion:

- MIC (the authorised capacity ESB can provide)
- Substation location
- Connection and metering point
- Application process

RFI Originator: [redacted]		Date	16/09/2020
Signed:			
CRE / PM: [redacted]		Date	16/09/2020
Signed:			

Reply or Confirmation of Action taken

Communications with ESB should go through [redacted], Assistant PM, DART+ Coastal for now. The ESB's Design Manager for the Drogheda area has been identified as the point of contact for the project.

Authorised: Iarnrod Eireann	Type Name Here	Date	30 September 2020
Signed:			
Accepted:	Type Name Here	Date	
Signed:			

Request For Information

Date: 18/09/2020	**RFI No:** IE-BEMU-SET-RFI-0005

Project:	BEMU Options Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0005	Doc Title:	
Other Ref:		Response required by:	25/09/2020
RFI Title: Land Boundary Information			
Contractors request for information:			
We are seeking information regarding the land ownership on the Northside of Drogheda station & depot and the potential movement of the turntable situated between the running lines and the depot stabling lines north of the storage shed. This information will be used to influence the design options regarding the proposed position of a new substation. Please can you clarify whether the highlighted area is within Irish Rails existing land boundary? The area in question is highlighted in figure 1 encapsulated within the red outline. Please can you specify whether there is a requirement to retain the existing turntable identified in *Figure 2?*			



Figure 1: Google Maps view – North side of Drogheda station and depot

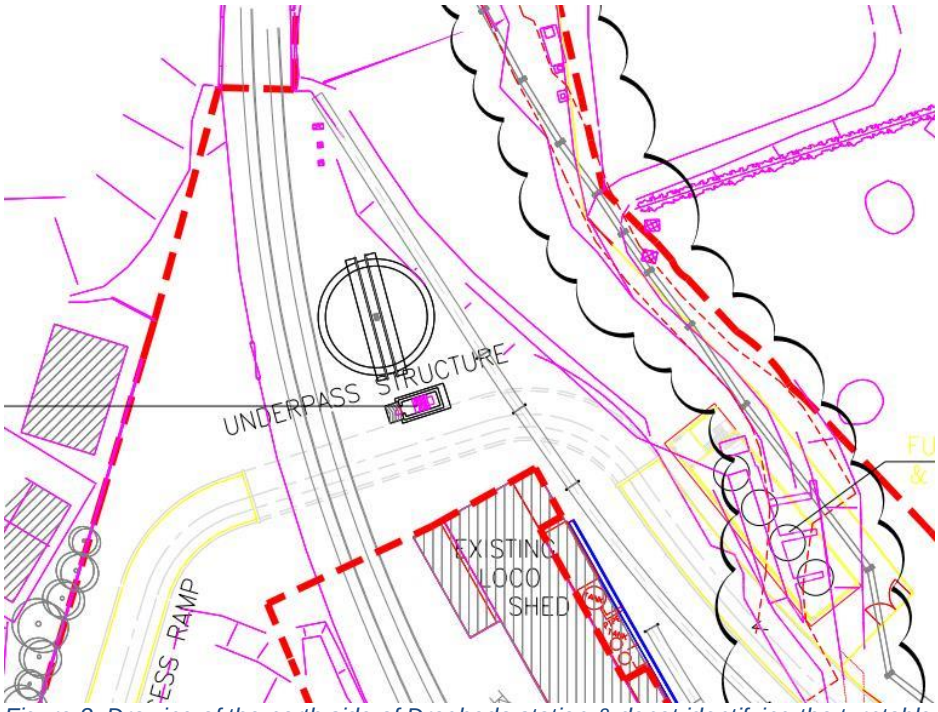


Figure 2: Drawing of the north side of Drogheda station & depot identifying the turntable.

RFI Originator:	[redacted]	Date	18/09/2020
Signed:			
CRE / PM:	[redacted]	Date	18/09/2020
Signed:			
Reply or Confirmation of Action taken			
1. The area marked in red at Drogheda Depot (Fig 1) is in the ownership of Irish Rail / CIE. The area marked is located on the concrete roof of the Depot roadway underpass tunnel. 2. The turntable (Fig 2) is purely a display item and can be relocated if desired. It is not connected to the rail line and was relocated as a display when the new Depot was constructed about 20 years ago.			
Authorised: Iarnrod Eireann	Type Name Here	Date	23 September 2020
Signed:			
Accepted: IDOM	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 25/09/2020	**RFI No:** IE-BEMU-SET-RFI-0006

Project:	BEMU Options Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0008	Doc Title:	
Other Ref:		Response required by:	29/09/2020

RFI Title: Depot road usage

Contractors request for information:

As part of our consideration of options for charging stations at Drogheda for the new BEMU fleet, we are considering the possibility of locating one of the charging stations in the first (western most) depot lane immediately adjacent to bay Platform 3.
Whilst it looks unlikely that it will be possible to have a platform in this location to allow full passenger service, a charging station that can be used for operational purposes, allowing trains to then be flighted to Laytown where they will commence passenger service would provide additional capacity and operational flexibility to the BEMU service.
As it is envisaged that an electrified road will be required in the depot in any case (for maintenance of BEMUs and commissioning of EMUs and BEMUs) it is felt that this could be the ideal location.
As this charging station would only likely be required at higher operational levels of service (e.g. to achieve 6tph) it could be utilized perhaps at times outside the busiest depot times (such as for peak hours when most trains are out in service anyway and do not need depot space).

Can IE confirm if this is an option they want to pursue?

RFI Originator:	[redacted]	Date	25/09/2020
Signed:			
CRE / PM:	[redacted]	Date	25/09/2020
Signed:			

Reply or Confirmation of Action taken			
IÉ is happy for this option to be included in the 6tph scenario. Jacobs should also investigate if a platform could also be utilised if 2 roads were taken and alternative maintenance arrangements were put in place.			
Authorised: Iarnrod Eireann	Type Name Here	Date	29 September 2020
Signed:			
Accepted:	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 21/10/2020	**RFI No:** IE-BEMU-SET-RFI-0007

Project:	BEMU Options Study	Project:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0007	IÉ Doc Ref:	RFI0009
Other Ref:		Other Ref:	

RFI Title: Stabling of BEMUs

Contractors request for information:

The TSS documents do not give first and last train time nor the number of trains at the start of service - this information is required to understand the most likely stabling plan at Drogheda.

In reference to TSS1b and TSS3 timetables, what is the stance on stabling EMUs fleets at Drogheda and was there an assumption of expanding the depot?

RFI Originator:	[redacted]	**RFI Originator:**	[redacted] [redacted]
Signed:			
CRE / PM:	[redacted]	[redacted] **/ PM:**	[redacted]
Signed:			

Reply or Confirmation of Action taken

2/3 BEMU DARTs per hour

- Today's timetable has 5 trains departing Drogheda each morning;
    1. 06:20 is 8* 29000 to Dundalk
    2. 06:28 is 8 * 29000 to Pearse
    3. 06:45 is 7 * 22000 to Pearse
    4. 07:05 is 8 * 29000 to Bray
    5. 08:00 is 8 * 29000 to Bray

- When the 41 ICR's enter service in mid to late 2022 this will increase to 6 trains each morning;
    1. 06:20 is 8* 29000 to Dundalk
    2. 06:28 is 8 * 29000 to Pearse
    3. 06:45 is 8 * 22000 to Pearse
    4. 07:05 is 8 * 29000 to Bray
    5. 08:00 is 8 * 29000 to Bray
    6. Xx:xx is 8 * 22000 to yyyy

- When BEMU arrive the following will happen;
    1. Train 1 (06:20 to Dundalk) will stay as a 29000 diesel train because BEMU has not the range to operate from Dundalk.
    2. The five other trains will be BEMU trains
    3. The diesel units (ICR's & 29000's) will cascade to provide additional services elsewhere.
        a. 29000's primarily on the Maynooth line
        b. ICR's other Intercity routes
    4. The 29000's cascaded to the Maynooth line will still need to come to the Drogheda Depot for Maintenance and this would most likely happen during the day.

- Assumed over night train stabling locations after BEMU introduction based on above;
    1. Drogheda;
        a. 40 * BEMU [Morning services ex Drogheda]
        b. 4 * BEMU [Maintenance holding]
        c. 8 * 29000 [Morning service ex Drogheda to Dundalk ety]
        d. 16 * 29000 [Maintenance holding]
        e. 8 * XXXXX fleet [Contingency for an extra 8 piece train]
    2. Dundalk
        a. 16 * 29000 [Morning service ex Dundalk]
    3. Connolly
        a. 8 * BEMU [Morning Service ex Connolly]
        b. 80 * 29000 [Morning services ex Connolly]

- Maintenance strategy
    1. BEMU
        a. All maintenance out of Drogheda
    2. 29000
        a. Fuelling and some A exams at Connolly
        b. Fuelling and some A exams at Drogheda
        c. All B Exams, HM, wheel turning & casualty repairs at Drogheda
    3. ICR's
        a. Fuelling and some A exams at Connolly
        b. Fuelling and some A exams at LTCD
        c. All B Exams, HM, wheel turning & casualty repairs at LTCD
        d. There will be no ICR's maintained or stabled at Drogheda.

TSS Scenario 1b

The stabling strategy for the DART+ Programme has not yet been finalised, however, for the purposes of this study please make the following assumptions for TSS Scenario 1b:

- 10no. 8-piece BEMU trains stabled in Drogheda (the number of BEMUs required should be confirmed by Jacobs as per email correspondence on 24/09/2020).

- Remaining BEMUs to be stabled elsewhere. The study should determine the extent of the charging infrastructure required at these locations.
- The TSS does not provide a detailed outline of the first and last train times. The modelling has only ever been based on the 3 hour AM Peak, the rationale behind this being that if the system can deliver a 3 hour peak period it can by default deliver a lower frequency off peak timetable. It can however be taken that the morning service will commence immediately into the AM peak service which would indicate the max number of fleet required to commence service.

TSS Scenario 3

The stabling strategy for the DART+ Programme has not yet been finalised, however, for the purposes of this study please make the following assumptions for TSS Scenario 3:

- 10no. 8-piece BEMU trains stabled in Drogheda (132no. BEMUs may not be enough for this scenario. The study should determine how many units are required as per email correspondence on 24/09/2020).
- Remaining BEMUs to be stabled elsewhere. The study should determine the extent of the charging infrastructure required at these locations.
- The TSS does not provide a detailed outline of the first and last train times. The modelling has only ever been based on the 3 hour AM Peak, the rationale behind this being that if the system can deliver a 3 hour peak period it can by default deliver a lower frequency off peak timetable. It can however be taken that the morning service will commence immediately into the AM peak service which would indicate the max number of fleet required to commence service.

Authorised: Iarnrod Eireann	Type Name Here	Date	03 November 2020
Signed:			
Accepted:	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 11/11/2020	**RFI No:** IE-BEMU-SET-RFI-0008

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:		Doc Title:	RFI0010
Other Ref:		Response required by:	16 Nov 2020
RFI Title: Drogheda, Connolly, Bray, Greystones timetables and platform workings			
Contractors request for information:			
For TSS1b and TSS3, can you please supply a timetable that shows train times and platform workings at Drogheda, Connolly, Bray and Greystones. This will allow us to calculate a BEMU fleet size for each of TSS1b and TSS3.			

RFI Originator:	Type Name Here	Date	
Signed:			
CRE / PM:	Type Name Here	Date	
Signed:			

Reply or Confirmation of Action taken			
The relevant files have been uploaded to Jacobs' SharePoint: Documents > From Irish Rail > Request For Information (RFI) > RFI0010. Link: https://jacobsengineering.sharepoint.com/sites/CPD3422300/Shared%20Documents/Forms/AllItems.aspx?viewid=33496242%2D6f4f%2D4301%2Db86c%2D9a5abe3511a9&id=%2Fsites%2FCPD3422300%2FShared%20Documents%2FFrom%20Irish%20Rail%2FRequest%20For%20Information%20%28RFI%29%2FRFI0010			
Authorised: Iarnrod Eireann	Type Name Here	Date	26 November 2020
Signed:			
Accepted: Jacobs	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 03/09/2020	**RFI No:** IE-BEMU-SET-RFI-0001

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0001	Doc Title:	
Other Ref:		Response required by:	10 Sept 2020

RFI Title: Electrical interface with BEMU vehicles for charging

Contractors request for information:

We are aware that there is a tender process taking place for the new DART fleet including BEMUs. The electrical interface with the BEMU vehicles for charging that should be allowed for to give optimized solutions in the BEMU Infrastructure Study will be set to a significant extent by the technical clarifications made to the bidders and their emerging responses.

Therefore, as far as is possible within the tendering process, please can you supply the following information:

1. Confirmation of any changes to line current limits from I-ETR-4020, for a unit drawing current while static, as supplied to the bidders for the new fleet. [Why needed: This confirms the infrastructure constraint statically.]
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RFI Originator:	Type Name Here	Date	
Signed:			
CRE / PM:	Type Name Here	Date	
Signed:			

Reply or Confirmation of Action taken			
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Authorised: Iarnrod Eireann	Type Name Here	Date	Initial response: 09 September 2020 Updated response: 29 September 2020
Signed:			
Accepted: Jacobs	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 08/09/2020	**RFI No:** IE-BEMU-SET-RFI-0002

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0002	Doc Title:	
Other Ref:		Response required by:	10 Sept 2020
RFI Title: Electrical interface with BEMU vehicles for charging			
Contractors request for information:			

1. Can you confirm if a potential option for BEMU operation is to have a newly installed platform on one or both of the existing Navan branch lines at Drogheda?
2. If so, do IE have a view on the most appropriate location for platform(s)?

RFI Originator:	[redacted]	Date	4/9/20
Signed:			
CRE / PM:	[redacted]	Date	7/9/20
Signed:			

Reply or Confirmation of Action taken			
1. Yes, a potential option is to install a new platform on the Navan branch. This may appear in Scenario 3 of the TSS (alternative TSS) when it is published. 2. The preferred location would likely be where IÉ own the most property i.e. the northern side of the Navan branch. However, all options should be assessed. Part of the assessment should include the accessibility of trains to the location(s).			
Authorised: Iarnrod Eireann	Type Name Here	Date	11 September 2020
Signed:			
Accepted: Jacobs	Type Name Here	Date	
Signed:			

Request For Information

Date: 14/09/2020	**RFI No:** IE-BEMU-SET-RFI-0003

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0003	Doc Title:	
Other Ref:		Response required by:	21/09/2020

RFI Title: Train Shed

Contractors request for information:

With reference to reviewing records and examining aerial photos it seems like the Train Shed to the North of Drogheda depot may be redundant. Please can Irish Rail confirm whether the building is disused and whether it can be repurposed to house the new traction/charging substation equipment? This location would be ideal for a charging substation due to the proximity to the platform lines. Aerial photo provided below:



RFI Originator:	[redacted]	Date	14/9/20
Signed:			
CRE / PM:	[redacted]	Date	15/9/20
Signed:			
Reply or Confirmation of Action taken			
The area highlighted comprises the main warehouse for storage of 29000 DMU spare parts at Drogheda and is strategically located beside the depot. The 29000s will continue to be maintained at this depot in conjunction with BEMUs (which will require additional storage), for the initial number of years until full electrification is in place. Therefore, it would not be an option to remove this as a warehouse facility for the depot use.			
Authorised: Iarnrod Eireann	Type Name Here	Date	16 September 2020
Signed:			
Accepted:	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 16/09/2020	**RFI No:** IE-BEMU-SET-RFI-0004

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0004	Doc Title:	
Other Ref:		Response required by:	23/09/2020

RFI Title: ESB Communication protocol

Contractors request for information:

Please can Irish rail confirm the communication protocol with ESB. The BEMU project will require a new traction substation to electrify the charging station infrastructure. Thus, Jacobs needs to discuss the power requirements with energy supplier to ensure the proposals presented are feasible. This communication would be best served as a direct channel between Jacobs and ESB. Please inform Jacobs if there are other protocols in place for liaising with the ESB.

The information that requires discussion:

- MIC (the authorised capacity ESB can provide)
- Substation location
- Connection and metering point
- Application process

RFI Originator:	[redacted]	Date	16/09/2020
Signed:			
CRE / PM:	[redacted]	Date	16/09/2020
Signed:			

Reply or Confirmation of Action taken

Communications with ESB should go through [redacted], Assistant PM, DART+ Coastal for now. The ESB's Design Manager for the Drogheda area has been identified as the point of contact for the project.

Authorised: Iarnrod Eireann	Type Name Here	Date	30 September 2020
Signed:			
Accepted:	Type Name Here	Date	
Signed:			

Request For Information

Date: 18/09/2020	**RFI No:** IE-BEMU-SET-RFI-0005

Project:	BEMU Options Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0005	Doc Title:	
Other Ref:		Response required by:	25/09/2020
RFI Title: Land Boundary Information			
Contractors request for information:			
We are seeking information regarding the land ownership on the Northside of Drogheda station & depot and the potential movement of the turntable situated between the running lines and the depot stabling lines north of the storage shed. This information will be used to influence the design options regarding the proposed position of a new substation. Please can you clarify whether the highlighted area is within Irish Rails existing land boundary? The area in question is highlighted in figure 1 encapsulated within the red outline. Please can you specify whether there is a requirement to retain the existing turntable identified in *Figure 2?*			



Figure 1: Google Maps view – North side of Drogheda station and depot

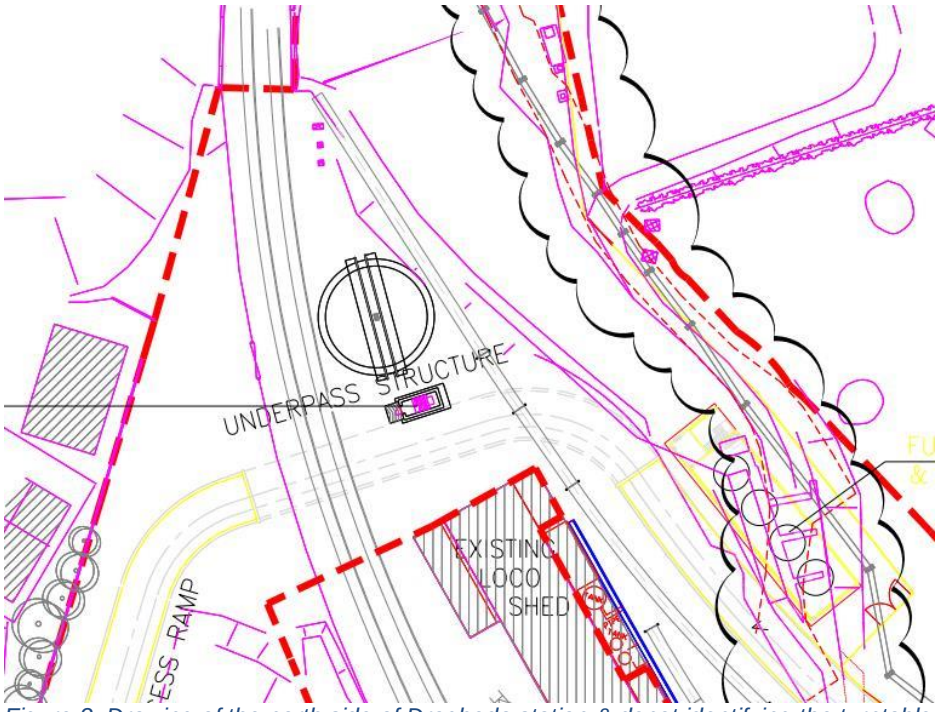


Figure 2: Drawing of the north side of Drogheda station & depot identifying the turntable.

RFI Originator:	[redacted]	Date	18/09/2020
Signed:			
CRE / PM:	[redacted]	Date	18/09/2020
Signed:			
Reply or Confirmation of Action taken			
1. The area marked in red at Drogheda Depot (Fig 1) is in the ownership of Irish Rail / CIE. The area marked is located on the concrete roof of the Depot roadway underpass tunnel. 2. The turntable (Fig 2) is purely a display item and can be relocated if desired. It is not connected to the rail line and was relocated as a display when the new Depot was constructed about 20 years ago.			
Authorised: Iarnrod Eireann	Type Name Here	Date	23 September 2020
Signed:			
Accepted: IDOM	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 25/09/2020	**RFI No:** IE-BEMU-SET-RFI-0006

Project:	BEMU Options Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0008	Doc Title:	
Other Ref:		Response required by:	29/09/2020

RFI Title: Depot road usage

Contractors request for information:

As part of our consideration of options for charging stations at Drogheda for the new BEMU fleet, we are considering the possibility of locating one of the charging stations in the first (western most) depot lane immediately adjacent to bay Platform 3.
Whilst it looks unlikely that it will be possible to have a platform in this location to allow full passenger service, a charging station that can be used for operational purposes, allowing trains to then be flighted to Laytown where they will commence passenger service would provide additional capacity and operational flexibility to the BEMU service.
As it is envisaged that an electrified road will be required in the depot in any case (for maintenance of BEMUs and commissioning of EMUs and BEMUs) it is felt that this could be the ideal location.
As this charging station would only likely be required at higher operational levels of service (e.g. to achieve 6tph) it could be utilized perhaps at times outside the busiest depot times (such as for peak hours when most trains are out in service anyway and do not need depot space).

Can IE confirm if this is an option they want to pursue?

RFI Originator:	[redacted]	Date	25/09/2020
Signed:			
CRE / PM:	[redacted]	Date	25/09/2020
Signed:			

Reply or Confirmation of Action taken			
IÉ is happy for this option to be included in the 6tph scenario. Jacobs should also investigate if a platform could also be utilised if 2 roads were taken and alternative maintenance arrangements were put in place.			
Authorised: Iarnrod Eireann	Type Name Here	Date	29 September 2020
Signed:			
Accepted:	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

Date: 21/10/2020	**RFI No:** IE-BEMU-SET-RFI-0007

Project:	BEMU Options Study	Project:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:	RFI0007	IÉ Doc Ref:	RFI0009
Other Ref:		Other Ref:	

RFI Title: Stabling of BEMUs

Contractors request for information:

The TSS documents do not give first and last train time nor the number of trains at the start of service - this information is required to understand the most likely stabling plan at Drogheda.

In reference to TSS1b and TSS3 timetables, what is the stance on stabling EMUs fleets at Drogheda and was there an assumption of expanding the depot?

RFI Originator:	[redacted]	**RFI Originator:**	Signed: [redacted]
Signed:			
CRE / PM:	[redacted]	**CRE / PM:**	[redacted]
Signed:			

Reply or Confirmation of Action taken

2/3 BEMU DARTs per hour

- Today's timetable has 5 trains departing Drogheda each morning;
    1. 06:20 is 8* 29000 to Dundalk
    2. 06:28 is 8 * 29000 to Pearse
    3. 06:45 is 7 * 22000 to Pearse
    4. 07:05 is 8 * 29000 to Bray
    5. 08:00 is 8 * 29000 to Bray

- When the 41 ICR's enter service in mid to late 2022 this will increase to 6 trains each morning;
    1. 06:20 is 8* 29000 to Dundalk
    2. 06:28 is 8 * 29000 to Pearse
    3. 06:45 is 8 * 22000 to Pearse
    4. 07:05 is 8 * 29000 to Bray
    5. 08:00 is 8 * 29000 to Bray
    6. Xx:xx is 8 * 22000 to yyyy

- When BEMU arrive the following will happen;
    1. Train 1 (06:20 to Dundalk) will stay as a 29000 diesel train because BEMU has not the range to operate from Dundalk.
    2. The five other trains will be BEMU trains
    3. The diesel units (ICR's & 29000's) will cascade to provide additional services elsewhere.
        a. 29000's primarily on the Maynooth line
        b. ICR's other Intercity routes
    4. The 29000's cascaded to the Maynooth line will still need to come to the Drogheda Depot for Maintenance and this would most likely happen during the day.

- Assumed over night train stabling locations after BEMU introduction based on above;
    1. Drogheda;
        a. 40 * BEMU [Morning services ex Drogheda]
        b. 4 * BEMU [Maintenance holding]
        c. 8 * 29000 [Morning service ex Drogheda to Dundalk ety]
        d. 16 * 29000 [Maintenance holding]
        e. 8 * XXXXX fleet [Contingency for an extra 8 piece train]
    2. Dundalk
        a. 16 * 29000 [Morning service ex Dundalk]
    3. Connolly
        a. 8 * BEMU [Morning Service ex Connolly]
        b. 80 * 29000 [Morning services ex Connolly]

- Maintenance strategy
    1. BEMU
        a. All maintenance out of Drogheda
    2. 29000
        a. Fuelling and some A exams at Connolly
        b. Fuelling and some A exams at Drogheda
        c. All B Exams, HM, wheel turning & casualty repairs at Drogheda
    3. ICR's
        a. Fuelling and some A exams at Connolly
        b. Fuelling and some A exams at LTCD
        c. All B Exams, HM, wheel turning & casualty repairs at LTCD
        d. There will be no ICR's maintained or stabled at Drogheda.

TSS Scenario 1b

The stabling strategy for the DART+ Programme has not yet been finalised, however, for the purposes of this study please make the following assumptions for TSS Scenario 1b:

- 10no. 8-piece BEMU trains stabled in Drogheda (the number of BEMUs required should be confirmed by Jacobs as per email correspondence on 24/09/2020).

- Remaining BEMUs to be stabled elsewhere. The study should determine the extent of the charging infrastructure required at these locations.
- The TSS does not provide a detailed outline of the first and last train times. The modelling has only ever been based on the 3 hour AM Peak, the rationale behind this being that if the system can deliver a 3 hour peak period it can by default deliver a lower frequency off peak timetable. It can however be taken that the morning service will commence immediately into the AM peak service which would indicate the max number of fleet required to commence service.

TSS Scenario 3

The stabling strategy for the DART+ Programme has not yet been finalised, however, for the purposes of this study please make the following assumptions for TSS Scenario 3:

- 10no. 8-piece BEMU trains stabled in Drogheda (132no. BEMUs may not be enough for this scenario. The study should determine how many units are required as per email correspondence on 24/09/2020).
- Remaining BEMUs to be stabled elsewhere. The study should determine the extent of the charging infrastructure required at these locations.
- The TSS does not provide a detailed outline of the first and last train times. The modelling has only ever been based on the 3 hour AM Peak, the rationale behind this being that if the system can deliver a 3 hour peak period it can by default deliver a lower frequency off peak timetable. It can however be taken that the morning service will commence immediately into the AM peak service which would indicate the max number of fleet required to commence service.

Authorised: Iarnrod Eireann	Type Name Here	Date	03 November 2020
Signed:			
Accepted:	Type Name Here	Date	
Signed:			

Iarnród Éireann
Irish Rail

Request For Information

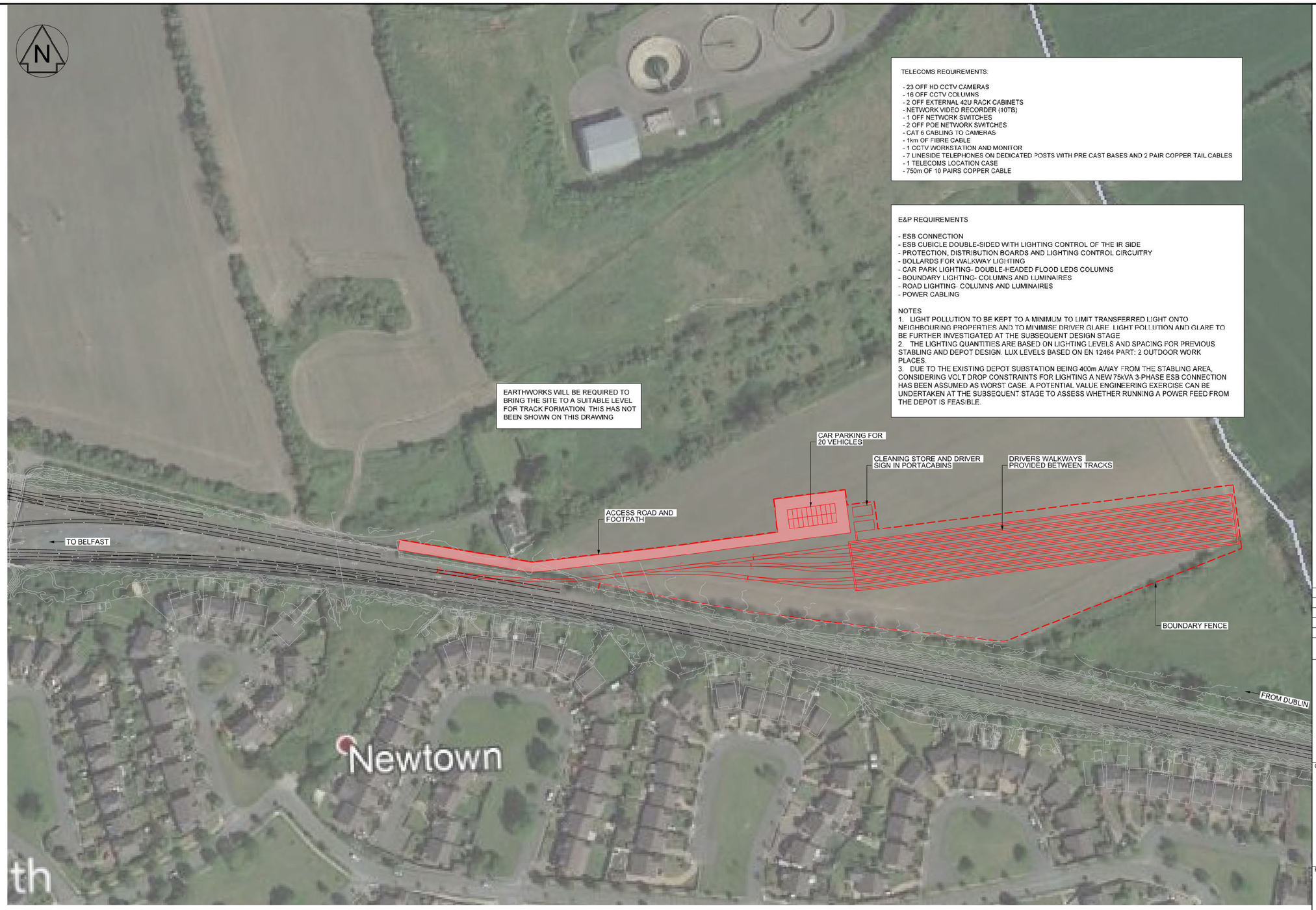
Date: 11/11/2020	**RFI No:** IE-BEMU-SET-RFI-0008

Project:	BEMU Infrastructure Study	IE Project Ref:	DART+ Coastal (BEMU PMP1 Study)
Doc Ref:		Doc Title:	RFI0010
Other Ref:		Response required by:	16 Nov 2020
RFI Title: Drogheda, Connolly, Bray, Greystones timetables and platform workings			
Contractors request for information:			
For TSS1b and TSS3, can you please supply a timetable that shows train times and platform workings at Drogheda, Connolly, Bray and Greystones. This will allow us to calculate a BEMU fleet size for each of TSS1b and TSS3.			

RFI Originator:	Type Name Here	Date	
Signed:			
CRE / PM:	Type Name Here	Date	
Signed:			

Reply or Confirmation of Action taken			
The relevant files have been uploaded to Jacobs' SharePoint: Documents > From Irish Rail > Request For Information (RFI) > RFI0010. Link: https://jacobsengineering.sharepoint.com/sites/CPD3422300/Shared%20Documents/Forms/AllItems.aspx?viewid=33496242%2D6f4f%2D4301%2Db86c%2D9a5abe3511a9&id=%2Fsites%2FCPD3422300%2FShared%20Documents%2FFrom%20Irish%20Rail%2FRequest%20For%20Information%20%28RFI%29%2FRFI0010			
Authorised: Iarnrod Eireann	Type Name Here	Date	26 November 2020
Signed:			
Accepted: Jacobs	Type Name Here	Date	
Signed:			

Drawing Number
D3422300-JAC-DRG-EMF-000004



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STABLING YARD
GENERAL ARRANGEMENT
SCALE 1:1000

DRAWING TO BE READ IN COLOUR

EXISTING
PROPOSED
MODIFIED
REMOVED

0 10 20 30 40 50 60 70 80 90 100m
SCALE 1 : 1000

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Legend/Notes

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. DESIGN BASED UPON LIDAR SUPPLIED TO JACOBS BY IE ON 03/09/2020
3. ESB INCOMER OMITTED AS FULL COORDINATION OF THEIR INSTALL IS REQUIRED AT THE SUBSEQUENT DESIGN STAGE

KEY:

Rev	Date	Description of Revisions	Drawn	Chkd	Appr
P01	27/11/20		[redacted]		

Status: Initial Status or Work in Progress
Suitability:

Iarnród Éireann Infrastructure

Contractor(s)
Jacobs

Project
BEMU INFRASTRUCTURE STUDY

Drawing Title
STABLING YARD
GENERAL ARRANGEMENT

Designed		Signed	Date
Drawn	[redacted]	Signed	Date 27/11/20
Checked		Signed	Date ---
Approved		Signed	Date 27/11/20

Scale(s): 1:1000
ELR & Mileage:
Alternative Reference: Alternative Ref
Sheet: of
Drawing Number: D3422300-JAC-DRG-EMF-000004
Revision: P01

Sheet Size A1 594 x 841

BEMU Options Study

D3422300-JAC-REP-EMF-000001 | P04

10 February 2021

Iarnród Éireann



Project:	**BEMU Infrastructure Study**		
Client:	**Irish Rail**	**Project Number:**	**D3422300**
Document Title:	BEMU Options Study		
Doc. No:	D3422300-JAC-REP-EMF-000001		

		Originated by		**Checked by**		**Reviewed by**	
ORIGINAL	**ISSUE P01**	NAME [redacted]	Initials [redacted]	NAME [redacted]	Initials [redacted]	NAME [redacted]	Initials [redacted]
Approved by		NAME [redacted]		I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**			INITIALS [redacted]
DATE	**29.10.2020**	**Document status: Draft for Information**					

REVISION	**ISSUE P02**	NAME [redacted]	Initials [redacted]	NAME [redacted]	Initials [redacted]	NAME [redacted]	Initials [redacted]
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DATE	**20.11.2020**	**Document status: Draft for Review (Update to base scenario)**					

REVISION	**ISSUE P03**	NAME [redacted]	Initials [redacted]	NAME [redacted]	Initials [redacted]	NAME [redacted]	Initials [redacted]
Approved by		NAME [redacted]		I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**			INITIALS [redacted]
DATE	**03.12.2020**	**Document status: Draft Final Issue**					

REVISION	**ISSUE P04**	NAME [redacted]	Initials [redacted]	NAME [redacted]	Initials [redacted]	NAME [redacted]	Initials [redacted]
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DATE	**10.2.2021**	**Document status: Final Issue**					

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Executive Summary

As part of the DART + Programme, Iarnród Éireann is purchasing a new fleet of trains to enhance the capacity on the DART network. This procurement forms Work Package 1 of the overall programme and has been designed to allow the purchaser to choose a fleet made up of Electric Multiple Units (EMUs) and Battery Electric Multiple Units (BEMUs). The provision of BEMUs is to allow for the possibility of running enhanced services on the network in advance of full electrification. For BEMUs to operate successfully, charging facilities are required to recharge the batteries to enable operations that are not on the electrified network. IÉ have identified the Northern Line as the most suitable route for potential BEMU deployment and Drogheda Station and depot area as the preferred charging station location.

In August 2020, IÉ commissioned Jacobs to identify the BEMU infrastructure requirements at Drogheda Station (including maintenance infrastructure and equipment), with an aim of minimal intervention and operational impact, for 3 different timetable scenarios and to develop Life Cycle Costs accordingly for the resulting requirements. Following timetabling work that IÉ completed as part of DART+ WP3 (Maynooth Line upgrade), three alternative Train Service Specifications (TSS's) were generated. IÉ asked Jacobs to consider these three alternative timetable scenarios as follows:

- A Base Scenario of 2 or 3 trains per hour (tph) (based on the current timetable)
- Train Service Specification 1b (this has a total of 5tph DART services to/from Drogheda, of which 2tph operate as empty stock (not in passenger service) between Laytown and Drogheda)
- Train Service Specification 3 (6tph DART services to/from Drogheda)

Jacobs performed an operational assessment of these three different scenarios and from that formulated the platforming requirements of the BEMU trains. This was based on a 12-minute turnaround time for charging each BEMU. With the platforming requirements established for the three different scenarios, Jacobs undertook a 2 stage optioneering exercise in line with Common Appraisal Framework guidelines to consider the best approach for each scenario. The conclusion of that exercise led to the proposals for the following infrastructure options for each of the TSS scenarios:

- **Scenario 1: (Base TSS)**: Infrastructure Option 1a – Charging Station on Platform 3 and Depot Road 4 (Completion Nov 2023)
- **Scenario 2: TSS 1B**: Infrastructure Option 1b – As option 1a above plus Charging Station on Platform 2 (Completion July 2024)
- **Scenario 3: TSS 3**: Infrastructure Option 2b – As option 1b above PLUS Charging Station on Navan Line (single tracking short section) (Completion July2024)

Note completion dates are based on commencement of Multi-Disciplinary Consultant in Jan 2021 (See Appendix I for programme details).

Scenario 1: Base TSS (2/3 tph)

Infrastructure Option 1a was chosen for the base scenario because it provides the simplest, lowest cost and least disruptive way of meeting the requirements. In normal service, trains would charge in Bay Platform 3. The depot road no.4 would generally be used for servicing the BEMUs or initially for commissioning purposes. In terms of redundancy, should there be a breakdown in Platform 3, trains could be directed into depot road 4 to be charged. In this situation, once charged, they would need to move out onto the mainline and back into one of the through platforms (most likely platform 2) to allow passenger boarding. Alternatively, if this manoeuvre was not considered an attractive prospect, the train could be sent empty to Laytown where it would commence passenger service.

If neither of these scenarios was considered acceptable in a failure situation, an additional charging station could be provided on Platform 2. To do this, the additional cost of installing and maintaining this extra piece of

infrastructure would have to outweigh the operational limitations outlined above. [This situation has been provided for as Option 1c].

It should be noted that in this situation, even with three charging stations now in place (Platform 3, Platform 2 and Depot Road 4), only one train could be charged at a time due to the limitation in the power available from the installed sub-station.

In terms of stabling requirements in this scenario, the existing depot plus the addition of one stabling berth on the Navan Branch line will suffice.

Scenario 2: TSS 1b (5tph)

Infrastructure Option 1b was chosen as the preferred solution for TSS 1b. Once again, this was considered the most cost-effective way of achieving the requirements of this train operating scenario. This option builds on Option 1a with the addition of a charging station on Platform 2 AND an upgrade in power availability from the existing installed sub-station to allow up to three trains to be charged simultaneously. It was found that the power demand would be greater than could reasonably be made available by ESB and the concept of battery buffers was developed (These allow input power at a lower level to be "stored up" and released at a greater rate and thereby reducing the input power requirements. In this scenario, there are up to 5 trains per hour required to depart Drogheda, however in this TSS, two of these would do so running empty to Laytown. The intention of this option is that the two empty running vehicles would be charged in Depot Road 4 (where there are no platform facilities or passenger access) and from there would depart directly for Laytown once sufficiently charged. In normal operation, there should be no more than two trains charging simultaneously (on two of the three charging stations available). However, it is possible during perturbation that three trains would require to be charged at the same time but the power available from the existing installed sub-station will not be enough to provide for this situation. Therefore, battery buffers will be utilised in this scenario to provide the additional power requirement without the need for an increased rate of input power from the ESB.

It should be noted that under normal operation for Scenario 2, only 2 charging roads would be used and hence there would still be 1 spare road. However, in a failure situation where 3 trains require simultaneous charging, there would not be further redundancy to fall back on. If a further level of redundancy was required an additional charging platform would be needed, as proposed under Option 2a or 2b as described below for example, where the Navan branch line is utilised.

In terms of stabling requirements in this scenario, IÉ have confirmed that an adjacent field should be considered for the stabling of 48 additional vehicles (in addition to those stabled in the existing depot).

Scenario 3: TSS 3 (6tph)

The preferred solution for TSS 3 is **Infrastructure Option 2b.** In addition to charging stations on Platforms 2, 3 and Depot Road 4, this option involves the construction of a new platform on the Navan branch line just to the south and west of Drogheda station. This platform would also require a charging station to be installed, bringing the total number of charging stations to 4 in this case (i.e. Platforms 2 and 3, Depot Road 4 and the Navan Line platform). Battery buffers would also be required for this option.

As the Navan Line is currently lightly utilised, it is possible to install a platform on the existing track bed on the north side of this branch line, thereby converting this section to single track and avoiding the need for additional land purchase and the environmental impact that would occur by locating a new platform adjacent to the existing twin track layout.

In normal operation for this scenario there should be no more than 2 trains charging simultaneously. In a delay situation there could be a need to have 3 trains charging at one time but even in this case, there will still be further redundancy via the charging station in depot road 4.

In terms of stabling requirements for Scenario 3, (as for Scenario 2) IE have confirmed that an adjacent field should be considered for the stabling of 48 additional vehicles (in addition to those stabled in the existing depot).

Costing of Options

Once the preferred infrastructure options were selected for each of the three operating scenarios, concept designs were developed in order to provide enough information to develop high level cost estimates. These estimates provide Life Cycle Costs in each case covering the capital and operational expenditures required to facilitate each option. It is noted that the CAPEX costs are the predominant driver in all cases and the annual cost profile for Option 1a is the lowest cost.

The Life Cycle Costs for each of the preferred options for each TSS scenario are estimated as follows:

		Fleet size	Capital Cost (€millions)	Discounted Cumulative Cost (€millions)	
Operating Scenario	Infrastructure Option	(no. of BEMUs)	Capex	Year 5	Year 35
Base Scenario (2/3 tph)	Option 1a	52	[redacted]		
Base Scenario (2/3 tph)	Option 1c [1a + charging OHLE on Platform 2]	52			
TSS 1b (3tph in service + 2 empty to Laytown)	Option 1b	216			
TSS 3 (6tph)	Option 2b	196			

Note as per Common Appraisal Framework guidance all costs stated are exclusive of VAT (see also 8.1.1)

In the case of Option 1a, the infrastructure installed could be utilised in a future full electrification scenario and would not be abortive cost. In the case of Option 1b, most of the infrastructure installed could be utilised in a future full electrification scenario with the battery buffers then being surplus to requirements. In the case of Option 2b, all the additional electrical infrastructure works on the Navan line branch along with the battery buffers would be surplus to requirements in a future full electrification scenario.

As Jacobs understand from IE that scenario TSS 3 requires a platform on the Navan branch line in any case, the cost of the new platform would not be abortive. In the case of Options 1b and 2b stabling, this work would not be abortive assuming the stabling facility could be used for EMUs. Note in this case additional expenditure would then be required since the yard would need to be fully electrified.

BEMU Operational Constraints

It should be noted that there are some operational challenges associated with BEMUs. The requirement for charging limits BEMU turnaround flexibility in responding to timetable delays. In a similar vein, further enhancement of the timetable is also limited by the use of BEMUs compared to EMUs. Timetable recovery options which exist today during disruption on the Northern line by way of interchanging DMU fleets from other routes will not be possible as other routes will now be operated by EMUs; during disruption, operating EMUs north of Malahide will not be an option and this will reduce operational flexibility.

Section 3.5.3 deals with these limitations in more detail.

1. Introduction

1.1 Purpose of the Study

In July 2020, Iarnród Éireann invited consultants to tender for a study entitled, "*DART+ Studies and Cost Estimate associated to the BEMU operating infrastructure on the Northern Line*". Jacobs Engineering Ireland Ltd. was subsequently appointed, and we are pleased to present this document and its findings. The study is intended to feed into the overall DART+ Programme under the National Development Plan 2018-2027, which is a series of projects that will create a full integrated metropolitan area DART network for Dublin. It consists of seven interrelated projects to expand the heavy rail electrified commuter network in Dublin from the existing c.50 km to c.150km. These projects or "Work Packages" are as follows:

- Work Package 1 – Rolling Stock
- Work Package 2 – City Centre Enhancements
- Work Package 3 – Maynooth Line
- Work Package 4 – Kildare Line
- Work Package 5 – Northern Line
- Work Package 6 – Southeast Line
- Work Package 7 – DART Underground

The Suburban network envisaged is shown in Figure 1-1.

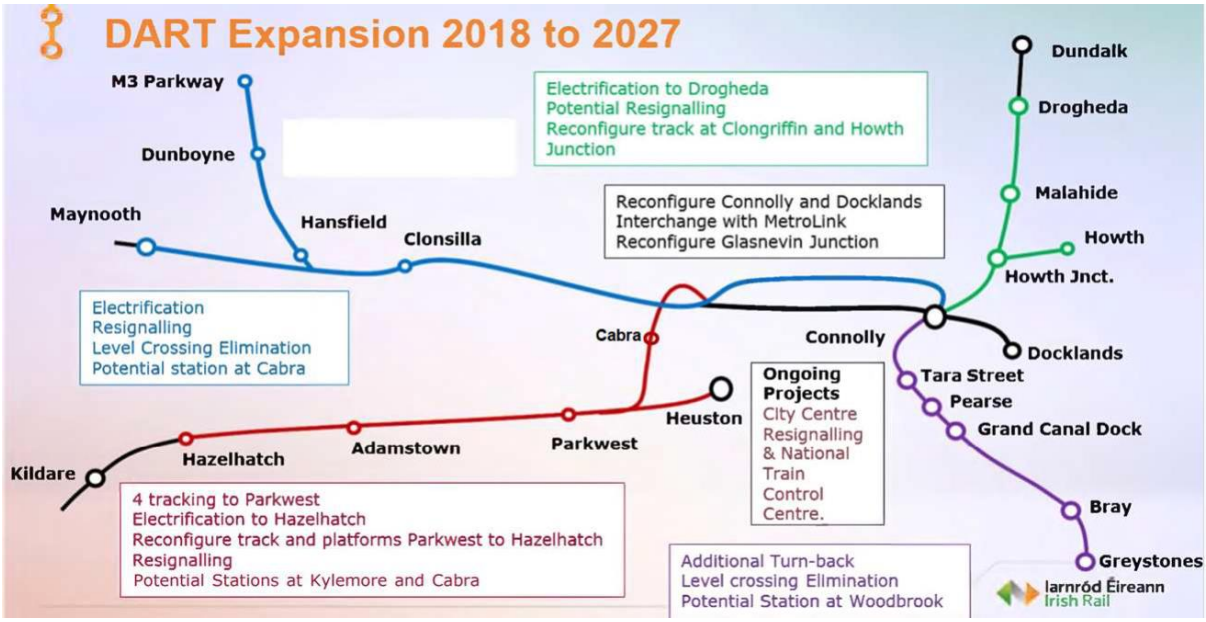


Figure 1-1 DART Expansion Programme 2019 to 2027 (rebadged DART+ Programme)

"Work Package 1 – Rolling Stock" allows for the procurement of a new fleet of trains consisting of both Electric Multiple Unit (EMU) and Battery Electric Multiple Unit (BEMU) trains. The EMUs will run under the electrified wires (both existing on the current DART line and newly installed as part of the DART + Programme). Work Package 1 allows for the purchase of BEMUs to operate in areas where electrification has yet to be delivered.

IÉ has identified the Northern Line as suitable for implementation of the BEMU strategy. Under Work Package 5 – Northern Line electrification is planned as far north as Drogheda. However, until electrification is completed to this point trains would run north under the existing DART electrification system as far as Malahide and then from there under battery power on to Drogheda. At this terminus, the train batteries would need to be charged to a sufficient level for the return leg from Drogheda to Malahide, where they would re-join the existing DART electrified network.

The necessary charging stations require investment both in terms of capital expenditure (CAPEX) and operating expenditure (OPEX). The purpose of this report is to present the infrastructure requirements for a range of operating scenarios and BEMU fleet sizes, so that IÉ can confirm their plan for BEMU fleet procurement and take account of the Life Cycle Cost (LCC) of installing and operating the infrastructure.

The following table notes the scope requirements and indicates where these items are addressed in the report.

Scope Requirements	Report Reference
Operation of BEMUs on the Northern Line, from Drogheda to Grand Canal Dock, including the Loop Line Bridge, with charging at Drogheda Station & Depot.	Covered in Section 3 - Operational Assessment
Determine Electrical Infrastructure	Covered in section 5 under discipline comments on each option and Appendix F
Determine Mechanical Infrastructure	Covered in section 5 under discipline comments on each option
Determine Civil Infrastructure	Covered in section 5 under discipline comments on each option
Determine Track Infrastructure	Covered in section 5 under discipline comments on each option
Consider the following operating frequencies	This is revised now to the following and covered in Section 3 - Operational Assessment
BEMU units at 2tphpd	BEMU units at 2/3 tphpd (as per current timetable)
BEMU units at 3tphpd	BEMU units at 2/3 tphpd (as per current timetable)
BEMU units at 4tphpd	BEMU units at 3 tphpd + 2 empty runners (as per IE provided TSS 1b)
BEMU units at 6tphpd	BEMU units at 6 tphpd (as per IE provided TSS 3)
BEMUs are to operate from Drogheda to Grand Canal Dock, including the Loop Line Bridge and back, with no upgrade to the existing electric infrastructure between Malahide and Connolly	Covered in Section 3 - Operational Assessment
Investigating impact of extending BEMU operation further south of grand Canal Dock to Greystones	Covered in Section 3 - Operational Assessment
Development of the study deliverables	
Operational Requirements and Impacts	Covered in Section 3 - Operational Assessment
Interfaces of the Preferred Options with all disciplines inter alia track, SET including OLE, Civils, structures.	Covered in section 5 under discipline comments on each option

Infrastructure - all infrastructure requirements, designs & impacts	Covered in section 5 under discipline comments on each option
Property - the outline right of way, impacts on properties,	Base Option does not require land outside IE ownership. Other options covered in section 5 under discipline comments and Appendix U.
Mitigations – for works, noise etc.	Covered under Environment comments in Section 5 for each option.
Cost – outline costs of schemes & value management	Covered in Section 8 - Cost (and Appendix D)
Risk – assessment of risks, safety, planning, commercial	Covered in Section 10 - Risk (and Appendix J)
Environmental – general impacts, etc	Covered under Environment comments in Section 5 for each option and Appendix E.
Utilities – supplies, existing services	Covered in section 5 under discipline comments on each option where applicable.
Draft implementation plan and programme	Covered under Section 9 - Programme (and Appendix I)
Safety Approvals – APIS, SMS 14	Covered under Section 7 - Safety in Design
Lifecycle costs (Operation & Maintenance) for electrification and BEMU's and associated infrastructure	Covered under Section 8 (and Appendix D)
Assessment of options and recommendation for preferred option.	Covered under Section 4 - Option Assessment
Strategy for implementation & next steps.	Covered under Section 12 - Recommendations and next steps
Advise on eventual need for Planning Permission / Railway Order application	Covered under Environment comments in Section 5 for each option and Appendices E and U.
Report Deliverables	
The proposed operational pattern strategy, to be developed in collaboration with IE	Covered in Section 3 - Operational Assessment
Functional, Technical and Operational Requirements of the infrastructure	Covered in Section 5 under discipline comments on each option
Architecture and specification of the charging infrastructure	Covered in Section 5 under discipline comments on each option
Specification of the track infrastructure modifications required to operate BEMUs (depot, platforms, sidings – including	Covered in Section 5 under discipline comments on each option

potential property acquisition - turnouts, etc)	
Specifications of additional ESB power supply(ies) and route to required locations	Covered in Section 5 under discipline comments on each option and Appendix F
Advice on the upgrades required specifically at Drogheda depot (electrification for BEMUs, specialist equipment, sidings, storage, etc…) to support commissioning & maintenance of the BEMU fleet in advance of Maynooth depot being ready	Covered in Section 6 - Depot
High-level Lifecycle Cost estimate and implementation Schedule of the proposed electrical, civil and track infrastructure on the Northern Line	Covered in Section 8 - Cost, and Section 9 - Schedule (and Appendices D and I respectively)
High-level Lifecycle Cost estimate and implementation Schedule of the Kildare Line (extrapolation exercise using data from the Northern Line);	Covered in Section 8 - Cost, (and Appendix D) – [Note schedule no longer required by IE] (CAPEX only agreed) Operational requirements Covered in Section 3 – Operational Assessment
List of potential manufacturers / installers	Covered in Appendix R
High-level project Risk Register (technical, commercial and safety)	Covered in Section 10

1.2 Report Overview

The Executive Summary gives the reader an overview of the task, how it was addressed and the consequent outcomes.

The main report introduces the task and describes its background, before outlining the methodology used to assess the operating scenarios and the identified infrastructure options. It then discusses the BEMU vehicles and their charging mechanism to be clear on the requirements of the proposed infrastructure installation.

The operational analysis of the Northern Line and its timetables, existing and proposed, are then evaluated to understand the operational pattern that will exist at Drogheda station and hence set the parameters for the options to be considered.

The optioneering process is then described, which aligns with the Common Appraisal Framework guidelines, followed by the options considered, the criteria against which they were assessed and the results of that assessment. This was done using a 2-stage Multi-Criteria Analysis with the first stage providing an initial sift for the options that were technically and operationally feasible and a second stage using the CAF guideline criteria to arrive at the preferred options for each scenario. The full details of the assessment can be found in the Options Matrix and CAF Matrix as part of the Appendices.

Once the preferred options for each operating scenario emerged, an engineering exercise was performed to develop the design required to further describe and evaluate each one. Any additional requirements for the depot are then outlined for each of the options. With the design sufficiently developed Capex and Opex costs were generated for each of the options. The proposed implementation schedule is presented complete with a Gannt Chart to show how the preferred option for each Scenario could potentially be developed.

Conclusions and Recommendations for next steps are then noted at the end of the report followed by a number of Appendices containing additional information for some of the report sections.

1.3 Methodology

1.3.1 Getting started

Jacobs approach to this task was to follow the steps outlined below, methodically working through the practical options, to arrive at the best solution in determining the amount of BEMU vehicles to purchase as part of the upcoming Fleet Framework contract. Life Cycle Costs (LCC) were developed which encompass the Capital Expenditure (Capex) and the Operational Expenditure (Opex) required for the BEMU infrastructure for BEMU (including maintenance costs) to give an overall Life Cycle Cost for the options to help inform the decision-making process.

Jacobs knowledge of other aspects of the DART+ programme, in particular, the work carried out last year on the Traction Options Report [as part of the Rail Fleet Advisory Services (DART+ WP1)] provided a strong basis for understanding the infrastructure requirements of charging stations, the cost of installing them and the operational expenditure to both run the fleet and maintain the infrastructure. Engagement with suppliers/manufacturers (such as for batteries or pantographs) on that task meant that Jacobs could save considerable time researching this information as we already had an awareness of the key issues such as battery charging times or current limitations of the conductor systems.

Jacobs were able to engage productively and in collaboration with Iarnród Éireann from day one with pre-determined, targeted and specific information requests, as we already had a lot of the information needed for this task, to hand. For example, we knew the type of vehicles likely to make up the BEMUs including the type of battery and charging systems they are likely to employ. From our previous work, we knew the lifetime of the batteries and their related maintenance requirements. We knew the limitations on charging the batteries from both the batteries themselves and the infrastructure required to charge them, such as the overhead wire and the pantograph. In addition, through our train scheduling expert Gavin Sinclair's work recently with the IÉ Operations department on timetabling, we also had the latest information available on the working timetable.

With our existing knowledge of Iarnród Éireann's systems for Requests for Information (RFIs) and Technical Queries (TQs) we were able to generate relevant and targeted RFIs and TQs right from project commencement. (See Appendix Q for the RFIs and TQs raised on the project). We also set up and maintained a shared working environment and correspondence log to collaborate and track communications.

With our background knowledge of the task, and early productive engagement with IÉ it was possible to present initial options to IÉ for consideration by the third week after the task commencement. As such we were able to transition very quickly from the Information Gathering phase to the Option Proposal phase, saving valuable time for the overall study programme.

1.3.2 Operations

We considered three timetable scenarios as instructed by IÉ instead of those originally specified:

- Base scenario of 2 and 3 trains per hour at Drogheda (which is the current timetable);
- Train Service Specification TSS 1b (this had a total of 5tph DART services, of which 2tph operated as empty stock (not in passenger service) between Laytown and Drogheda); and
- Train Service Specification TSS 3 (6tph DART services at Drogheda).

In order to examine the operational feasibility of BEMU operation we conducted a review of the current timetable.

For the Base scenario we identified train services currently operated by diesel rolling stock that could instead be operated by BEMUs. We assessed the operational changes that would be required, including longer turnaround times at Drogheda and the need to make changes to the rolling stock deployment plans because currently some services at Drogheda also work to Dundalk and on other routes such as to Maynooth, where BEMUs will not operate.

For TSS 1b and TSS 3, IÉ issued a timetable extract for each of these scenarios and these gave details of the times of trains at Drogheda and the proposed platform workings and turnaround times. The timetables were based on DART services being operated by electric rolling stock with short turnaround times at Drogheda. We then had to modify the timetable and rolling stock deployment to account for these services being operated by BEMU rolling stock and the implications of this, such as longer turnaround times and increased platform occupancy at Drogheda. This then informed our approach to train battery charging at Drogheda; assessing where this may be carried out, the charge duration, and the periods that BEMUs would be occupying platform(s) at Drogheda. Other services (operated by diesel rolling stock) between Dublin, Dundalk and Belfast were included in the analysis so that these trains were accommodated at Drogheda in the times stated in the timetables for TSS1b and TSS3. We then calculated the likely fleet sizes to operate TSS 1b and TSS 3 using BEMU rolling stock.

1.3.3 Rail Infrastructure

Jacobs met with IÉ to consider the possible options available to operate the BEMU vehicles effectively and efficiently on the Northern Line as per the service patterns specified key Jacobs team members ware already familiar with the situation from our work on the Rail Fleet Advisory Services project and in particular the Traction Options Report. Therefore, the project team could be expertly guided and quickly brought up to speed on the key issues and constraints. The team considered the most appropriate way to charge BEMUs at Drogheda station focusing on overhead charging with no specific intervention required by IÉ staff. (During previous work on the "DART Extension Traction Power Options report - Issue C" (as per Appendix 6.2 of the tender documentation for this project) as part of the Rail Fleet project, Jacobs and IÉ agreed that direct overhead charging was preferable compared to a shore supply. This was because of the additional operational requirements, additional manpower, additional training requirements, manual handling and safety considerations. This is in line with the developing scenario planned for the new fleet and offers the safest and most efficient means of recharging the BEMUs. The pros and cons of on-line vs. off-line charging were evaluated with the team - considering a possible bay platform or siding for charging as a possible alternative to charging from the existing service platforms.

The options to be considered were evaluated across a number of technical criteria such as the required track arrangements along with the corresponding signalling, OLE and civil engineering requirements. In addition, specific electrical infrastructure requirements to support charging, such as new or enhanced substations and potential ESB connections or upgrades, were also developed to ensure all capital costs for charging stations were considered. As well as the charging stations, the team also considered the required modifications to Drogheda Depot to fulfil the maintenance and stabling requirements of the proposed BEMU vehicles running on the Northern Line. Throughout the process Jacobs were cognisant of the instruction in the tender documents (section 3.3 of the Scope of Services) that "The consultant shall minimise the extent of infrastructural changes, wherever possible".

Jacobs designed Drogheda Depot so we have a unique insight into how it operates and how best to modify it as required to account for the new fleet requirements. The project team were able to consult the original design team to more fully understand the depot, and its numerous constraints, in developing the new options.

The development of these options was done in close consultation with our rail operations team to ensure that they fitted with timetabling and operational flexibility constraints. As the options were developed, their corresponding Life Cycle Costs were also developed by our costing team in parallel. As the infrastructure design evolved, we calculated Capex and Opex for building and maintaining the infrastructure. The combination of these items facilitated the production of the Life Cycle Cost for each option.

In addition to the basic engineering elements mentioned above, the options were also evaluated on their environmental and planning implications by our environmental specialist. Any potential property impacts were

also considered although we have sought to find solutions that stay within current IÉ boundaries as much as possible.

1.3.4 Life Cycle Cost

We developed high level models to determine the life cycle cost associated with BEMU operating infrastructure, providing comprehensive through-life capital and operating costs to inform the Business Case (done by others) and demonstrate Value for Money comparisons.

The lifecycle cost models were developed iteratively, based on the options considered, by applying an agile methodology to expedite delivery. This is our standard approach, which is proven from similar schemes we have undertaken, and tailored specifically to this project. The steps taken were to:

- Define the cost drivers and value criteria against which the feasible options will be appraised, in accordance with the Multi Criteria Analysis (MCA) framework.
- Develop, configure and validate lifecycle models; capturing key assumptions.
- Collate alternative CAPEX cost schedules for the proposed electrical, civil and track infrastructure i.e. battery charging system, sidings and turnouts. (We referenced the extensive experience we have acquired from major rail infrastructure projects globally including those in the UK and Republic of Ireland and these provided appropriate benchmark costs for the proposed solutions and alternatives.)
- Estimate OPEX costs from use of benchmarked unit cost data to include all through-life expenditure including planned maintenance costs.
- Validate the outputs to support the narrative and for each feasible option.

1.3.5 Option Selection

We developed three options sufficiently to capture the following items:

- Operational Pattern
- High level design for infrastructure upgrades (e.g. charging point, depot, station)
- Capex and Opex for these infrastructure upgrades
- Life Cycle Cost (LLC) (from a combination of the above)

The NTA published "Guidelines for the Management of Public Transport Investment Projects" states (in relation to Phase 2 - Option Selection):

"The purpose of Phase 2 is to assess the more significant options for the various features that make up the Scheme and, through applying a robust and systematic selection process, to determine a preferred solution which will fulfil the Project Brief."

As such, we tested the three options developed through our Multi-Criteria-Analysis (MCA) developed for the project. We engaged early with IÉ to demonstrate and agree on the testing criteria to be used for the MCA. This resulted in some alterations such as the addition of a specific "Planning/Railway Order" criterion in the Options Matrix. The successful options were then further tested under the CAF criteria to arrive at the final selected options. Further detail of the Optioneering phase is given under section 4 "Optioneering".

Our Environmental team ensured that environmental issues were considered as part of option assessment. For example, issues pertaining to architectural heritage, land contamination or ecology may impact on possible charging station locations or on proposed modifications to the depot. They also considered any possible planning or railway order implications to the options under consideration.

The project team liaised closely to ensure any potential property requirements and the implications of same were highlighted at an early stage. We have attempted to minimise additional property requirements as part of the option selection process.

The result of the MCA was to conclude on a preferred option for each of the required BEMU operational patterns.

1.3.6 Report Development

With the selected options clear from the previous phase, we compiled our final option selection report outlining the options considered, approach taken, results obtained, and conclusions drawn. The report provides Iarnród Éireann with a preferred option, including an overall Life Cycle Cost, for the scenarios agreed.

1.3.7 Key Assumptions

Some key assumptions that were made at the outset of this report were as follows:

- A maximum of three options were to be developed
- All information required to complete the assessment would be readily available from Iarnród Éireann
- No surveys were to be required to perform the study
- Study was to be undertaken entirely remotely (especially considering Covid-19 restrictions in place)

[For a comprehensive list of the assumptions that were made in developing the report, please see Appendix S].

1.3.8 BEMU Report Review

A review of the document was undertaken by a senior reviewer within Jacobs that was not part of the project team nor had any involvement in the development of the report. This review was undertaken by [redacted], (Director of Operations – Rail, a senior role within Jacobs) as part of his role as Project Principal on this project. The Project Principal role in Jacobs is that of an experienced reviewer independent of the project and is designed to ensure high quality project deliverables are produced. [redacted] is an experienced rail professional with over 40 years' experience in the industry including extensive experience of Irish projects such as DART Underground and Metro North for example.

2. BEMU Overview

2.1 Introduction to BEMU

The purpose of the BEMU is to allow for operation of new DART multiple units on lines for the DART Expansion which are not electrified at present, prior to, full electrification of those lines. Previous work and discussions between Irish Rail, the NTA and Jacobs has identified that the Malahide to Drogheda route is the most likely of the DART Expansion routes to be feasible for battery operation, because of the relatively low service frequency and potential locations for charging the batteries at Drogheda.

For the purposes of this report, 316 kWh per HLU has been assumed as an indicative amount of energy that needs to be replaced at Drogheda. This has been taken from the Traction Power Options report 32109500/B.06/0005, Issue C, dated 23 August 2019 and produced by Jacobs. It should be noted that this was based on an early estimate using average station spacings and speeds but did not involve computer modelling of specific routes. Further simulations done by Jacobs earlier in 2020 as part of the Rail Fleet Advisory Services project for the NTA gave the following for the energy needed to be supplied from train batteries for a round trip from Drogheda – Connolly – Drogheda (assuming use of the existing overhead line from Connolly to Malahide and then batteries from Malahide to Drogheda) of:

- Flat-out (running as fast as possible) = 436 kWh
- Optimised (introducing coasting to give timings to match the motion time requirements exactly but no faster) = 230 kW

It is therefore a reasonable assumption that 316 kWh represents a typical battery energy requirement for this route, which is at an intermediate level between the worst case (flat-out) and the optimised case, thus allowing for some level of recovery from delays between Drogheda and Malahide.

2.2 BEMU Technology

A tender process is underway at present for the new DART+ fleet, which includes the possibility of pure EMUs and BEMUs. The tenders are being evaluated at present, but it will be early 2021 before a firm decision is made on which manufacturer is chosen. In the meantime, it is necessary to make assumptions on the battery requirements. The estimated energy requirement stated above is consistent with the requirements that the bidders have been asked to meet.

The battery type that will be used for the new fleet will depend on the chosen vehicle supplier but is likely to be lithium ion or lithium titanate, in order to deliver the required energy and power capacity within a feasible mass and space envelope. For the purposes of this report, the exact choice of battery type does not need to be known. From Jacobs' experience and from the simulation work on the DART Expansion Rail Fleet Advisory Services project, it is considered likely that the maximum level of power that will be delivered by batteries during acceleration will be approximately 1200 kW per HLU.

2.3 Battery charging - Static

The main method of battery charging that is considered in this report is fast charging while stationary at Drogheda. It has been stated in the client brief for this project and confirmed subsequently in meetings that the time to be allowed for static charging at Drogheda is 12 minutes including turnaround activities.

Irish Rail has mentioned the possible need to provide trickle charging overnight for each BEMU. This would consist of supplying a relatively low current for a prolonged period. Jacobs has investigated this possibility by reading general literature on lithium ion and lithium titanate batteries, looking at technical data from companies that supply rail vehicle traction batteries such as Toshiba, Hoppecke and Akasol. We have also discussed the matter with technical staff from Jacobs and Stadler working on the Energy Storage project on the Merseytravel

class 777 units, which involves fitting Toshiba lithium titanate batteries as part of a system supplied by ABB and integrated by the vehicle manufacturer Stadler.

We do not have any evidence from the research and discussions referred to above to consider that it is necessary to have overnight trickle charging. This could be confirmed with the bidders for the fleet if necessary.

2.4 Battery charging – from a new section of overhead line

One further possible solution is to have a section of new overhead line fitted to allow electrified running and battery charging from Drogheda southwards for some distance short of Malahide.

It should be noted that this is not a solution to allow for the use of battery units in advance of electrification, given that it involves a level of electrification, with the associated planning, costs, need for a Railway Order, etc. However, since it is a possible solution to providing battery charging, an estimate can be made of how long this electrification would have to be. This is given below. Note that this is an approximation and detailed analysis would require specific simulations.

It has been agreed through discussion with Irish Rail that it is reasonable to assume a minimum turnaround of 6 mins at Drogheda, which is time that can therefore be used for charging from a normal overhead line.

Assume that the current through a normal overhead line is approximately 200 A per pantograph. Assuming two pantographs on an HLU gives a power of 2 x 200 A x 1500 V = 600 kW per HLU. Assuming that the minimum turnaround time at Drogheda is 6 mins (=0.1 h), the energy that can be stored during that time is 600 kW x 0.1 h = 60 kWh per HLU. Therefore, the amount of energy that would need to be supplied from the OHL while running south from Drogheda would be 316 kWh – 60 kWh = 256 kWh per HLU.

It is known that the existing DART OHL can deliver a line current of 3000 A for 60 s and 1300 A continuously. For the purposes of this calculation, assume that a new higher specification overhead line would be able to deliver 3000 A continuously. This means that the power that can delivered from the new OHL is 3000 A x 1500 V = 4500 kW. From previous simulation work done by Jacobs, it is likely that the power that will be delivered while accelerating by a BEMU is approximately 1200 kW per HLU, and that a large proportion of the motion time will be spent drawing this power. It is a reasonable assumption that the BEMUs will run when under the new section of OHL with the same performance as in battery mode, rather than with the same performance as an EMU running in normal operation on an electrified section, to reduce the power demand for traction and so maximise the spare power available for charging. This means that the total power demand of 2 x HLUs would be 2 x 1200 kW = 2400 kW.

Therefore, the spare power available from the OHL will be 4500 kW – 2400 kW = 2100 kW.

There will be some time when the power demand is less than assumed above, for example, if the train has reached line speed or is coasting, meaning that more power would be available for charging. On the other hand, while the train is braking, the batteries are not likely to have sufficient power capacity to absorb braking energy (which is allowed for in the original value of 316 kWh) and take additional current from the OHL and so no additional charging can be allowed for while braking. To gain an estimate, it is considered reasonable to assume that these two effects approximately cancel each other out and so an average spare power of 2100 kW per train can be used. Taking half of that for an HLU gives an average charging power of 1050 kW per HLU.

Assume that the section of OHL for charging is fitted on the lines in both directions south of Drogheda for a proportion of the overall distance to Malahide, where P represents this proportion. (For example, if a quarter of the distance between Drogheda and Malahide was fitted, P would be a value of 0.25).

Where new OHL is fitted, a train can be powered from the OHL rather than drawing from the battery, so the total energy that needs to be supplied from the battery will be reduced as the value of P increases. What this means in particular is that the energy that needs to be supplied = 256 kWh per HLU (from above) can be reduced to a value of 256 x (1-P) kWh.

The total motion time allowed for in the new fleet Train Technical Specification for the BEMU on a journey from Drogheda to Connolly is 50 mins. From previous simulation work done by Jacobs, this would be made up of approximately 34 mins for Drogheda to Malahide and approximately 16 mins for Malahide to Connolly. So, the total round trip motion time for a journey Drogheda – Malahide – Drogheda is 2 x 34 mins = 68 mins.

The proportion of this journey fitted with OHL, as defined above, is P, so the time spent by a BEMU running on the OHL section in both directions is 68 x P mins, which is 1.13 x P hours.

This is the best case, in that it assumes that the train runs no faster than the maximum time allowed by the timetable, so would not be able to make up for any lost time while under the new section of OHL. This is considered to be a reasonable assumption because it is logical to carry out charging where the new OHL is fitted to the greatest extent possible, which means maximising the time and so running the train as slowly as is practical over that section.

The energy that can be supplied by the OHL for the length fitted is 1050 kW per HLU x time spent under the OHL, which is 1050 x 1.13 x P kWh = 1186.5 x P kWh.

Equating the energy that needs to be supplied and the energy that can be supplied by the new OHL for the length fitted gives 256 x (1-P) = 1186.5 x P. This can be rewritten as 256 – 256 x P = 1186.5 x P; and rearranging gives (1186.5 + 256) x P = 256.

This gives P = 256 / (1186.5 + 256) = 0.18.

The single journey distance from Drogheda to Malahide is 36.63 km, so a proportion of 0.18 of that is 6.6 km.

So, the new OHL would need to be fitted in both directions over a distance of approximately 6.6 km. Laytown is at a distance of approximately 7.64 km from Drogheda so the electrification would need to reach from Drogheda to just north of Laytown. If this was done, it would be reasonable to install the OHL from Drogheda to Laytown itself, to allow for contingency through the additional motion time under the OHL and for some charging while static at Laytown.

Note that the actual amount of OHL new needed could be more (flat-out) or less (fully optimised) and assumptions may vary from those made above.

It should be noted that there are two additional opportunities to reduce the amount of charging needed at Drogheda or over a new section of OHL. Firstly, if battery units only operate as single HLUs then the energy that needs to be supplied in total to a train halves. Secondly, if BEMUs run beyond Connolly they can store more braking energy.

The energy consumption estimate of 316 kWh allows for brake energy recovery while in the existing OHL between Malahide and Connolly, but not beyond. Simulations have indicated that the amount of braking for a typical station stop allows approximately 6 kWh per HLU. It is useful to note that allowing for running further than Connolly gives additional battery charging and reduces the amount of charging needed at Drogheda or on new OHL running south from Drogheda, as follows:

- Connolly to Grand Canal Dock – 3 stops in a single journey = 6 stops in a return journey = 6 x 6 kWh = 36 kWh
- Connolly to Greystones – 18 stops in a single journey = 36 stops in a return journey = 36 x 6 kWh = 216 kWh.

This could potentially reduce the amount of charging needed at or around Drogheda, potentially to a significant degree for running as far as Greystones. It is noted that this would increase the number of BEMUs needed since it would extend the length of the round trip and therefore extend the time for a given unit to do a round trip and be back at Drogheda ready for a following service.

3. Operational Assessment

3.1 Introduction

As stated previously, as part of the DART+ Programme, IÉ has identified that the operation of self-powered Battery Electric Multiple Units (BEMU) rolling stock will be required to operate train services where the network is currently not electrified between Drogheda and Malahide. South of Malahide trains will operate on existing overhead electric power infrastructure through to Dublin Connolly, Grand Canal Dock and Greystones.

This section of the report presents the assessment of the BEMU train operations, taking account of the charging requirements and necessary infrastructure.

3.2 Timetable Option Testing

The study brief identified scenarios for train service frequencies on the Northern Line to be considered with trains operating between Drogheda and Grand Canal Dock based on train service frequencies of 2, 3, 4 and 6 trains per hour. In discussion with IÉ, this has been modified to be three scenarios:

- Scenario 1: 2 and 3 trains per hour (tph) with 52 BEMU vehicles.

This scenario is effectively the December 2019 timetable and is the current Train Service Specification (TSS). This will be used as the base case service for timetable option testing.

In addition, an enhanced train service frequency scenario will be assessed based on TSS 1b and TSS 3 as provided by IÉ. These TSSs have superseded the 4 and 6tph scenario in the study brief and are based on trains operating with Electric Multiple Unit (EMU) rolling stock between Dublin and Drogheda. The following train service frequencies apply:

- Scenario 2: TSS 1b: 5tph; and
- Scenario 3: TSS 3: 6tph.

The analysis in this report is to assess the timetable and infrastructure interventions required if these three TSSs are operated by BEMU rolling stock. Concept infrastructure options will be considered at Drogheda to allow the batteries in BEMU trains to be charged whist trains turnaround at the station. The engineering of these options is presented in Section 5 of this report.

3.3 Northern Line

A route map is shown in Figure 3-1, which shows key stations relevant to the timetable options discussed in this report. This does not show all stations.

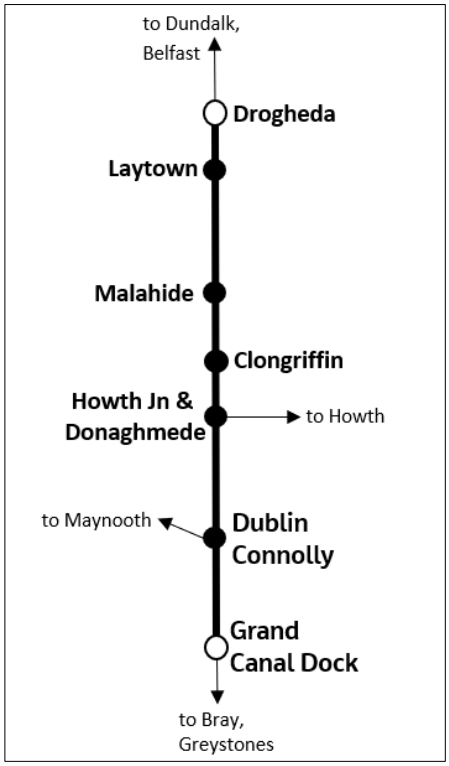


Figure 3-1 Northern line route map showing key stations between Dublin and Drogheda

3.4 Train Service Scenarios

Train Service Scenario 1 is the December 2019 timetable, and this will be used as the base for assessing infrastructure options for 2tph and 3tph.

3.4.1 Train Service Scenario 1 as the Current Situation

As an overview of train service on the Northern Line between Drogheda and Dublin Connolly, in the high peak there are 11 trains arriving at Dublin Connolly between 07:59 and 08:59. This comprises 6tph DART services (3tph from each of Malahide and Howth), 4tph from Dundalk/Drogheda and 1tph Enterprise service from Belfast (or Newry, as counted in the 08:00 hour at Dublin). Off-peak, the 10-minute interval DART timetable continues to operate all day with 3tph to each of Malahide and Howth. Typically, 1tph operates between Dundalk/Drogheda and Dublin Connolly. The Enterprise service operates every two hours.

The 6tph DART service continues to operate through the evening peak with 4tph operating north of Malahide to Balbriggan, Drogheda and Dundalk – these services originate from Bray, Pearse or Connolly.

3.5 Train Service Scenario 2 and 3: DART+ Train Service Specification

The Northern line Operational Pattern comprises an uplift in train service as part of the DART+ enhancement. The TSS is indicative and does not specify intermediate calling patterns but rather origin and destination pairings and service frequency expressed as the number of trains per hour.

There are two DART+ TSSs to be considered in addition to the base case of the current timetable:

- Scenario 2: TSS 1b; and
- Scenario 3: TSS 3.

In relation to the Northern line, both TSSs assume that other than the Belfast and Dundalk services, which are operated by Enterprise and DMU rolling stock respectively, all other services are operated by EMU rolling stock.

Howth is served by a frequent 6tph shuttle service from Howth Junction with connections there for Dublin.

The design of TSS 1b and TSS 3 was based on EMU operation and as such consideration of a 12-minute turnaround was not applied as a planning principle. The planning assumption was of an 8-minute turnaround. In the design of all TSS options the key deliverable was to maximise operation of services over the Loop Line Bridge at Connolly, it was established that the maximum stated capacity of 15tph could be delivered. All of the TSS options deliver this service level at this location and this by default became the primary service design point of each of the options. The variation of EMU and limited stop Dundalk and Belfast services on the Northern line provides a particularly difficult timetabling pattern, which required the flighting of services to allow for limited stop services on the route. The amalgamation of the above timetabling challenges and the at-grade nature of the network does not easily allow for manipulation of the timetable at terminals because the above issues dictate a service pattern at terminals in order to deliver a specific sequence of trains at the convergence of all lines at Connolly. Each TSS is described briefly in the next section in relation to the Northern line.

3.5.1 Scenario 2: TSS 1b

The proposed Northern line timetable comprises a total of 12tph. These are shown here with the possible BEMU services in bold:

- 1tph Dublin Connolly to Belfast;
- 2tph Dublin Connolly to Dundalk;
- **5tph Bray to Drogheda †;**
- 2tph Bray to Clongriffin;
- 2tph Greystones to Malahide.

† – of the 5tph Bray to Drogheda services (operated by EMUs), it is planned that 2tph will operate as empty coaching stock (not in passenger service) between Laytown and Drogheda. This means that these 2tph can turnaround in the depot rather than occupying a passenger platform at Drogheda.

3.5.2 Scenario 3: TSS 3

The proposed Northern line timetable comprises a total of 15tph. These are shown here with the possible BEMU services in bold.

- 1tph Dublin Connolly to Belfast;
- 2tph Dublin Connolly to Dundalk;
- **2tph Dublin Connolly to Drogheda;**
- **4tph Bray to Drogheda;**
- 3tph Dublin Connolly to Clongriffin;
- 3tph Bray to Malahide;

There are a total of 6tph operated by EMU rolling stock at Drogheda that are required to turnaround in passenger platforms.

3.5.3 Operational Challenges

The operational challenge of operating train services on the Northern line with BEMUs is the indicated minimum charging time of 12 minutes at Drogheda. While the current timetable and service levels can accommodate this turnaround requirement, there is concern that during periods of disruption and late running these delays cannot be recovered at the terminal, as is the case today, due to the minimum charging time required at Drogheda. This requirement will extend delays onto the second leg of the journey. With only one exception in TSS 3, turnaround times at Drogheda exceed the minimum 12-minute turnaround time, so operational contingency will exist (given that the TSS required turnaround times are greater than the required battery charging times).

Greater enhancement of the timetable above the current service levels, even with the purchase of additional BEMUs, will create greater platforming requirements due to the minimum charging requirements. Any further increase in service level beyond TSS 1b and TSS 3 will further increase capacity and platforming requirements.

Timetable recovery options which exist today during disruption on the Northern line by way of interchanging DMU fleets from other routes will not be possible as other routes will now be operated by EMUs; during disruption, operating EMUs north of Malahide will not be an option and this will reduce operational flexibility.

The use of BEMUs requires extending the turnaround times at Drogheda due to the charging requirement (as opposed to when EMUs are used where no charging is required). This in turn means extra vehicles are required to support the timetable.

3.6 Rolling Stock

3.6.1 Current Situation

Train services between Dundalk, Drogheda and Dublin Connolly are operated by 29000 Class DMUs and 22000 Class Intercity Rail Cars. Rolling stock diagrams are not self-contained; trains from Drogheda operate through to Bray for example, or also operate to and from Maynooth during part of the day.

Belfast services are operated by Enterprise sets consisting of a locomotive and eight vehicles including a generator van and driving van trailer.

It is proposed that BEMUs will replace the current diesel rolling stock on services between Drogheda, Dublin Connolly and Grand Canal Dock. This means that:

- Existing rolling stock diagrams will have to be re-worked to keep Dundalk, Drogheda and Maynooth services separate;
- Timetable changes will be required to serve some through journeys between Drogheda and Bray;
- Service levels south of Dublin Connolly will have to be maintained by extending Maynooth or Hazelhatch trains through to Bray instead;
- The aim should be to create self-contained diagrams that operate between Drogheda and Grand Canal Dock.

3.6.2 Battery Electric Multiple Units

It is planned that BEMUs will operate as a pair of Half-Length Units (HLU) to form one train consist of eight vehicles. For the 2tph and 3tph scenarios, a total of 52 vehicles (13 HLUs) will be in the fleet. Based on trains operating as a pair of HLUs, then a total of 12 HLUs can be in diagrammed service (6 circuits).

For the purposes of this report, we have been advised by IÉ to assume that BEMUs will require12 minutes turnaround time including battery charging time at Drogheda.

3.6.3 Electric Multiple Units

The Train Service Specifications 1b and 3 for 5tph and 6tph respectively are based on trains between Drogheda and Dublin being operated throughout by EMUs. The operational issues of these services being operated instead with BEMUs is considered in this report.

3.7 Drogheda Station

3.7.1 Overview

Drogheda station is situated 31.5 miles (50.7 Km) from Dublin Connolly on the main line linking Dublin with Dundalk and Belfast. The station has 3 platforms:

- Platform 1 – northbound through platform for trains from Dublin to Dundalk and Belfast;
- Platform 2 – southbound through platform for trains from Belfast and Dundalk to Dublin; and
- Platform 3 – for trains arriving from – and departing to – the south.

Operationally, the preferred platforming arrangements would have all terminating services use platform 3, with through services using platforms 1 and 2. There is flexibility in the layout with bi-directional working allowed in platforms 1 and 2 (southbound trains from Belfast and Dundalk can use platform 1 for example).

The Navan line to Tara Mines branches off immediately before and south of Drogheda station. This line is now lightly used. Inspection of the December 2019 Working Timetable shows a total of five freight trains per weekday. The rolling stock depot for the DMU fleet is adjacent and east of Drogheda station. Trains can access the depot directly from platform 3. Trains in platforms 1 and 2 require a shunt to access the depot. Immediately to the north of Drogheda station is the single line section across the Boyne Viaduct. Figure 3-2 shows the platform and track locations at Drogheda station.

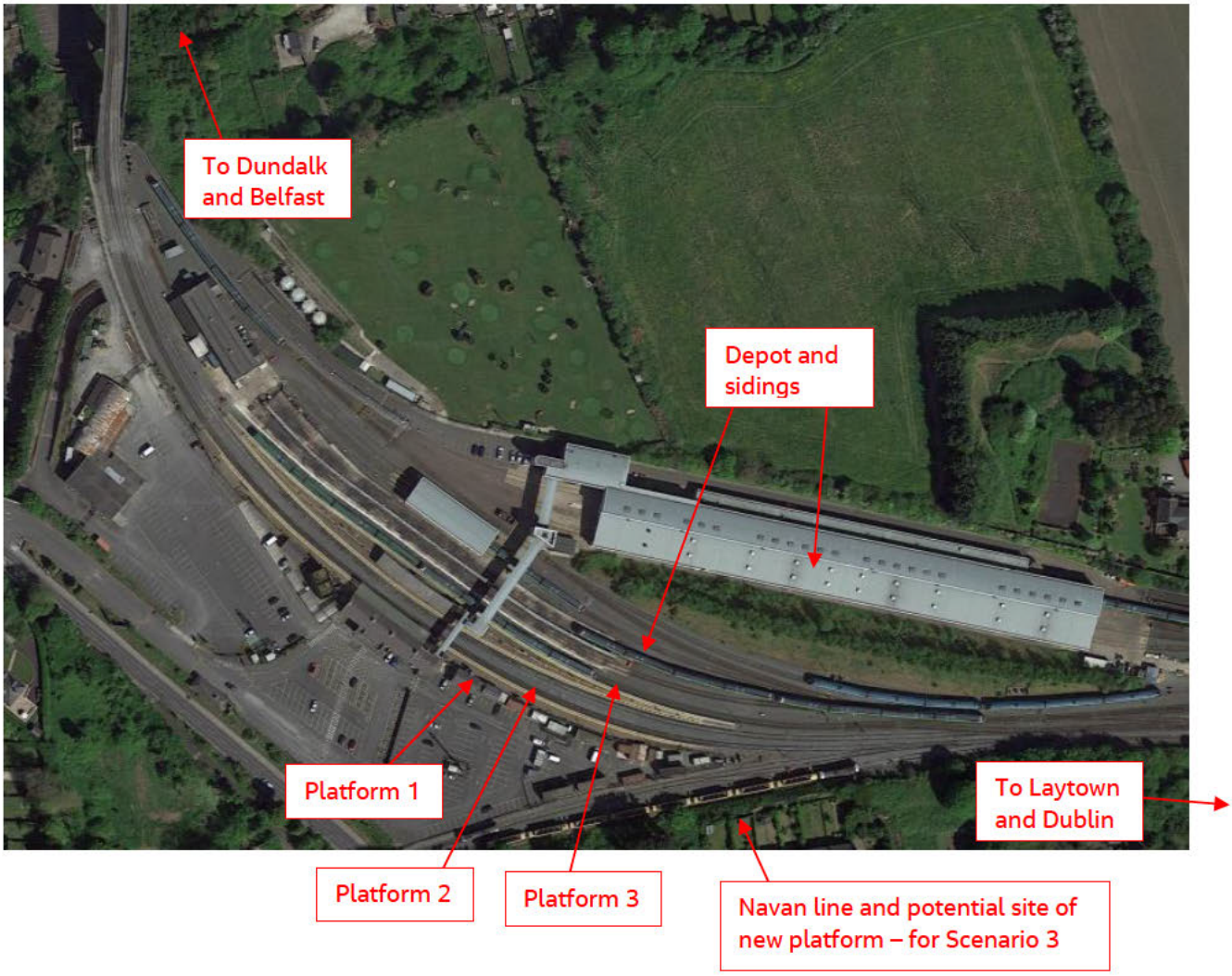


Figure 3-2 Drogheda Station and Depot

3.8 Infrastructure Options for Charging Points at Drogheda

The BEMU trains need to be charged at Drogheda station and/or at the depot. The turnaround time at Drogheda will be used to charge the train batteries and therefore it is planned that trains will require 12 minutes at Drogheda for charging purpose. It is assumed that the 12 minutes charging time is inclusive of turnaround activities, for example passengers boarding and alighting and pantograph raising/lowering.

Each of these options assumes a charging point is provided in the depot (depot road 4) – the Scenario 2: TSS 1b timetable requires use of the depot charging point twice per hour during the day to enable trains (not in passenger service) to turnaround at Drogheda.

Infrastructure Option 1a – Charging Point on Platform 3 and Depot Road 4

Only one platform (Platform 3) will have a charging point for this Option. This can accommodate up to 3tph. Therefore, the Scenario 1: December 2019 timetable level of service can be accommodated with selected trains operated with BEMU rolling stock turning around in platform 3. Depot road 4 will also have a charging point. We have assumed that as the number of BEMUs increase and enter service, the number of diesel trains required in traffic on the Northern line will be reduced therefore reducing the instances of fuelling required at Drogheda in the busiest times of the day and that one fuelling road would be sufficient. Redundancy here is available by charging a train in depot road 4 should there be a problem in platform 3.

To provide contingency and redundancy, **Infrastructure Option 1c** is proposed so that a BEMU can also be charged in platform 2 should platform 3 be unavailable for any reason. This will only be used to charge one train at a time and will not be used in the planned timetable operation.

Infrastructure Option 1b – Charging Point on Platforms 2 and 3 and Depot Road 4

In this option two platforms will have a charging point. Platform 3 and a through platform (platform 2) will both have a charging point that can be used simultaneously. In terms of redundancy this provides greater operational flexibility in accommodating 3tph turning around in two platforms, for example during service perturbation when two BEMUs might be at Drogheda at the same time, or if platform 3 is occupied or blocked with another train. Both the Scenario 2: TSS 1b (5tph) timetable and the Scenario 1: December 2019 timetable level of service can be accommodated in this option.

Infrastructure Option 2 – Charging Point on Platforms 2 and 3 and New Platform and Charging Point on the Navan line and Depot Road 4

A new platform situated on the Navan line would allow trains from Dublin to terminate and turnaround here. Operationally, trains terminating in the new platform would be conflict free with Dundalk and Belfast services. Trains departing from the new platform would cross to the Up line (towards Dublin) and this is a conflicting move with trains heading north to Dundalk and Belfast.

Any new platform on the Navan line would have to be of sufficient length to accommodate an eight vehicle FLU (or two HLUs joined together).

In this option, it is assumed that a new platform and charging point on the Navan line would be in addition to a charging point on platforms 2 and 3, and depot road 4 and this means that 6tph could be timetabled to turnaround at Drogheda and this therefore delivers Scenario 3: TSS 3.

3.9 Option Testing

3.9.1 Scenario 1 – Current Timetable (DART 2tph and 3tph)

The 2tph and 3tph scenario is based on the December 2019 timetable and replacing existing DMU rolling stock with BEMUs on selected services. This is based on a fleet size of 52 BEMU vehicles. With 48 vehicles expected to be available for passenger service, this means 12 HLUs can be diagrammed in traffic. Since trains will be paired (two HLUs operating together in one 8-vehicle formation), there are six trains that could be operated by BEMUs as replacements for the Class 29000 DMUs, as set out in **Error! Reference source not found.**.

The Working Timetable shows all passenger and freight train schedules along with ancillary moves such as empty coaching stock schedules. Movements between the depot and the station at Drogheda are, however, not shown (it is likely these are planned under local arrangement). Based on the rolling stock diagrams a platforming plan can be worked out – this is shown in Appendix N.

Based on the December 2019 Working Timetable, this shows that:

- Four trains start from Drogheda station in the morning originating from the depot;
- There is one empty stock move from Drogheda to Dundalk in the morning to form an early service from there to Dublin;
- During the day there are instances of 11-minute turnaround times at Drogheda – these will need to be extended slightly to allow for battery charging should BEMUs be deployed on these particular diagrams; and;

- There are two instances in the evening of six-minute turnarounds at Drogheda – if these trains are to be formed of BEMUs then a timetable and diagramming solution will have to found to allow for a 12-minute turnaround at Drogheda.

Based on the December 2019 timetable, there are four opportunities to use BEMU rolling stock. However, this cannot be a 'like-for-like' replacement as the diagrams will require to be modified as discussed briefly here (more detail is shown in Appendix N):

- **06:28 Drogheda to Pearse** – the next working is a service from Pearse to Dundalk. A timetable and diagram swap will be required.
- **06:45 Drogheda to Pearse** – after arriving at Pearse this diagram then works a service to Maynooth which will have to be swapped with an inbound train from Maynooth.
- **07:05 Drogheda to Bray** – this diagram can still be self-contained by working an evening Bray to Drogheda service (16:50 from Bray) rather than working the 17:30 service from Bray to Maynooth as it currently does. Based on the current timetable and diagrams, this 8-vehicle BEMU could then stable at Bray during the day, or return empty stock to Drogheda if required.
- **07:58 Drogheda to Bray** – can turnaround at Connolly (or at Grand Canal Dock, assuming the Phoenix Park Tunnel line timetable is different) and work a service back to Drogheda. The service to Bray will have to be worked by a train from Maynooth or Hazelhatch.

Additionally, there is one diagram that starts at Connolly that could be operated by a BEMU:

- **07:50 Connolly to Drogheda** – this diagram starts at Connolly and can be self-contained. Assumes out-stabling at Connolly rather than being stabled overnight at Drogheda. This diagram will no longer be able to act as a standby should the Enterprise set be unavailable to work the 07:35 from Dublin Connolly to Belfast.

This train plan uses 40 out of 52 vehicles.

In 2022 it is planned that 41 intermediate ICR vehicles will be added to the 22000 Class InterCity Railcar fleet. In respect of the Northern line this means that cascaded rolling stock will be available to operate an additional peak service, departing Drogheda after 08:00. This is could then be operated by an 8-vehicle BEMU which then accounts for operating 48 vehicles in traffic.

With some timetable and platform alterations trains can turnaround in platform 3 and therefore a charging point need only be provided here for trains in passenger service. Operational flexibility would be increased if a charging point was also installed in platform 2. Depot road 4 will also have a charging point.

The current timetable is shown at Drogheda for the start of service covering the time period 06:00 to 08:30 and this shows trains identified as being formed of BEMUs using platform 3.

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Use BEMU Stock?
05:40 Dundalk	06:03	2	06:04	Pearse	8 x 29000	No
Depot	Arrive platform 3 no later than 06:16	3	06:28	Pearse	4 x 29000	Yes
Depot	Arrive platform 3 no later than 06:33	3	06:45	Pearse	7 x 22000	Yes
06:30 Dundalk	06:54	2	06:55	Bray	8 x 29000	No

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Use BEMU Stock?
Depot	Arrive platform 3 no later than 06:53	3	07:05	Bray	8 x 29000	Yes
06:30 Newry	07:19	1	07:21	Connolly	7 x 22000	No
07:10 Dundalk	07:34	1	07:36	Pearse	8 x 29000	No
Depot	Arrive platform 3 no later than 07:46	3	07:58	Bray	8 x 29000	Yes
07:35 Connolly	08:09	1	08:11	Belfast	Enterprise	No
Depot	Arrive platform 3 no earlier than 08:02	3	08:xx (no earlier than 08:14)	To be confirmed; new service from 2022		Yes
06:45 Belfast	08:22	1	08:24	Connolly	Enterprise	No
07:09 Pearse	08:05	2	08:30	Pearse	8 x 29000	No
07:50 Connolly	08:49 (retimed to arrive 1 minute earlier)	3	09:00	Connolly	8 x 29000	Yes

A platform occupancy chart is shown in Figure 3-3, where:

- Minutes are shown on the x-axis and platform numbers are shown on the y-axis;
- Green bars show BEMU trains turning around at Drogheda;
- Blue bars show DMU trains turning around at Drogheda;
- Yellow bars are northbound trains to Dundalk/Belfast; and
- Orange bars are southbound trains from Dundalk/Belfast;

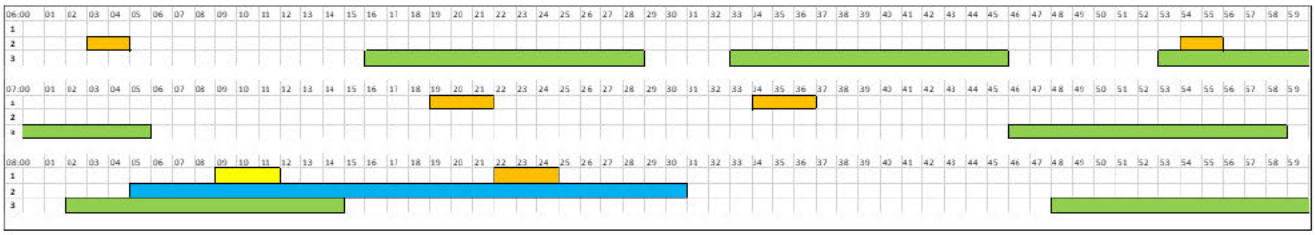


Figure 3-3 Platform Occupancy Chart at Drogheda station for base scenario

3.9.2 Scenario 2 – TSS 1b (DART 5tph)

The 5tph DART EMU services (to be replaced with BEMUs) together with the Belfast and Dundalk services are shown in Table 3-2, using the 08:00 – 08:59 hour as a typical hour (sorted by departure time). This shows all trains arriving at, and departing from, Drogheda together with platform details. BEMUs can replace the EMU diagrams without any change to the turnaround times at Drogheda.

Table 3-2 TSS 1b timetable and platform workings at Drogheda

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Note
Dublin Connolly	08:08	1	08:09	Dundalk	DMU	
Bray	07:53	3	08:10	Bray	BEMU	

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Note
Empty from Laytown	07:45	Depot	08:17	Laytown	BEMU	Empty to Laytown then passenger service to Bray
Belfast	08:19	1	08:20	Dublin Connolly	Enterprise	
Dundalk	08:27	1	08:28	Dublin Connolly	DMU	
Dublin Connolly	08:36	1	08:37	Dundalk	DMU	
Empty from Laytown	08:25	Depot	08:41	Laytown	BEMU	Empty to Laytown then passenger service to Bray
Bray	08:13	2	08:46	Bray	EMU	
Bray	08:23	3	08:50	Bray	BEMU	
Dublin Connolly	08:49	1	08:54	Belfast	Enterprise	Extended dwell waiting for the Southbound Dundalk service to arrive
Dundalk	08:54	2	08:55	Dublin Connolly	DMU	

This shows that:

- The EMU turnaround times at Drogheda are no less than 12 minutes;
- Trains turnaround in platforms 2 and 3;
- 2tph use the depot to turnaround; and
- With one exception, Belfast and Dundalk services use platform 1.

If Bray-Laytown/Drogheda services were operated by BEMUs then charging points would be required on:

- Platform 2;
- Platform 3; and
- Depot road 4.

Platforming at Drogheda

A platform occupancy chart is shown in Figure 3-4, where:

- Minutes are shown on the x-axis and platform numbers are shown on the y-axis;
- Green bars show BEMU trains turning around at Drogheda;
- Yellow bars are northbound trains to Dundalk/Belfast;
- Orange bars are southbound trains from Dundalk/Belfast; and
- DR4 is Depot Road 4.

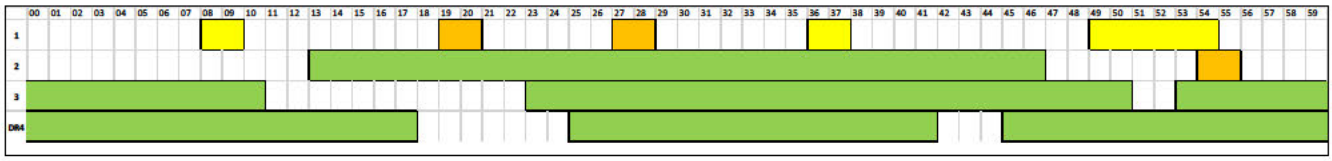


Figure 3-4 Platform Occupancy Chart at Drogheda station for TSS 1b

3.9.3 Scenario 3 – TSS 3 (DART 6tph)

The 6tph service operated by EMU rolling stock together with the Belfast and Dundalk services are shown in Table 3-3, using the 08:00 – 08:59 hour as a typical hour (sorted by departure time). This shows all trains arriving at, and departing from, Drogheda together with platform details.

Table 3-3 TSS 3 timetable and platform workings at Drogheda

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Note
Belfast	08:00	2	08:01	Dublin Connolly	Enterprise	
Dublin Connolly or Bray	07:59	3	08:07	Dublin Connolly or Bray	EMU	8-minute turnaround
Dublin Connolly	07:17½	1	08:19½	Dundalk	DMU	
Dundalk	08:19	2	08:19½	Dublin Connolly	DMU	
Dublin Connolly or Bray	08:04	New	08:23	Dublin Connolly or Bray	EMU	
Dublin Connolly or Bray	08:11	3	08:27	Dublin Connolly or Bray	EMU	
Dublin Connolly or Bray	08:30	3	08:35	Dublin Connolly or Bray	EMU	5-minute turnaround
Dublin Connolly	08:40½	1	08:41	Dundalk	DMU	
Dundalk	08:47	2	08:47½	Dublin Connolly	DMU	
Dublin Connolly or Bray	08:43	3	08:51	Dublin Connolly or Bray	EMU	8-minute turnaround
Dublin Connolly	08:53	1	08:54	Belfast	Enterprise	
Dublin Connolly or Bray	08:46	New	08:55	Dublin Connolly or Bray	EMU	9-minute turnaround

This shows that:

- There are four instances each hour where EMU turnaround times at Drogheda are less than12 minutes;
- Trains turnaround in platform 3 and in a new platform;
- Platforms 1 and 2 are used by Belfast and Dundalk services (no EMUs turnaround in these through platforms).

If services between Bray/Dublin Connolly and Drogheda are to be operated by BEMUs, then:

- Turnaround times at Drogheda will need to be increased to be at least 12 minutes;
- Platforms 2, 3 and two new additional platforms will require charging points at Drogheda;
- The new platforms could be on the Navan line and depot road 4 (with a platform face).

Increasing Turnaround Times

To remove the instances of 5, 8 and 9-minute turnaround times, the following associations (inbound train forms outbound train) should apply, as shown in Table 3-4. Note that the increases in turnaround times are based on keeping DART services at the times specified in TSS 3.

Table 3-4 Changes required to trains operated by BEMUs at Drogheda in TSS 3

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Turnaround Time(minutes)
Dublin Connolly or Bray	07:46	2	08:07	Dublin Connolly or Bray	BEMU	21
Dublin Connolly or Bray	07:59	3	08:23	Dublin Connolly or Bray	BEMU	24
Dublin Connolly or Bray	08:11	2	08:27	Dublin Connolly or Bray	BEMU	16
Dublin Connolly or Bray	08:04	New	08:35	Dublin Connolly or Bray	BEMU	31
Dublin Connolly or Bray	08:30	3	08:51	Dublin Connolly or Bray	BEMU	21
Dublin Connolly or Bray	08:43	New	08:55	Dublin Connolly or Bray	BEMU	12

The use of BEMUs requires extending the turnaround times at Drogheda due to the charging requirement (as opposed to when EMUs are used where no charging is required). This in turn means extra vehicles are required to support the timetable. The extra BEMU requirement is two additional HLUs in traffic (8 vehicles).

Platforming at Drogheda

Changing the associations at Drogheda to create longer turnaround times means that the BEMU trains would need to turnaround in platforms 2, 3 and 2 additional new platforms (shown here as platform 4 and DR4 for example). This is shown in the platform occupancy chart in Figure 3-6, where

- Green bars show BEMU trains turning around at Drogheda;
- Yellow bars are northbound trains to Dundalk/Belfast; and
- Orange bars are southbound trains from Dundalk/Belfast

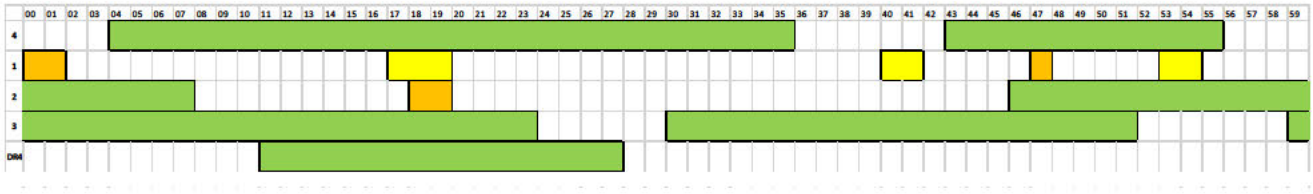


Figure 3-5 Platform occupancy chart for Drogheda (TSS 3) based on BEMU rolling stock (with no timetable change)

To avoid the construction of two new platforms at Drogheda, either:

- One of the six trains per hour DART services that uses Depot Road 4 will do so operating as empty stock between Laytown and Drogheda (this then fails to meet the requirements of TSS 3); or
- Minor adjustments to the timetable will be required to make better use of the available platform capacity (avoiding platforms 1 and 2 being occupied by a diesel service at the same time)

Timetable Changes

One Dublin Connolly to Dundalk service is required to be retimed to arrive at Drogheda later and then operate 4 minutes later throughout to Dundalk. This then creates space in platform 1 to allow a southbound train to depart first, freeing up space in platform 2 to allow a BEMU to turnaround there. All the DART timings and southbound departures from Drogheda remain unaltered therefore not impacting on the tightly defined operating pattern on the Northern line.

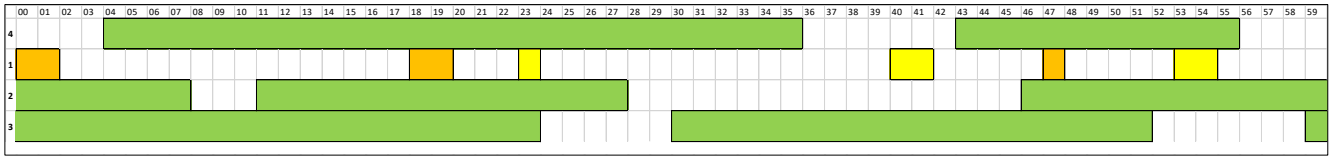


Figure 3-6 Platform occupancy chart for Drogheda (TSS 3) based on BEMU rolling stock (with a timetable change)

3.10 BEMU Fleet Size

3.10.1 BEMU Fleet Size for Current Timetable (DART 2tph and 3tph)

IÉ have advised that 52 BEMU vehicles are specified for the 2 and 3tph scenario. This means that 48 vehicles can be in service giving 92% availability.

This could either be reduced to 44 vehicles out of 52 (85% availability meaning one train will have to be formed of 4 vehicles rather than 8), or 48 vehicles out of an increased fleet size of 56 vehicles (86% availability).

3.10.2 BEMU Fleet Size for TSS 1b

The information provided by IÉ for TSS 1b shows the times of trains at Drogheda and at Bray, together with the associations at Bray. This shows that services inter-work between routes and origin-destination pairs (for example, a service from Drogheda would then work a service to Maynooth or to Clongriffin). When all services are operated by the same train type of rolling stock, then this is not a problem and makes productive use of the rolling stock and the available capacity at Bray to turnaround (there are three sidings on the Down side of the station – a train arrives at Bray from the north and then proceeds forward to the siding to turnaround before returning to Bray station to form a northbound service). With Drogheda services now planned to be operated by BEMUs, this would mean operating BEMUs on some Maynooth services. However, to avoid this, some re-working of the associations at Bray means that 3tph Maynooth services can be self-contained with EMUs working these trains. BEMUs would have to operate both the Drogheda and Clongriffin services (the timetable extract showing these services is shown in Appendix O).

This requires in total 24 circuits (48 HLU) BEMUs in traffic. Based on 89% availability, 216 vehicles (54 HLU) will be required in the fleet.

3.10.3 BEMU Fleet Size for TSS 3

TSS 3 requires some inter-working between services at Bray but with some minor swaps Drogheda services can be self-contained with Hazelhatch and Maynooth inter-working in one instance each hour out of a total of 6tph. At Connolly, the 2tph Drogheda service has to inter-work with two out of the three Connolly to Clongriffin services (the third train per hour at Clongriffin is operated by a self-contained circuit, which can be an EMU). A timetable extract is shown in Appendix P.

With BEMUs operating services between Drogheda, Clongriffin, Connolly and Bray, 22 circuits are required in traffic (44 HLU). Based on 90% availability, 49 HLU (196 vehicles) will be required in the fleet.

It is noted (perhaps counter intuitively) that TSS 1b requires more BEMUs than TSS 3 because:

- TSS 1b has 5tph between Drogheda and Bray whereas TSS 3 has 4tph between Drogheda and Bray;
- TSS 1b requires interworking at Bray so BEMUs are required to operate the Bray-Clongriffin service whereas in TSS 3 interworking is required at Connolly to work Connolly-Clongriffin service.

The use of BEMUs requires extending the turnaround times at Drogheda due to the charging requirement (as opposed to when EMUs are used where no charging is required). This in turn means extra vehicles are required to support the timetable. The extra BEMU requirement is two additional HLUs in traffic (8 vehicles).

3.10.4 Extensions to Greystones

Both TSS 1b and TSS 3 show 2tph operating through to Greystones (from Malahide in TSS 1b and Maynooth in TSS 3). The single line section between Bray and Greystones limits the overall capacity to 2tph in both directions. Extension of Drogheda BEMU operated services to Greystones will either be on the assumption of replacing the existing 2tph, or will require additional infrastructure. As part of the DART+ Coastal South enhancement, there is a potential proposal that a short section of track is doubled, and this intervention would allow for one additional train to operate in each direction.

If 2tph from Drogheda were extended to Greystones (instead of the Malahide or Maynooth service), then this would require additional BEMU vehicles in traffic. One additional circuit (one 8-vehicle FLU) would be required bringing the total fleet size required in traffic to:

- TSS 1b: 200 vehicles out of a fleet size of 224 (89% availability);
- TSS 3: 184 vehicles out of a fleet size of 204 (90% availability).

3.11 Stabling Requirements

3.11.1 Current Situation (2 – 3 TPH)

There is a total of 35 vehicles stabled overnight at Drogheda that are required in passenger service on weekdays. This comprises 28 vehicles of the 29000 Class DMU and 7 vehicles of the 22000 Class Intercity Railcar fleet. The train consists are shown in Table 3-5.

Table 3-5Stabling requirement at Drogheda (December 2019 timetable)

Departure Time	Formation	No of Vehicles	Destination	Note
06:20	8 x 29000	8	Dundalk	empty stock to Dundalk
06:28	4 x 29000	4	Pearse	Could be 8 x BEMU
06:45	7 x 22000	7	Pearse	Could be 8 x BEMU
07:05	8 x 29000	8	Bray	Could be 8 x BEMU
07:58	8 x 29000	8	Bray	Could be 8 x BEMU
08:xx	8 x 22000	8	To be confirmed	▪ New service from 2022 when additional intermediate Inter City Railcars enter service; ▪ Could be 8 x BEMU

It is planned that once the 41 intermediate InterCity Railcars are added to the fleet this allows for services to be strengthened and vehicles cascaded to allow for additional services to operate from 2022. On the Northern line it is planned that one additional peak service will be provided in the morning, departing Drogheda after 08:00.

In addition, at Drogheda there are also:

- 16 vehicles of the 29000 Class DMUs in the depot for maintenance; and
- 4 vehicles of the DART EMU fleet for wheel turning.

When BEMUs become operational and are introduced into service, the trains identified in Table 3-5 will be diagrammed to be formed of 8-vehicle BEMUs. This requires 40 vehicles starting from Drogheda in the morning (10 HLU). The diesel units (22000 Class ICR's & 29000 Class DMUs) will be cascaded to provide additional services elsewhere. The 29000 Class DMUs cascaded to the Maynooth line will still need to come to the Drogheda Depot for Maintenance and this would most likely happen during the day between the peak hours. One service starting from Connolly in the morning will also be operated by a 8-vehicle BEMU.

It is planned that with the introduction of BEMUs, a total of 76 vehicles will be required to be accommodated overnight at Drogheda:

- 40 x BEMU vehicles;
- 4 x BEMU vehicles in maintenance;
- 8 x 29000 vehicles (for the Dundalk service);
- 16 x 29000 vehicles in maintenance; and
- 8 x other vehicles as contingency capacity.

The capacity at Drogheda depot is for 70 vehicles (or 68 vehicles useable space when trains are in multiple of 4-car sets), as shown in Table 3-6.

Table 3-6Stabling Capacity at Drogheda Depot

Location	Capacity (Vehicles)
Road 3 – Bay Road	8
Road 4 – Service Slab	8
Road 5 – Service Slab	8
Road 6 – 1 in lathe	4
Road 7a (10 vehicles, but useable space for 8 when trains are in 4-car sets)	8
Depot Building	24
Sidings at McGraths Lane (1 x 4-car leaves the 174m and 2-car shunts free)	4
Viaduct shunt head	4
Navan branch line (New stabling facility to be added)	8

(To accommodate all of the 40 BEMU vehicles it is proposed to stable one 8-vehicle BEMU on the Navan line)

3.11.2 TSS Scenarios

The overall stabling strategy for the DART+ Programme has not yet been finalised. However, for the purposes of this study it is assumed that 80 BEMU vehicles will be stabled at Drogheda overnight utilising a new stabling facility to augment capacity, which will be constructed to the south of the existing Drogheda depot.

The overall stabling requirement is determined by the timetable, particularly the specified first and last trains times and service frequency by time of day. Sensitivity to operating earlier services from either Drogheda or Dublin or Bray also informs stabling requirement. The stabling requirement could be reduced if departures in the 06:00 hour from Drogheda are reduced to 2, 3 or 4tph, or the stabling requirement could increase if the first train from Drogheda is required to arrive in Dublin earlier at 06:30.

Based on the December 2019 timetable, the starting point is to assume that the first southbound departure from Drogheda should arrive at Dublin Connolly no later than 07:00, and that the first northbound arrival at Drogheda should be no later than 08:00.

3.11.3 TSS 1b

Based on the TSS 1b timetable, the following departures from Drogheda will have to be formed of rolling stock starting from Drogheda in the morning:

- Departures from Drogheda at: 06:10, 06:46, 06:50, 07:10, 07:46, 07:50 (and in addition the following empty coaching stock moves from Drogheda to Laytown at 06:17, 06:41, 07:17 and 07:41);
- 10 trains start from Drogheda before the first northbound train arrives. This requires 20 HLU trainsets at Drogheda (80 vehicles);
- Dundalk services will require five circuits with trains operated by 8-vehicle 29000 Class DMUs. 16 vehicles will be stabled each night at Dundalk and the remaining 24 vehicles at Drogheda;
- At a minimum, 4 x BEMU and 16 x DMU vehicles will be at Drogheda for maintenance purposes.

At Drogheda, there will be useable stabling space for a total of 116 vehicles:

- 68 vehicles within the existing depot footprint (Table 3-6);
- 48 vehicles in the new stabling site;

Based on the TSS 1b timetable (Appendix O) and extending this back to show the first services arriving at Bray in the morning (based on the assumption the first service arrives at Bray no later than in the December 2019 timetable at 06:55), then six trains (12 HLU, 48 vehicles) are required to start at Bray in the morning (06:14, 06:22, 06:34, 06:42, 06:50 and 06:54). Early southbound Northern line services that start from Connolly requires 14 HLU, 56 vehicles. Two services that start from Clongriffin (07:01 and 07:29) can originate from Connolly or Maynooth.

Table 3-7 shows indicative stabling locations for BEMUs for TSS 1b.

Table 3-7 BEMU Stabling for TSS 1b

Location		DMU (Vehicles)	BEMU (Vehicles)
Existing Drogheda Depot & Sidings	Road 3 – Bay Road	8	
	Road 4 – Service Slab	8	
	Road 5 – Service Slab	8	

	Road 6 – 1 in lathe		4
	Road 7a (10 vehicles, but useable space for 8 when trains are in 4-car sets)		8
	Depot Building	16	8
	Sidings at McGraths Lane (1 x 4-car leaves the 174m and 2-car shunts free)	4	
	Viaduct shunt head	4	
New Drogheda Sidings	Road 1		8
	Road 2		8
	Road 3		8
	Road 4		8
	Road 5		8
	Road 6		8
Bray			48
Connolly	(Northbound service start)		16
Connolly	(Southbound service start)		56
Connolly	(Clongriffin service start)		8
Maynooth			20

3.11.4 TSS 3

Based on the TSS 3 timetable, the following departures from Drogheda will have to be formed of rolling stock starting from Drogheda in the morning:

- Departures from Drogheda at: 06:07, 06:23, 06:27, 06:35, 06:51, 06:55, 07:07, 07:23, 07:27, 07:35, 07:51, 07:55 and 08:07;
- 13 trains start from Drogheda before the first northbound train arrives. This requires 26 HLU trainsets at Drogheda (104 vehicles);
- Given 104 vehicles exceeds the capacity at Drogheda, it is assumed that the TSS will have the first service from Dublin arriving at Drogheda earlier or trains will operate as empty stock from Connolly (or Maynooth depot) to Drogheda in the morning;
- Dundalk services will require five circuits with trains operated by 8-vehicle 29000 Class DMUs. 16 vehicles will be stabled each night at Dundalk and the remaining 24 vehicles at Drogheda;
- At a minimum, 4 x BEMU and 16 x DMU vehicles will be at Drogheda for maintenance purposes.

Based on the TSS 1b timetable (Appendix P) and extending this back to show the first services arriving at Bray in the morning (based on the assumption the first service arrives at Bray no later than in the December 2019 timetable at 06:55), then two trains are required to start from Bray in the morning (06:27 and 06:39), four trains would start from Connolly (Northern line southbound), one train would start from Connolly (northbound, to Clongriffin at 07:15) and two train would start from Clongriffin (07:04 and 07:12). One service that starts from Drogheda would have to operate as empty stock to Drogheda – shown in Table 3-8 as operating from Connolly.

Table 3-8 BEMU Stabling for TSS 3

Location		DMU (Vehicles)	BEMU (Vehicles)
Existing Drogheda Depot & Sidings	Road 3 – Bay Road	8	
	Road 4 – Service Slab	8	
	Road 5 – Service Slab	8	
	Road 6 – 1 in lathe		4
	Road 7a (10 vehicles, but useable space for 8 when trains are in 4-car sets)		8
	Depot Building	16	8
	Sidings at McGraths Lane (1 x 4-car leaves the 174m and 2-car shunts free)	4	
	Viaduct shunt head	4	
New Drogheda Sidings	Road 1		8
	Road 2		8
	Road 3		8
	Road 4		8
	Road 5		8
	Road 6		8
Bray			16
Connolly	(Northbound service start)		40
Connolly	(Southbound service start)		32
Connolly	(Clongriffin service start)		16
Maynooth			24

3.12 Kildare Line

3.12.1 Current Timetable

In the current timetable there is an hourly service between Hazelhatch and Grand Canal Dock during the day increasing to 2tph in the Peaks. Services are operated by 22000 Class ICRs which also interwork with other services and not completely self-contained to Hazelhatch-Grand Canal Dock services. For the purposes of calculating a fleet size, five diagrams/circuits are required and assuming trains operate in 8-car formation, then 10 HLU, 40 vehicles are required in traffic. 11 HLU (44 vehicles) would be needed assuming a 91% availability (or 12 HLU, 48 vehicles, 83% availability).

In addition, we have also been asked to consider 2tph service between Hazelhatch and Heuston which doesn't currently exist. This would require three diagrams/circuits (6 HLU, 24 vehicles) in traffic if operated separately from the Grand Canal Dock service. When combined with the 2tph Grand Canal Dock service a total of seven diagrams (14 HLU, 56 vehicles) with a total fleet size of 16 HLU (64 vehicles) assuming 88% availability. The net saving of one diagram is based on shorter turnarounds at Hazelhatch.

Two platforms (or sidings) would be required at Hazelhatch to turn trains around and therefore both would require a charging point.

3.12.2 TSS 1b

The TSS 1b timetable has 11tph at Hazelhatch on the Slow Lines. These services operate to Heuston (4tph), Docklands (4tph) and Grand Canal Dock (3tph). Based on the information in the TSS 1b timetable, if these

services were operated by BEMUs then five platforms or sidings would be required at Hazelhatch to accommodate BEMUs turning around (Note the TSS 1b EMU timetable requires three turnback sidings).Turnaround times would be between 17 and 22 minutes.

This shows that 19 diagrams/circuits (38 HLU, 152 vehicles) are required in traffic. A fleet size of 42 HLU, 168 vehicles (90% availability) would be the required fleet size

4. Option Assessment

4.1 Process

The operational analysis described above outlines the differing scenarios that Jacobs were required to analyse and provide options for, based on the initial scope in the brief to look at the following train frequencies arriving at Drogheda: 2tph; 3tph; 4tph; and 6tph.

However, during the task IÉ advised new Train Service Specifications had been developed and these were provided to Jacobs with an instruction that they were to be used instead of the originally briefed train frequencies. The revised timetable scenarios are described as follows:

- **Scenario 1**: 2/3 tph as per the existing timetable
- **Scenario 2**: Train Service Specification 1b (3tph in normal service + 2 empty running vehicles arriving/departing Drogheda)
- **Scenario 3**: Train Service Specification 3 (6 tph)

Once the operational analysis was completed, it was possible to understand what platforming capacity was required to achieve the above timetables given the charging time needed for BEMUs to charge in Drogheda. The direction by IÉ was that a12-minute turnaround time should be allowed for the charging and associated activities.

Jacobs undertook an optioneering exercise to select the best option for the three timetable scenarios. The optioneering process followed the Common Appraisal Framework guidelines using a two stage Multi Criteria Analysis (MCA) approach. The first stage allows for an initial "sift" based on a number of operational, technical and other criteria, to identify options that are technically and operationally feasible. The result of this first stage is essentially a "Pass" or "Fail", determining which of these options are carried through to the second stage. This second stage uses the criteria specified in the CAF Guidelines (as outlined below) to further evaluate the options and select the ones that are most appropriate to the three specified scenarios.

This process began with a brainstorming workshop which was held by the Jacobs project team to consider potential options. Following the meeting, the options were documented in the Optioneering Matrix that was developed for the project, with an assessment made on each option against numerous criteria covering technical, operational, environmental, commercial and other considerations.

The options were evaluated against each of the criteria and a summary comment provided in each case. A colour coding was also assigned to each evaluation based on the traffic light or RAG (Red-Amber-Green) system. Green represents the most favourable assessment with few difficulties or disadvantages considered for the option. Amber (or Yellow) represents the next level of assessment where there may be some disadvantages, but which are generally considered to be at a level that can be overcome by reasonable intervention. And finally, Red represents an assessment where there were some significant concerns or disadvantages with the proposed option for that particular criterion which would likely make it difficult to achieve the intended result.

Based on the assessment, the options with the most "Green" categories received a favourable assessment whilst the options with the most "Red" categories received a less favourable assessment. These assessments were then followed with a Pass/Fail designation being awarded to each option as appropriate. Please see Appendix L for the full Stage 1 Options Matrix.

Once the above assessment was complete, it was clear that a number of options were not operationally or technically feasible. Those options that were considered feasible were brought forward for a second stage assessment using the criteria of the Common Appraisal Framework.

These criteria are as follows:

- Economy
- Safety
- Integration
- Environment
- Accessibility and Social Inclusion
- Physical Activity (if applicable)

For an assessment such as this which is looking at the potential installation of technical infrastructure in one fixed location, it was considered that the Integration and Physical Activity criteria could be scoped out of the assessment.

- **Physical Activity** – This criterion is included in the CAF procedure to consider benefits such as walking or cycling if they are applicable to the particular options being assessed. As the options here all relate to a technical installation in one location at Drogheda station/depot, this criterion is deemed to be not applicable for the purpose of this assessment.
- **Integration** – This criterion is included in the CAF procedure to consider benefits such as how a newly proposed piece of transport infrastructure connects with existing transport infrastructure and the community into which it is to be located. As the options here all relate to a technical installation in one location at Drogheda station/depot, this criterion is deemed to be not applicable for the purpose of this assessment.

Furthermore, it was noted that there will likely be little to separate the options under the criteria of Safety and Accessibility and Social Inclusion although these were assessed for completeness. In essence then, as far as the CAF process is concerned, the main criteria are Economy and Environment. Whilst it is permissible under the CAF guidelines to give "weightings" to the most significant criteria, it is not mandatory. It was felt that this was not necessary in this case. With "Economy" and "Environment" being the key criteria here, additional weightings would have provided the same result. Please see Appendix M for the full stage 2 CAF Matrix.

4.2 Optioneering Outcome

The result of this assessment process yielded the following preferred infrastructure options for each of the Timetable Scenarios:

- **Scenario 1:** 2/3 tph as per the existing timetable – Infrastructure Option 1a. Charging station only on Platform 3 and conversion of depot road 4 to a charging station for depot functionality.
- **Scenario 2:** Train Service Specification scenario 1b (3tph in normal service + 2 empty running vehicles arriving/departing Drogheda) – Option 1b. Charging points on Platforms 2 and 3 and conversion of depot road 4 to a charging point for depot functionality and to serve empty runners.
- **Scenario 3:** Train Service Specification scenario 3 (6 tph) – Option 2b. Charging stations on Platform 3 and 2 and conversion of depot road 4 to a charging station for depot functionality - PLUS new platform and charging station on the Navan line branch. In this case, the platform is located on the existing track (north side), thereby single-tracking the required section length.

5. Preferred Infrastructure Option for each Timetable Scenario

5.1 Scenario 1 (Base Scenario 2 or 3 tph): Infrastructure Option 1a – Charging at Platform 3 and Depot Road 4.

5.1.1 Permanent Way (Base Scenario)

The proposed alterations to the existing Permanent Way infrastructure are limited to the installation of new Insulated Rail Joints (IRJs) as required by Electrical & Power to block traction return, as detailed within Section 5.1.4 below. At each location, this will involve the removal of the existing rail which is to be replaced by a shop-glued IRJ rail.

In total, eight IRJ rails are proposed, as shown on drawing D3422300-JAC-DRG-EMF-000001 within Appendix A. The position of each IRJ rail shown is indicative only and is to be reviewed at a subsequent stage when further survey information is available to ensure that minimum rail lengths, etc. are achieved.

Along with the above IRJ works, new trapping protection is proposed to protect the mainline from trains proposed to be stabled overnight on the Navan Line. This trapping protection will be provided via a turnout leading to a buffer stop positioned within the cess. It is currently envisaged that the IRJs proposed in this location to block traction return can be utilised as part of this trapping arrangement.

5.1.2 Civils (Base Scenario)

The civils input to this option is limited to providing ancillary civils support to E&P and OLE equipment. At this design stage it assumed this will principally be as follows:

- New concrete raft foundation to support new substation building. Assumed to be formed of 250mm thick reinforced concrete slab with a minimum 250mm well compacted subbase. This is subject to confirmation of ground conditions and equipment loading.
- Assumed pile foundations to new OLE support structures. Assumed to be 610mm diameter steel driven piles subject to confirmation of the ground conditions.
- Cable troughing to facilitate new cable routes.
- New approximately 135m long sheet piled retaining wall, between 1m-1.5m high, along the cess of the down Navan line to create space for a new driver's walkway to facility stabling of one full train set. Walkway to be formed of a 700mm wide gravel walking route along the base of the new retaining wall. Retaining wall embedment depth and form will be subject to confirmation of ground conditions.

[A gravity precast L-shaped unit was also considered here to avoid sheet piling given the proximity of residential properties. However, the over dig for installing the L retaining wall would be more labour intensive and it would need temporary works and temporary land access for its installation. Also, it would then be required to confirm the new backfilled 1 in 1 slope is suitable and it would probably need to utilise some slope stabilisation such as a GEOgrid/Geotextile/Soil Nails (subject to GI outcome)]

5.1.3 Overhead Line Equipment (OLE) (Base Scenario)

The new BEMU trains are to be charged at Drogheda station. For charging these units, a number of possible charging systems were considered.

5.1.3.1 Overhead Charging Options

Two different overhead line systems were considered for the charging process: Conductor Bar and an OLE wire system. These different systems are explained below with their pros and cons.

- **Conductor bar system:** A contact wire of conventional cross section is clamped into the conductor rail profile. The conductor bar is extruded from aluminium alloy. It is usually 12m in length so the conductor bar will require support at 10m-12m intervals. Figure 5-1 below (*photos taken from Furrer & Frey manual*) shows a typical conductor bar and its support assembly. Due to its simplicity the overall conductor bar system requires less maintenance and fewer interventions than a wire system although the cost of installation is typically 20% more expensive than the equivalent wire system.

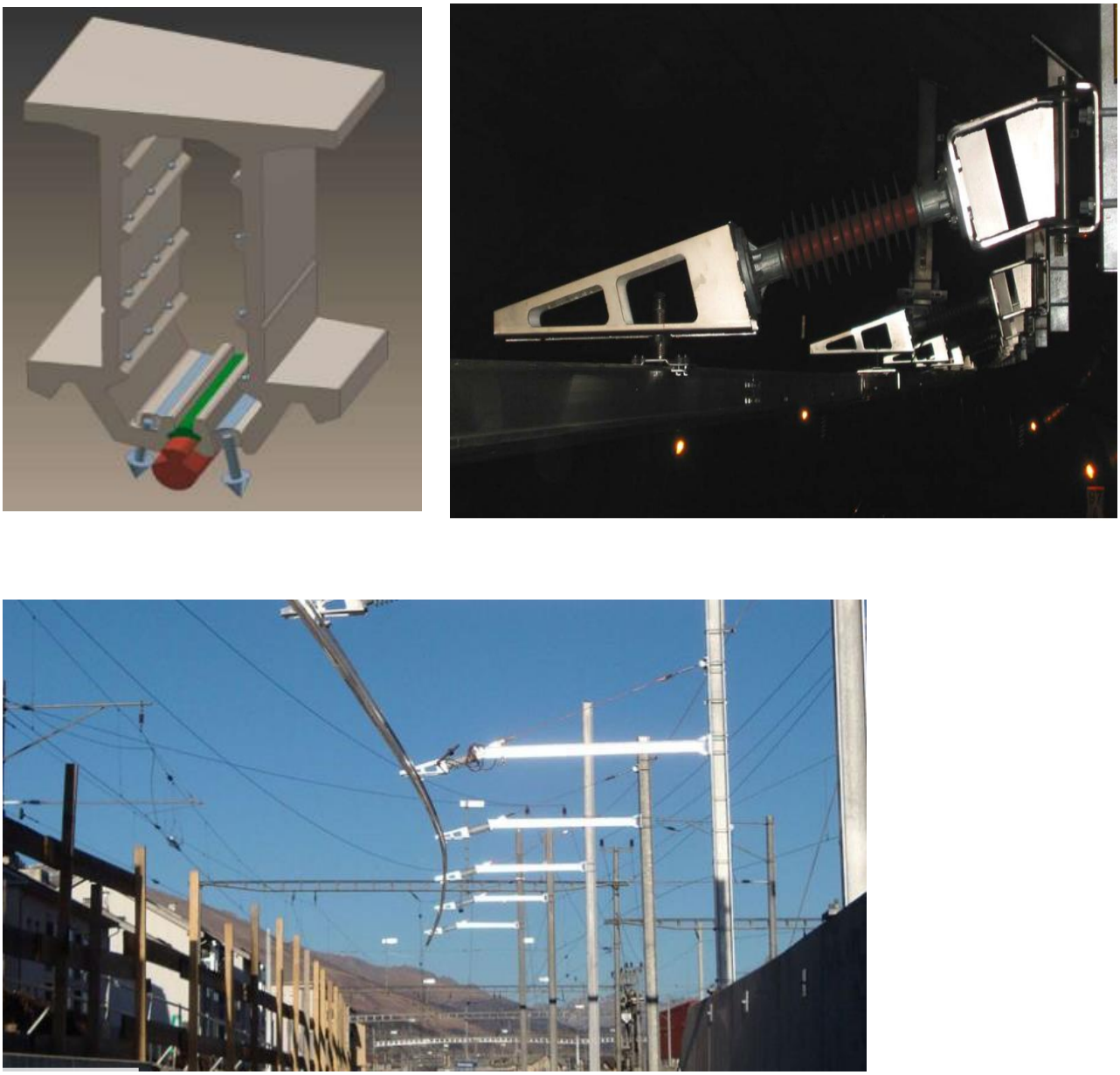


Figure 5-1 Typical Conductor Bar Installation

- **Wire system:** As shown in Figure 5-2, a conventional wire system consists of contact wires, catenary wire and current carrying droppers, which are supported by cantilevers installed on the structures. For bonding, an earth wire will be connected to all the structures which carries any return current back to the substation.



Figure 5-2 OLE System

5.1.3.2 Option selection for overhead charging

Based on the two systems describe in the previous section, three options have been considered for the Drogheda situation. These are the Continuous Conductor Bar System through the Platform Area; Discrete Conductor Bar System; and the Wire system.

- **Continuous Conductor Bar System Through Platform Area**
  The continuous conductor bar system throughout the platform area will have conductor bar, contact wire, support assembly and structure. For future electrification the conductor bar system can be interfaced with the conventional wire system. Although the installation of a conductor bar system has several advantages compared to a wire system, this option is not favoured due to the following points:

  - At Drogheda station, the length of platform 2 and platform 3 is approximately 217m as they share the same island, which means number of structures required will be approximately 21.
  - Due to the bi-metallic contact between the conductor bar and the contact wire, extreme humidity in conjunction with aggressive dust can cause fast wear/oxidation of the components.
  - For bridge clearances the conductor bar is approximately 115mm deep, so in extreme cases the twin contact wire system (OLE catenary system), gives better clearance than the conductor bar.
  - With this conductor bar option there will be major modifications required to the existing canopy.
  - Due to track curvature, and number of structures required for conductor bar this will impact with signal sighting. Relocation of signals would very likely be required and may be very difficult to achieve successfully.

- **Discrete Conductor Bar System**
  This system will have a conductor bar system with two structures at the location where the train pantograph will be raised during the static condition. There will be 4 pantographs per FLU at 42m centres (i.e. 2 pantographs per HLU). To feed power to each pantograph, a conductor bar with two supports are required.

  Although the installation of a conductor bar system has several advantages compared to a wire system. This option is not favoured due to following points:

- To feed every pantograph through conductor bar there will be a separate cable route, these will be difficult to install and maintain on the platform area.
- To have a feeder wire from the first conductor bar arrangement to all of them will require even more structures to support the aerial feeder wire.
- For future planning, when this route will be electrified using a catenary system, the conductor bars and structures will be redundant.
- With this conductor bar option there will be modifications required to the existing canopy.

- **Wire system**
  The contact/catenary wires are supported by cantilever assemblies mounted on the structures. These structures are placed 65-70m apart for straight routes or 20-40m apart on routes with curvature. For bonding, an earth wire will be connected to all the structures which helps to carry return current back to the substation. Bridge clearances could be achieved with a different catenary system arrangement and transition to a future wire system will require minimal changes.

A type description is given in Table 5-1 below.

Table 5-1 Brief summary of all above system and different comparison between them

Description/ System	Discrete Conductor bar system	Conductor bar system through platform area	Catenary/Wire system
Number of Structures	2 structures to feed per pantograph. For FLU with 4 pantographs require 8 structures	Every 10-12m	Maximum span of 65m and due to curvature, every 20-40m
Bridge Clearance	Not applicable as this option will have conductor bar only at specific locations	Conductor bar is approximately 115mm high, so can't use in very reduced clearance structures	In extreme cases twin contact wire system gives better clearance
Cost	[redacted]	[redacted]	[redacted]
Static or dynamic charging	Static charging only	Static or Dynamic charging	Static or Dynamic charging
Modification to Existing Infrastructure	Major as cable route to be routed on platform area, modification to existing canopy	Major modification required for existing canopy	Minor, modification not required to canopy as structures could be place either side of canopy
Maintenance	Less maintenance as compared to catenary system	Less maintenance as compared to catenary system	Maintenance requirement is more than conductor bar system due to the number of elements of the system
Tensioning Devices	No tensioning devices are required as contact wire is clamped with conductor bar	No tensioning devices are required as contact wire is clamped with conductor bar	Tensioning devices are required for anchoring contact wire and catenary wire

Signal Sighting	May impact signal sighting and relocation of signals may require solving signal sighting issue	May impact signal sighting and relocation of signals may require solving signal sighting issue	Relocation of signals not required, OLE structure could be positioned to avoid signal sighting issue

5.1.3.3 Wire system description

For all the charging options (1a,1b and 2b), the wire system is the preferred option. Due to the current (amperage) requirement the proposed wire system will consists of two contact wires, instead of one as per the existing Irish rail system, and catenary wire with droppers. The current required to charge a FLU is approx. 2.1kA Based on the current required there will 2x107mm^2 contact wires and 1x153mm^2 catenary wire. (ref: Appendix G). The dual contact wire design has been used extensively in the ADIF (Administrator of Railways Infrastructure) CR-160, known as Conventional system in Spain and is designed for use up to 160km/h. The Conventional system is designed for 3000 V DC with power traction substations approximately 20 km apart.

The photographs in Figure 5-3 show the dual contact wire system installed on the Madrid-Albacete line in Spain.



Figure 5-3 dual contact wire dropper arrangement(left) and registration support(right)

Based on current requirement ADIF has designed different systems as shown in ADIF manual and copied in Table 5-2.

Table 5-2 ADIF Manual Designs

CONCEPTO	CR 160	C.R.U. 220	CR 200/220	A.V.E.
H.C. (Cu).	2 x 107 mm²	2 x 120 mm²	2 x 150 mm²	1 x 120 mm²
SUSTENTADOR.	CU 153 mm²	CU 153 mm²	CU 184 mm²	Bz 70 mm²
SEC. TOTAL (H.C. +SUST.) mm²	367	393	484	190
Y. MÁXIMA (A).	1.651/3.302	1.768/3.537	2.178/4.356	850
FEEDER (mm²).	NO	Cu 2 x 153	Cu 1 x 225	
TENSE H.C. (Kg.).	1.000	1.530	2.025	1.529
TENSE CARACTERÍSTICO (Kg/ mm²).	9.35	12.75	13.5	12.74
TENSE SUSTENTADOR (Kg.).	1.389	1.620	2.550	1.529
VELOCIDAD ONDA (Km/h).	365	426	439	426
VELOCIDAD TREN (Km/h).	160	220	220	300
VELOCIDAD ONDA/V. TREN (Km/h).	2.28	1.93	1.99	1.42
PÉNDOLAS (TIPO).	NO. EQUIPOTENC	EQUIPOTENCIAL	EQUIPOTENCIAL	EQUIPOTENCIAL
MÉNSULAS (TIPO).	ADIF	ADIF	TUBULAR/ACERO	TUBULAR/ACERO
LONGITUD MÁXIMO VANO.	60	60	60	65
LONGITUD MÁXIMO CANTÓN.	1.200	1.200	1.200	1.200
Nº EJES SECCIONAMIENTOS.	1	1	1	2
RELACIÓN COMPENSACIÓN.	5 a 1	3 a 1	5 a 1	3 a 1
AGUJAS.	CRUZ Y TANG	TANGENCIALES	TANGENCIALES	CRUZADAS

Based on above details for the CR 160, at Drogheda the proposed catenary system will be 2 x contact wires, 1 x catenary wire and current-carrying droppers.

The incoming power to the OLE will be from the newly installed substation through feeder cables to the switching mast. A switch will be mounted on the mast for isolation purposes. Each track will have a separate feed taken from the substation. The mast to support the contact wire and catenary wire will be installed on the platform and/or near the cess. The type of mast will be single track cantilever, two track cantilever, portals and self-supporting anchor structures. The contact wire and catenary wire anchor system will be either Balance Weight Anchor (preferred for the proposed system) or a Tensorex. There will be a Balance Weight Anchor on one end of contact/catenary wire and a fixed anchor on another end. The foundation for the mast will be either concrete gravity foundation or a pile foundation as preferred at this stage by our civil engineers.

5.1.3.4 OLE Option 1a development

- The proposed option 1a will provide charging infrastructure for platform 3 and depot road 4.
- For OLE registration and supports, back to back single-track cantilever structures will be proposed in the cess between platform 3 and depot road 4. (ref: Appendix A for details).
- The incoming supply will be from the north end of the platform taken from a new substation. There will be a switching portal at the end of depot road 4 to feed to the OLE through a switch. The switch will be a 2-position switch or a CME (circuit main earth) switch. (Type of switch to be discussed at later stages.)
- The switching will also have a fixed anchor for OLE wires to run for depot road 4. Instead of this portal a Twin Track Cantilever (TTC) could be used depending on the structure loading calculation at a later design stage. At the end of the depot road these wires will be terminated with a balance weight anchor (preferred for this design) or Tensorex.
- The OLE wiring for platform 3 will begin from north of platform 3 with BWA or Tensorex and will run through the platform and at the south end this will be terminated.
- An earth wire will be installed connecting all the structures together for carrying return current back to the substation and for bonding.

- It has been noted that there is a footbridge crossing this track leading to the depot. According to data received from IE the vertical clearance is 5.765m. and with reduced encumbrance bridge clearances could be achieved. For details of bridge clearance assessment refer to Appendix H.

- All bridges that are within contact line zone (as per standard BS EN 50119-2020, BE EN 50122-1 and BS EN 50122-2) are bonded to main earth terminal of the station area to allow a robust earthing system. Detailed Bridge bonding assessment to undertaken at later stages.

5.1.4 Electrification & Plant (E&P) (Base Scenario)

The proposed E&P works associated with Option 1a are based on the provision of a new traction substation located between the mainlines and the Drogheda Depot turn back siding on the north side of Drogheda Station. The disused turntable will need to be relocated to build the substation in this location. The approximate price of relocation is provided in section 8. Figure 5-4 below shows the preferred indicative location for the traction substation identified:

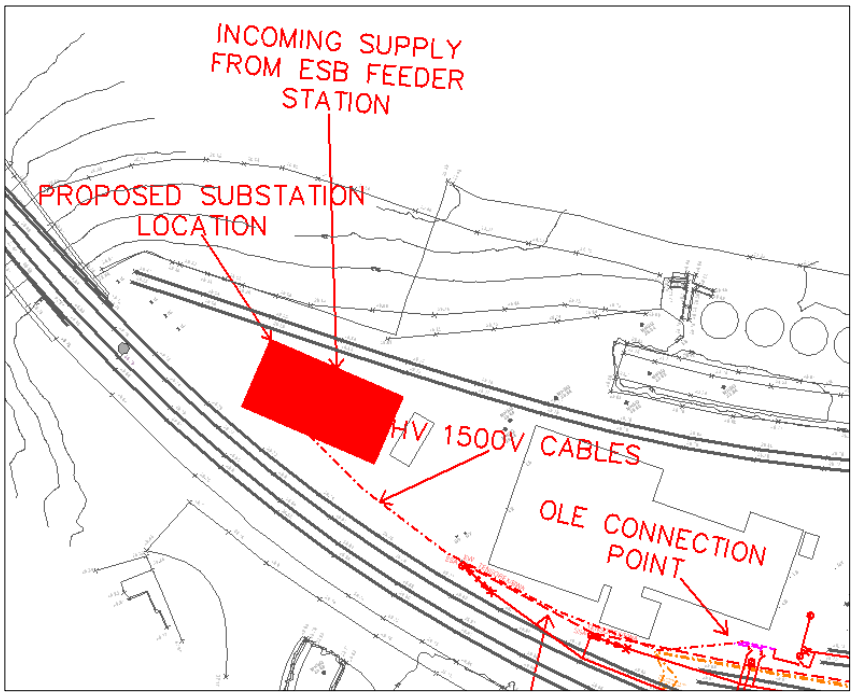


Figure 5-4 Proposed traction substation location for Option 1a

The proposed traction substation will supply the charging OLE equipment positioned through Platform 3 and on the depot road 4. The operational priority charging is to be reserved for Platform 3 with automatic switchgear control provided to limit charging to a single BEMU train at any given time. Therefore, the depot lane will only charge trains when no BEMU's are charging in the main charging station.

Based on the operational and rolling stock requirements of the BEMU rolling stock, the size of the traction substation required to supply the charging infrastructure for Option 1a has been calculated as a minimum of 3.2MVA, Maximum Import Capacity (MIC) from the ESB. An approximate cost of the ESB works is provided in section 8, it should be noted that formal quotations should be sought at subsequent stages of design. We note that ESB will require payment a minimum of 6 weeks prior to their works commencing.

The traction transformer will be supplied directly from an ESB grid connection with a secondary side terminating to a 12-pulse rectifier unit for the conversion of AC to DC. The High Voltage AC switchboard will provide protection on the primary side of the transformer and protection to the grid connection. DC circuit breakers on the secondary side of the transformer will protect the charging infrastructure and any secondary side equipment. A negative

return path will be provided through negative return cables via terminations between the rails and negative busbar in the traction substation. SCADA control and monitoring to be provided between the Substation and Connolly ECR.

Table 5-3 below shows a high-level breakdown of the equipment required for the traction substation for Option 1a.

Table 5-3 Option 1a Substation Equipment

Equipment	Rating	Quantity	Example Supplier
Grid Connection	MIC 3.2MVA	1 No	ESB
Positive DC Cable	500mm² (1500V DC)	4 (Length as required)	Caledonian Cables
Negative DC Cable	240mm² (1500V DC)	4 (Length as required)	Caledonian Cables
HV AC Switchboard	320A @10kV AC	1 No	Schneider Electric
Transformer	3.2MVA	2 No	ABB
12-Pulse Rectifier	2.1kA	2 No	ABB
DC Circuit Breaker for rectifier protection	2.1kA @ 1500V DC	1 No	Schneider Electric
DC Circuit Breakers for feeder	2.1kA @ 1500V DC	2 No + spare	Schneider Electric

Below Figure 5-5 provides a high-level view of the traction substation arrangement for Option 1a.

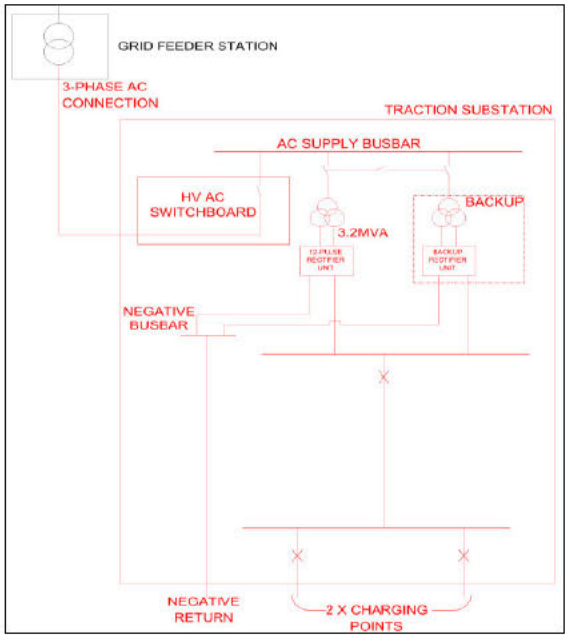


Figure 5-5 Traction substation schematic for Option 1a

To provide a defined DC return current path, a pair of IRJs positioned at both ends of the charging roads are required to provide a buffer zone. The DC return cables are to be bolted directly to the rail and will be routed to the traction substation to terminate on to the negative busbar. To ensure redundancy, 2 No return cables to substation will be provided per OLE charging point.

Stabling for Option 1a is envisaged to be in the existing depot with provision for one additional trainset on one of the Navan lines. To achieve this new lighting and CCTV cameras will be required, it is assumed that the new lighting and the cameras shall be fed from existing supplies at Drogheda Station. Costings for this equipment is provide in section 8.

Option 1a has the lowest energy demand out of the 3 options proposed. A smaller energy demand equates to a reduced operational cost as well as a reduced capital expenditure, because of the reduced capacity and cheaper equipment required.

During consultations with ESB and Irish Rail, details have been provided on the currently available grid connection and infrastructure in place. ESB has indicated that the existing 10kVA feeder station may have sufficient supply capacity, such that charging of a single BEMU train at one time may be possible without the need for network reinforcement. ESB has further stated that to provide power to more than one BEMU train at a time, significant resilience upgrades would likely be required to the local electricity grid.

A key design constraint and disadvantage is apparent in Figure 5-4 where it is shown that the traction substation will sit between the mainlines and the turnback siding of the depot. The problem with having a substation in this location is the availability of access for the ESB. It has been noted that ESB already has an agreement in place for the existing Depot substation. Agreements need to be in place between Irish Rail and the grid supplier (ESB) to allow for safe egress to the substation. We note that there is potential access stairs from the underbridge road access which avoids the need for ESB personnel crossing track to access the substation. Another design constraint of this location is the limited route for the incoming ESB cables to the substation. As the proposed location is between running lines, the ESB incoming cable route will either travel around the running lines, under the rails via the underbridge, or over the rails.

A Battery Buffer system has been investigated to reduce and smooth the overall demand. It is not deemed to be necessary for this option since the output power requirement will be similar to the input power provided. Thus, there would be little saving in terms of ESB connection cost or subsequent energy costs. As such the costs of installing a battery buffer system in this case would outweigh the benefits, however further detail on the system is provided for the other options discussed below.

For additional details regarding the E&P design decisions, infrastructure, systems, specifications, and limitations, refer to Appendix F. This Appendix Includes sections on DC stray currents, EMC, Earthing & Bonding, cable routes, and MOS equipment.

5.1.5 Signalling (Base Scenario)

Signal DA294 is positioned beyond the OLE anchor point structure which could compromise the signal sighting from the train cab stopping position on Platform 3. The most workable solution would be to relocate signal DA294 approximately 20m closer to the end of the platform and ensure that it is situated on the approach side of the anchor point structure. The cost for this signal relocation is reflected in the signalling allocation noted in Appendix D for the base option.

All existing signal positions are currently assumed. Actual positions are subject to survey. All signal sighting will need to be subject to a more detailed review in order to confirm the assumptions made in this study.

The immunisation of signalling infrastructure in and around the proposed OLE equipment would need to be investigated further to ensure any potential compatibility issues are addressed.

5.1.6 Environmental (Base Scenario)

A summary of key environmental and planning considerations is set out below.

1) The Railway Order 'route' is not considered to be the most appropriate mechanism to achieve consent for Option 1a as it is entirely within lands owned by Irish Rail. (However, where third party lands are required to facilitate additional stabling accommodation under Options 1b and 2b a Railway Order may be required).
2) In regard to Option 1a, the submission of a 'local' planning application to Louth County Council is potentially the most efficient mechanism. The Drogheda Borough Council Development Plan (DBCDP) 2011 – 2017 Drogheda Transport Development Area (DTDA) Zoning objective as well as the emerging Draft Louth County Development Plan 2021 – 2027 (DLCDP) J1 'Transport Development Bub' appears to support the proposed works as they are considered to be an enhancement to the operational needs of McBride Station and link with the DART expansion (see Appendix E 1-3). However, this does not guarantee planning consent and careful integration with the cluster of Protected Structures will require a built heritage led approach;
3) To facilitate all proposed options, it is understood that the ESB would need to upgrade the existing substation off the Marsh Road further to the north. It is noted that there is an existing connection from this substation to the existing substation at McBride Railway Station however a new connection will be required to the newly proposed substation for this project. It is understood that the ESB would require upgrades of a minimum of 3.2 MVA for Option 1a and (potentially) 9.48 MVA for Options 1b and 2b,unless battery buffers are provided. It is recommended that the feasibility of any required upgrade works to the substation and any potential upgrade works required to the existing electricity connection to McBride Station is reviewed before taking any options forward. It is apparent that any option that is taken forward will require off site (and outside Irish Rail owned lands) electricity network upgrade works. However, in regard to Option 1a, it is possible to submit two separate planning applications without the need to compulsory purchase lands through the mechanism of a Railway Order. A planning application for upgrade works to the substation off the Marsh Road as well as electricity cable connection to McBride Station could be made by ESB to Louth County Council ideally in advance of or in parallel with an application made by Irish Rail for the works required within the McBride Station lands. However, it is crucial that an assessment of the potential effects of both the proposed developments is undertaken and included with the Irish Rail application. Both proposals should be subject to an EIA/AA screening process. Furthermore, this approach should be agreed with both ESB and Louth County Council through pre application discussion well in advance of any application being submitted. Legal advice should be sought on the submission of two planning applications to facilitate whichever option is taken forward. There is potential to be accused of project splitting and a robust argument will need to be put forward to demonstrate that this is not the case and that the combined effects of both applications have been considered. It is a project risk if an application for the aforementioned ESB upgrade works is refused as it could lead to project delay and in worst case mean that the project cannot be delivered. (Alternatively, for Options 1b and 2b it may be possible to subsume the required ESB upgrade works within a Railway Order application.)

Option 1a Specific Considerations:

- Option 1a is not considered to 'trigger' the need for an EIA and an Environmental Impact Assessment Report (EIAR), however, this will require a full consideration through an EIA Screening process;
- Any application will require an Environmental Report to consider potential environmental impact. This is likely to include topics such as built heritage, landscape visual impact assessment, noise and potentially EMF. Also, the removal and replacement of any rail as well as any underground electricity cabling has the potential to raise issues with contaminated lands and vermin which would need to be assessed;
- Protected Structures is a key issue given the cluster of such buildings at McBride Station. The planning history shows that an assessment of the potential impacts upon these buildings and their settings must

be undertaken and any design process should include a built heritage consultant to guide from the outset. The potential relocation of the turntable was an issue discussed when Drogheda depot was developed within ABP Ref PL54.123480 (See Appendix E8) and formed part of the reasons of appeal taken forward by the Preservation Society of Ireland (PSOI). Any proposed relocation would need to be agreed with An Taisce/NMS/Louth County Council and should be discussed in detail with same prior to submission of any application;

- As with all proposed structures, the proposed substation which is nearby to the west of an existing Protected Structure should be designed sensitively so as to integrate appropriately and this should be led by a built heritage consultant;
- There is an SAC and SPA located further to the north and AA screening should be undertaken, including for any GI to support surveys prior to submission;
- The location of the proposed stabling on the Navan Line could cause potential amenity issues to those properties further to the south. Noise abatement fencing, adjusting the orientation of any proposed lighting downwards and the planting of semi-mature trees in the lands between the siding and the boundary nearest the residential properties to help 'soften' any perceived impacts is recommended;
- The DBCDP 2011-2017 indicates two areas of Protected Trees nearby that appear to be to the south of the Navan Line. The emerging DLCDP 2021 – 2027 appears to include 'Trees and Woodland of Special Amenity Value' to the immediate west/south west of McBride Station (but outside), see Appendix E) The proposals do not appear to impact upon these trees the potential for impacts upon same should be considered prior to the submission of any planning application as it is only by exception that these trees can be removed and, if permitted, replacement must be at a rate of four semi mature species for every tree lost.

5.2 Scenario 2 (TSS 1b) : Option 1b – Charging at Drogheda Platform 2 & 3 and Depot Road 4.

5.2.1 Permanent Way (TSS 1b)

The proposed alterations to the existing Permanent Way infrastructure are limited to the installation of new IRJs as required by E&P to block traction return, as detailed within Section 5.2.4 below. At each location, this will involve the removal of the existing rail which is to be replaced by a shop-glued IRJ rail.

In total, twelve IRJ rails are proposed, as shown on drawing D3422300-JAC-DRG-EMF-000002 within Appendix B. The position of each IRJ rail shown is indicative only and is to be reviewed at a subsequent stage when further survey information is available to ensure that minimum rail lengths, etc. are achieved.

Six additional stabling roads have been provided with access via the extension of an existing depot road headshunt. Each stabling road is long enough to accommodate an eight-car vehicle (assumed total length 168m) with sufficient additional length for buffer stop and signal stand back. Fixed buffers have been proposed on all roads.

The layout has been developed such that it utilises an IP10 turnout from the existing headshunt and IP8 turnouts throughout the stabling fan. The fan is arranged such that the stabling facility is split into three pairs of tracks.

Standard siding track spacings of 2.470m running edge to running edge has been proposed throughout. This should be reviewed at a subsequent design stage with respect to possibly increasing this dimension once inspection / maintenance regimes for this stabling facility are known.

The layout has been developed in 2D only at this stage and is shown on drawing D3422300-JAC-DRG-EMF-000004 within Appendix T

5.2.2 Civils (TSS 1b)

The civils input to this option is limited to providing ancillary civils support to PerWay, E&P and OLE equipment. At this design stage it assumed this will principally be as follows:

- New concrete raft foundation to support new substation building. Assumed to be formed of 250mm thick reinforced concrete slab with a minimum 250mm well compacted subbase. This is subject to confirmation of ground conditions and equipment loading.
- Assumed pile foundations to new OLE support structures. Assumed to be 610mm diameter steel driven piles subject confirmation of the ground conditions.
- Cable troughing to facilitate new cable routes.
- New 700mm wide gravel driver's walkway to be provided between each of the new stabling roads.
- New access road of off McGrath's Lane to provide access to the new stabling area.
- Provision of 20 new parking spaces.
- Provision of 2 new modular buildings, one for cleaner stores and one for drivers sign in including welfare facilities.
- New hardstanding area to provide space for two new modular buildings.
- New perimeter security fence to be provided around the new stabling area with lockable access gate at access road.
- The raising of the footbridge over platforms 1 and 2 to provide sufficient clearance for the OHLE required in this scenario.

5.2.3 Overhead Line Equipment (OLE) (TSS 1b)

For different OLE options and details of the system to be installed refer to section 5.1.3.

OLE Option 1b development

- Option 1b will need charging infrastructure for platform 2, 3 and depot road 4. The charging infrastructure for platform 3 & depot road 4 will be same as in option 1a.
- For OLE registration and supports for charging on platform 2, single track cantilever structures are proposed, maintaining minimum clearance of 2.73m from face of OLE structure and the running edge of the nearest rail. (Ref: drawings in Appendix B).
- Two TTC structures are proposed on either side of canopy, to avoid any modification to existing canopy.
- The incoming supply will be from the north end of the platform from the new substation. There will be a switching portal at the north end of depot road 4 to feed the depot road 4 OLE through a switch. There will be an another switching portal at the north end of platform to feed platform 2 & 3. The switch will be a 2-position switch or a CME (circuit main earth) switch. Type of switch to be discussed at later stages.
- The switching will also have a fixed anchor for OLE wires to run to depot road 4. Instead of a portal, a TTC could be used depending on the structure loading. At the end of depot road these wires will be terminated with a balance weight anchor (preferred for this design) or Tensorex.

- The OLE wire termination for platform 2 & 3 will be at both the ends of platform, with a BWA (preferred) or Tensorex to be determine at later stages.
- An earth wire will be installed connecting all the structures together for carrying return current back to substation and for bonding.
- It has been noted that there is a footbridge this track linking platforms 1 and 2. For details of bridge clearance assessment refer to Appendix H.
- All bridges which are within contact line zone (as per standard BS EN 50119-2020, BE EN 50122-1 and BS EN 50122-2) are bonded to main earth terminal of the station area to allow a robust earthing system. Detailed Bridge bonding assessment to undertaken at later stages.

Note: the soffit height data initially considered were estimates only. Different soffit heights will have different solutions to achieve electrical clearances. The assessments are to be undertaken at detailed design stage.

5.2.4 E&P (TSS 1b)

Option 1b introduces charging infrastructure on through platforms 2 and 3 in Drogheda Station. As detailed in the operational requirements it is also necessary to have Empty Coaching Stock (ECS) trains charging on depot road 4 to depart for Laytown Station. The operational requirement of the ECS movements equates to the need to have three BEMU trains charging simultaneously. Option 1b requires a minimum MIC from the ESB supply of 9.48MVA.

The preferred location of the traction substation as outlined in Option 1a is also the preferred location of the substation for Option 1b, as shown in Figure 5-6.

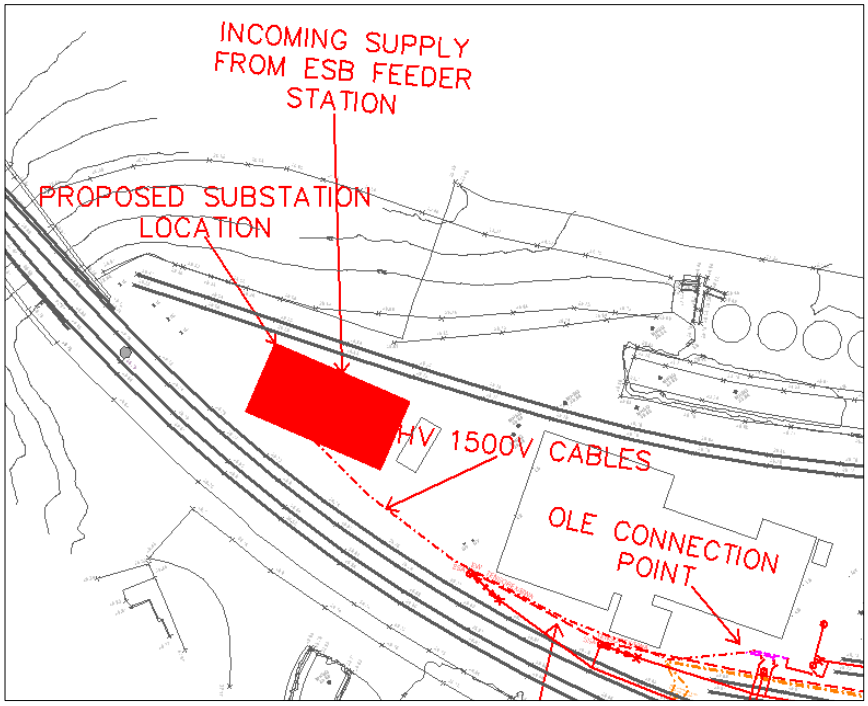


Figure 5-6 Proposed traction substation location for Option 1b

Option 1b requires the same amount of main traction substation equipment as specified under Option 1a, however, where the equipment for Option 1a is rated to supply charging for a single BEMU train, the equipment specified for Option 1b has been rated to supply 3No. BEMU trains simultaneously. Table 5-4 below provides a high-level breakdown of the primary equipment required.

Table 5-4 Option 1b Substation Equipment

Equipment	Rating	Quantity	Example Supplier
Grid Connection	MIC 9.48MVA	1 No	ESB
Positive DC Cable	500mm² (1500V DC)	6 (Length as required)	Caledonian Cables
Negative DC Cable	240mm² (1500V DC)	6 (Length as required)	Caledonian Cables
HV AC Switchboard	948A @10kV AC	1 No	Schneider Electric
Transformer	10MVA	2 No	ABB
12-Pulse Rectifier	6.4kA	2 No	ABB
DC Circuit Breaker for rectifier protection	6.4kA @ 1500V DC	1 No	Schneider Electric
DC Circuit Breakers for feeder	2.1kA @ 1500V DC	3 No + spare	Schneider Electric

Figure 5-7 below provides a high-level view of the traction substation arrangement for Option 1b.

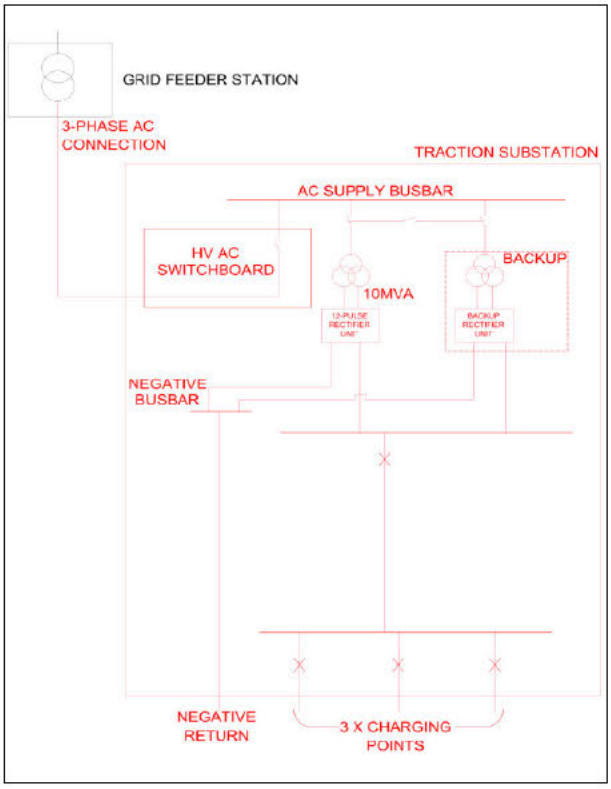


Figure 5-7 Traction substation schematic for Option 1b

Through initial consultations with ESB, it appears the limitation of the current grid infrastructure in proximity to Drogheda Station suggests that the current installation would not be capable of supplying more than one BEMU

simultaneously without major network reinforcements. To reduce the demand on the local grid network and to provide operational flexibility, a sequential control system may be implemented to control the number of BEMU trains charging simultaneously. The sequential control would be supplied via automatic electrical interlocking integral to the DC switchgear located in the traction substation.

Alternatively, a battery buffer system could be implemented to reduce demand and smooth instantaneous peaks. Costings of the battery buffer can be found in section 8 and it is noted that the manufacturer has quoted approximately [redacted] per kWh. Using the proposed operational timetable requirements, over an hour, the demand with and without battery buffer has been modelled for Option 1b as shown in Figure 5-8 and Figure 5-9:

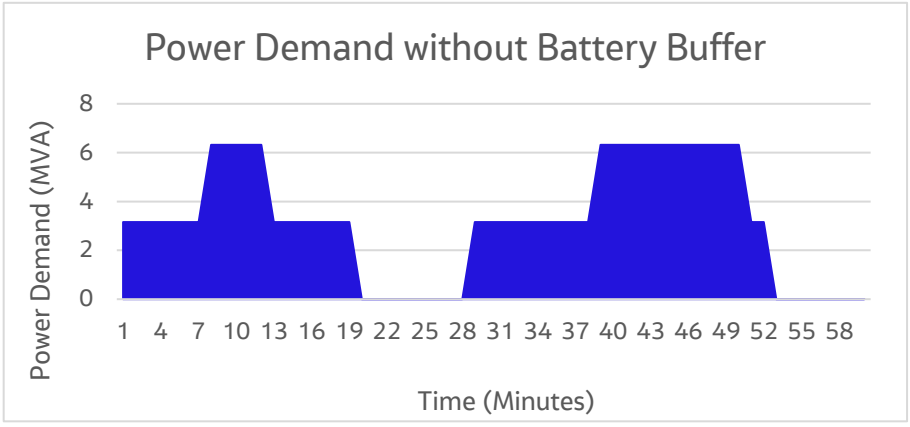


Figure 5-8 Option 1b Power Demand without Battery Buffer

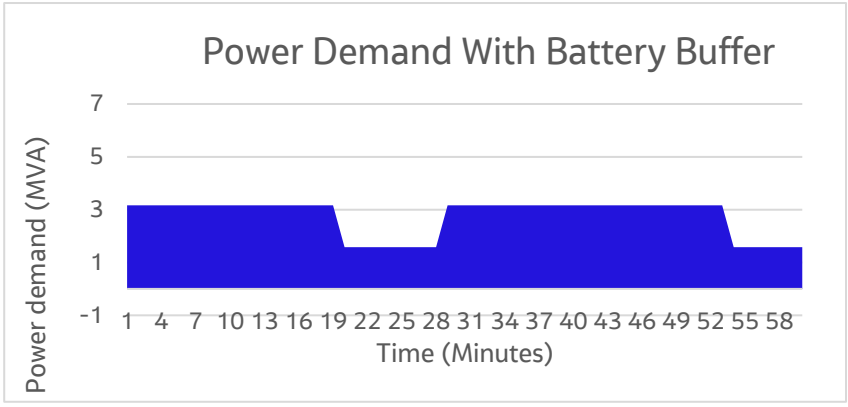


Figure 5-9 Option 1b Power Demand with Battery Buffer

There will be 6 No pairs of IRJs required for Option 1b to provide a DC current return path. Details of IRJ positions can be seen in the Option 1b Layout in Appendix B. The DC return cables to be bolted directly to the rail and will be routed to the traction substation to terminate on the negative busbar. To ensure redundancy, 2 No. return cables should be provided per OLE charging point.

Stabling for Option 1b could be located in a field east of Drogheda Depot and new lighting and telecoms will be required. As the entry to the field is 400m from the Depot a new LV 3-phase ESB connection will be required. The new ESB cubicle shall service new, road lighting, car park lighting, walkway lighting, boundary lighting, telecoms supplies and electrical supplies to the buildings. The lighting will as a minimum comply with EN 12464 part 2. The telecoms will include for boundary CCTV and Call points/ help points for communication back with the main depot area. See drawing D342200-JAC-DRG-EMF-000004 for details. Costings for this equipment is provide in section 8.

The key advantage of Option 1b is that it provides greater operational flexibility when compared with Option 1a (i.e. in the base scenario), and greater capacity with the capability of running more trains out of the station and depot (to facilitate TSS1b).

The disadvantages of Option 1b are similar to those covered in Option 1a. In addition, Option 1b has a further disadvantage as a result of the increased demand for charging multiple BMEU trains at a time. The increase in electrical demand will trigger the need for ESB to provide resilience on their network, increasing the project's operational and capital cost for the procurement, maintenance and running of the traction substation. The alternative to this is use a battery buffer system to reduce the peak power demand from the ESB. It should be noted that if the battery buffers were to fail, they could be switched out to continue to provide charging at the level of the input power (i.e. only one train at a time).

An access agreement will need to be in place with ESB. However, it has been noted that ESB already has an agreement in place for the existing Depot substation. We note also that there is access from the existing stairs via the underbridge road access which avoids the need for ESB personnel crossing track to access the substation.

For further details regarding the E&P design decisions, infrastructure, systems, specifications, and limitations, refer to Appendix F. Appendix Includes sections on DC stray currents, EMC, Earthing & Bonding, cable routes and MOS equipment.

5.2.5 Signalling (TSS 1b)

Signal DA294 is positioned beyond the OLE anchor point structure which could compromise the signal sighting from the train cab stopping position on Platform 3. The most workable solution would be to relocate signal DA294 approx. 20m closer to the end of the platform and ensure that it is situated on the approach side of the anchor point structure. The cost for this signal relocation is reflected in the signalling allocation noted in Appendix D for this option.

There are no potential sighting issues regarding signal DA296, however the OLE anchor point adjacent to signal D297 would need to be positioned beyond the signal structure.

The sighting on signal DA291 at the north end of Platform 2 will be potentially obscured by the introduction of OLE structures along the platform length. The worst-case scenario, based on a through platform speed of 25mph, would be the need to introduce a banner repeater mid-platform.

There are no potential sighting issues regarding signal DA289 at the north end of Platform 1.

The immunisation of signalling infrastructure in and around the proposed OLE equipment would need to be investigated further to ensure any potential compatibility issues are addressed. All existing signal positions are currently assumed. Actual positions are subject to more robust surveying and all signal sighting will need to be subject to a more detailed review in order to confirm the assumptions made in this study.

5.2.6 Environmental (TSS 1b)

Option 1b has the potential for greater impacts than Option 1a given the additional infrastructure and stabling required. In particular, the additional stabling outside Irish Rail lands may require the submission of a Railway Order and therefore trigger the need for an EIAR (see Appendix U). Also, the setting of Protected Structures is more likely to be affected and will require careful consideration.

As is has been identified that the footbridge crossing the mainline is not as high as was first thought and will likely need to be raised to accommodate the OLE here, careful consideration will need to be given to the treatment of this bridge during the planning process and it is recommended that costs are allowed for this treatment.

Specifically, in regard to the proposed stabling outside Irish Rail owned lands, it is noted that the notional area currently being investigated is zoned for residential use in both the current DBCDP 2011 – 2017 and the emerging DLCDP 2021 – 2027. The principle of Railway infrastructure as a main use on these lands does not appear to be

supported. Appendix U includes existing planning permission for residential development at the said lands. However, Irish Rail has confirmed that this site is not necessarily the lands that would be progressed and that the exercise is notional. In an email dated 27th November 2020 Irish Rail also advised of another potential site further to the south east within Meath County Council. It is noted that these lands have two separate zoning objectives for enterprise and employment and amenity use, both in the statutory and emerging development plans. The potential for these lands to be taken forward would require a full planning and environmental review before progressing.

However, both the current DBCDP 2011- 2017 and the emerging DLCDP 2021 – 2027 include zoning objectives DDTA and J1 'Transport Development Hub' (to the immediate north of McBride Station) that are favourable to transport infrastructure type uses. Potentially, the feasibility of these lands to accommodate additional stabling requirements could be discussed through pre application consultation with Louth County Council well in advance of any application to agree the principle and initial layout. It is noted that these lands border residential zoned land further to the north and lands with existing residential planning permissions to the immediate east. If the principle of development was agreed with Louth County Council any proposed scheme would need to mitigate for potential impacts upon residential amenity, such as noise, air quality, dust, visual impacts, etc.

5.3 Scenario 3 (TSS 3): Option 2b – New platform and charging points on Navan lines

5.3.1 Permanent Way (TSS 3)

For this Option 2b and to reduce this section of twin-track alignment on the Navan Line to a single-track alignment, the existing mainline connection and approximately 350m of the existing Navan mainline track is to be recovered, including the existing trap point and buffer stop.

A new IP10 turnout is proposed, along with 100m of plain line renewal and 120m of lift-and-slue, to the south of the proposed platform location to revert the alignment to twin-track; effectively creating a passing loop of approximately 450m as the alignment is single-track only further west.

Twelve IRJ rails are proposed as per Option 1b, along with four further IRJ rails within the vicinity of the new platform on the Navan line as required by E&P to block traction return, as detailed within Section 5.3.4 below. The position of each IRJ rail shown is indicative only and is to be reviewed at a subsequent stage when further survey information is available to ensure that minimum rail lengths, etc. are achieved.

These proposals are shown on drawing D3422300-JAC-DRG-EMF-000003 within Appendix C.

Six additional stabling roads have been provided with access via the extension of an existing depot road headshunt. Each stabling road is long enough to accommodate an eight-car vehicle (assumed total length 168m) with sufficient additional length for buffer stop and signal stand back. Fixed buffers have been proposed on all roads.

The layout has been developed such that it utilises an IP10 turnout from the existing headshunt and IP8 turnouts throughout the stabling fan. The fan is arranged such that the stabling facility is split into three pairs of tracks.

Standard siding track spacings of 2.470m running edge to running edge has been proposed throughout. This should be reviewed at a subsequent design stage with respect to possibly increasing this dimension once inspection / maintenance regimes for this stabling facility are known.

The layout has been developed in 2D only at this stage and is shown on drawing D3422300-JAC-DRG-EMF-000004 within Appendix T

5.3.2 Civils (TSS 3)

The civils input will be the same as options 1a and 1b above with the addition of a new platform over at the Navan line. At this design stage it assumed the civils works will entail the following:

- New platform will be constructed over the existing Navan line on the Up track. It is assumed to be a 174m long, 3m wide platform constructed as either a front wall or cross wall construction. A new access stair and ramp will be provided to the platform from the existing carpark. Alternatively, access to the new platform could be achieved by a connection to the end of platform 1 which will remove the need for separate access and revenue protection to be provided. This will need to be reviewed in conjunction with PED flow analysis.

- New concrete raft foundation to support new substation building. Assumed to be formed of 250mm thick reinforced concrete slab with a minimum 250mm well compacted subbase. This is subject to confirmation of ground conditions and equipment loading.

- Assumed pile foundations to new OLE support structures. Assumed to be 610mm diameter piles subject confirmation of the ground conditions.

- Cable troughing to facilitate new cable routes.

- New 700mm wide gravel driver's walkway to be provided between each of the new stabling roads.

- New access road of off McGrath's Lane to provide access to the new stabling area.

- Provision of 20 new parking spaces.

- Provision of 2 new modular buildings, one for cleaner stores and one for drivers sign in including welfare facilities.

- New hardstanding area to provide space for two new modular buildings.

- New perimeter security fence to be provided around the new stabling area with lockable access gate at access road.

- The raising of the footbridge over platforms 1 and 2 to provide sufficient clearance for the OHLE required in this scenario.

5.3.3 OLE (TSS 3)

For different OLE options and details of the system to be installed refer to section 5.1.3.

OLE Option 2b development

- Option 2B will need charging infrastructure for platform 2, 3, depot road 4 and also on the Navan line. The charging infrastructure for platform 2, 3 & depot road 4 will be same as explained for Option 1b. The only differences will be the incoming feeds to OLE will be from a substation located near the car park. There will switching portal with switches to feed the OLE for platform 3 and depot road 4 and a TTC with switch to feed the OLE for platform 2.

- The charging infrastructure for the Navan line will be TTCs installed on back side of the new platform. The feeding structure will be at the north end of the platform. The option to have switching portal at south end is excluded due to that the switching portal will be on the platform area and for safety reasons the switching structure will be at the north end. (ref drawing in Appendix C)

- The TTCs are proposed on the back side of platform as there is not enough land to locate them in the cess near the track on other side of the platform. This option thus avoids the need to acquire more land.

- An earth wire will be installed connecting all the structures together for carrying return current back to substation and for bonding.

5.3.4 E&P (TSS 3)

Option 2b proposes the introduction of OLE charging infrastructure on the Navan line as well as charging infrastructure on platform 2 & 3 and siding road 4. Based on the information provided by Irish Rail, the Navan lines are not frequently used which introduces the possibility of installing a new platform and charging lane. Further details can be seen in Option 2b Layout drawing in Appendix C.

The preferred location of the traction substation for the supply of the charging for Option 2b is located at the east end of Drogheda Station car park. Ultimately this location provides a direct connection between the traction substation and the charging infrastructure without crossing any tracks. The traction substation location for Option 2b is shown in Figure 5-10.

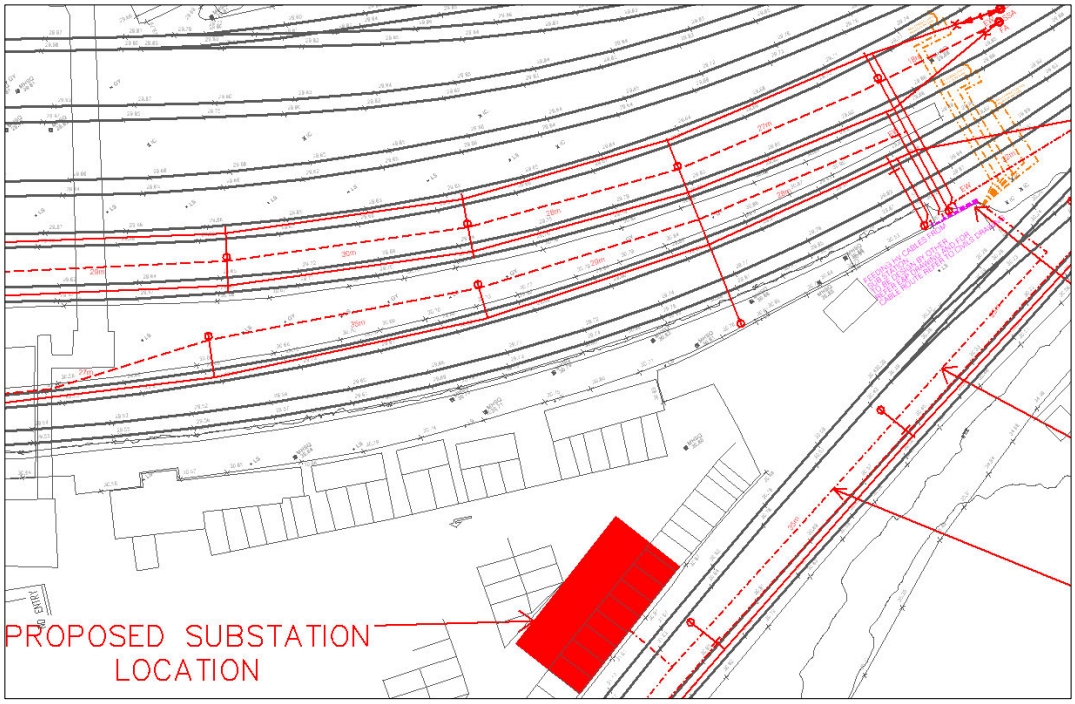


Figure 5-10 Preferred traction substation location for Option 2b

The DC feeder cables shall be routed through the new platform in both directions, as the OLE switch connection points are positioned at the east end Drogheda station and the Navan line OLE connection point positioned at the south of the proposed platform. Further details of the OLE infrastructure can be found in 5.1.3.

The maximum number of trains which can charge simultaneously in option 2b is three, thus the MIC equates to 9.48MVA. If it is not feasible to provide this demand, provision of sequential control could be applied to the DC Switchgear to limit the number of trains charging simultaneously. The sequential control system applies certain operation timetable restrictions.

Alternatively, a battery buffer system could be implemented to reduce demand and smooth instantaneous peaks. Using the proposed operational timetable requirements, over an hour, the demand with and without battery buffer has been modelled for option 2b as shown below:

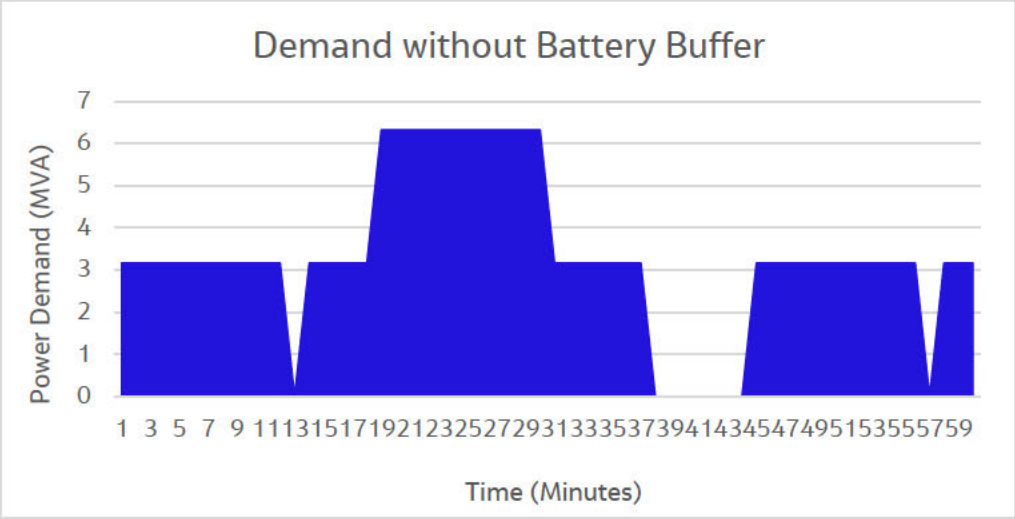


Figure 5-11 Option 2b Power Demand without Battery Buffer

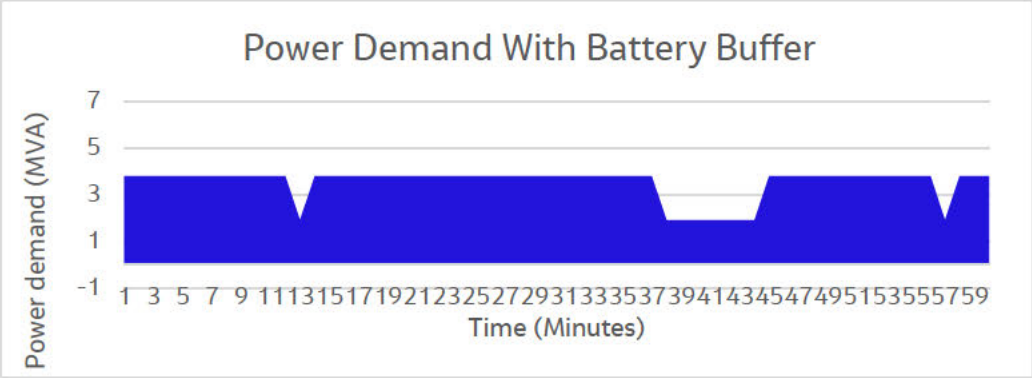


Figure 5-12 Effect of battery buffer on power demand for Option 2b

Table 5-5 below provides a high-level breakdown of the primary equipment for the traction substation with the additional DC circuit breaker for the feed to the Navan lines.

Table 5-5 Option 2b Substation Equipment

Equipment	Rating	Quantity	Example Supplier
Grid Connection	MIC 9.48MVA	1 No	ESB
Positive DC Cable	500mm² (1500V DC)	8 (Length as required)	Caledonian Cables
Negative DC Cable	240mm² (1500V DC)	8 (Length as required)	Caledonian Cables
HV AC Switchboard	948A @10kV AC	1 No	Schneider Electric
Transformer	10MVA	2 No	ABB

12-Pulse Rectifier	6.4kA	2 No	ABB
DC Circuit Breaker for rectifier protection	6.4kA @ 1500V DC	1 No	Schneider Electric
DC Circuit Breakers for feeder	2.1kA @ 1500V DC	4 No + spare	Schneider Electric

Figure 5-13 below provides a high-level view of the traction substation arrangement for Option 2b.

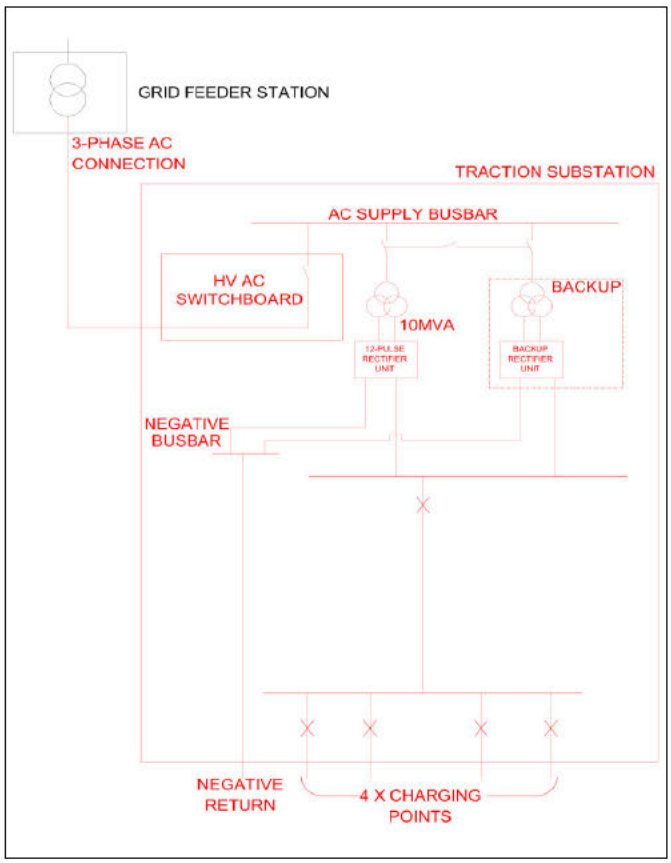


Figure 5-13 Traction substation schematic for Option 2b

Option 2b requires 8 No pairs of IRJs to provide the DC current a return path. Further details of IRJ positions can be seen in the Option 2b Layout in Appendix C. The DC return cables to be bolted directly to the rail and will be routed to the traction substation to terminate on to the negative busbar. To ensure redundancy, 2 No return cables to be provided per OLE charging point.

Stabling for Option 2b is envisaged to be constructed in a field east of Drogheda Depot. To achieve this new lighting and telecoms will be required for the new stabling. As the entry to the field is 400m from the Depot a new LV 3-phase ESB connection is assumed to be required. The new ESB cubicle shall service new, road lighting, car park lighting, walkway lighting, boundary lighting, telecoms supplies and electrical supplies to the buildings. The lighting will as a minimum comply with EN 12464 part 2. The telecoms will include for boundary CCTV and Call points/ help points for communication back with the main depot area. See drawing D342200-JAC-DRG-EMF-000004 for details. Costings for this equipment is provide in section 8.

The inherent disadvantage associated with Option 2b is due to the increased electrical demand of charging multiple BEMU's simultaneously. The increase in electrical demand will trigger the need for ESB to provide resilience on their network, increasing the project's operational and capital cost for the procurement, maintenance, and running of the traction substation. Furthermore, the preferred location of the substation is currently positioned

within the station car park and therefore the parking capacity will be reduced. The substation is also positioned south of the station and the closest known grid connection is located North of the station. Potentially causing difficulties for routing the HV connection to the substation and thus increasing cost for the connection.

For Further details regarding the E&P design decisions, infrastructure, systems, specifications, and limitations, refer to Appendix F. Appendix Includes sections on DC stray currents, EMC, Earthing & Bonding, cable routes and MOS equipment.

5.3.5 Signalling (TSS 3)

Signal DA294 is positioned beyond the OLE anchor point structure which will compromise the signal sighting from the train cab stopping position on Platform 3. The most workable solution would be to relocate signal DA294 approx. 20m closer to the end of the platform and ensure that it is situated on the approach side of the anchor point structure.

There are no potential sighting issues regarding signal DA296, however the OLE anchor point adjacent to signal D297 would need to be positioned beyond the signal structure.

There are no potential sighting issues regarding signal DA314. However, this option would need to be subject to an operational review as the charging point location will prevent usage of this route/line and the current passing loop length is reduced.

The sighting on signal DA291 at the north end of Platform 2 will be potentially obscured by the introduction of OLE structures along the platform length. The worst-case scenario, based on a through platform speed of 25mph, would be the need to introduce a banner repeater mid-platform.

There are no potential sighting issues regarding signal DA289 at the north end of Platform 1.

The immunisation of signalling infrastructure in and around the proposed OLE equipment would need to be investigated further to ensure any potential compatibility issues are addressed.

All existing signal positions are currently assumed. Actual positions are subject to more robust surveying.

All signal sighting will need to be subject to a more detailed review in order to confirm the assumptions made in this study.

For Option 2b (changes to the Navan Line) a further 2 additional signal changes have been allowed for and these costs are reflected in the signalling allocation noted in Appendix D for this option.

5.3.6 Environmental (TSS 3)

The comments in regard to the stabling for Option 1b also apply here to Option 2b (see Appendix U). As set out for Option 1b, Irish Rail has confirmed that the reviewed site is not necessarily the lands that would be progressed and that the exercise is notional. In subsequent correspondence Irish Rail also advised of another potential site further to the south east within Meath County Council. It is noted that these lands have two separate zoning objectives for enterprise and employment and amenity use both in the statutory and emerging development plan. The potential for these lands to be taken forward would require a full planning and environmental review before progressing.

It has been identified that the footbridge crossing the mainline is not as high as was first thought and will likely need to be raised to accommodate the OLE here, careful consideration will need to be given to the treatment of this bridge during the planning process and it is recommended that costs are allowed for this treatment.

Specific considerations for Option 2b include the following:

1) Works on the Navan Line could potentially have more planning and environmental issues given the proximity of residential dwellings and the potential for impacts upon amenity. Noise abatement fencing,

adjusting the orientation of any proposed lighting downwards and the planting of semi-mature trees in the lands between the siding and the boundary nearest the residential properties (to help 'soften' any perceived impacts is recommended.

2) It is an objective of the Drogheda Borough Council Development Plan (DBCDP) 2011 – 2017 and the emerging Draft Louth County Development Plan (DLCDP) 2021 – 2027 to re-open the Drogheda to Navan rail line to regular passenger traffic. Any option taken forward should not compromise this objective;
3) The DBCDP 2011-2017 indicates two areas of Protected Trees nearby that appear to be to the south of the Navan Line. The DLCDP 2021 – 2027 indicates these trees to the south/south west (see Appendix U). The proposals do not appear to impact upon these trees, however, the potential for impacts upon same should be considered prior to the submission of any planning application;
4) The DBCDP 2011-2017 and DLCDP 2021 – 2027 include an Architectural Conservation Area (ACA) to the south of the Navan Line. Part of the objective of such areas is to protect their setting. Similar to Protected Structures, any planning application should consider in the design any potential impact upon the setting of this ACA; and
5) As with all proposed structures, the proposed substation should be designed to integrate into the setting of the other existing Protected Structures.

6. Depot Requirements

This section applies to all three Train Service Scenarios.

6.1 Existing Facility

Drogheda maintenance depot is currently the principal location used to maintain the 29 four-car Class 29000 DMU fleet. The site consists of a three-road maintenance building, long enough for two four-car units on each, a wheel lathe, two roads with access to fuel facilities and a train wash.

The maintenance building has two roads with pits and one road with the capability for lifting vehicles.

6.2 Future Facility

6.2.1 General

It is assumed that BEMU servicing and light maintenance will be undertaken at Drogheda for a period of about three years, until the new depot at Maynooth opens. Thereafter, servicing of BEMUs will be undertaken at Maynooth.

Servicing is expected to include cleaning and daily checks such as screenwash and sand topping up. Servicing of BEMUs will be similar to that of EMUs. which includes fewer tasks than on DMUs and no additional facilities would be required for this.

DMU servicing additionally includes fuelling, and facilities for this remain available on Depot Road 5, which is unaffected in all the options chosen and discussed in this report.

The additional equipment that is required for both light and heavy maintenance and major component changes on the new fleet is assumed to be included in the Special Tools, which will be provided by the train supplier. However, the exact list of special tools proposed may vary between the possible suppliers and so it is recommended that this is verified later.

6.2.2 Facilities required – major component changes

During the first three years, it is assumed that no overhauls or changes of major components (heavy maintenance) will be scheduled.

However, a small number of major components may need to be changed due to unexpected failures. Therefore, changing major components that require lifting of vehicles needs to be considered. The existing lifting arrangements are by means of a Neuero underfloor lifting system dedicated to lifting a complete four-car class 29000 unit. Therefore, this may or may not be at the correct spacing for the BEMU fleet. From the meeting of 6th November 2020 Jacobs understands that Drogheda also has movable jacks, but the number of jacks and the extent that they can be moved is unknown, so it is expected that to lift the vehicles, they will need to be moved to another location and it is further assumed that, because a wide range of vehicles are already lifted at Inchicore, this work will be possible there.

For other major components, if the additional required equipment is not included in the Special Tools provided by the train supplier, such equipment would need to be procured, irrespective of whether the units are being maintained at Drogheda or Maynooth. The options for this include:

- Procure any such additional equipment that will be required at Maynooth, early in the programme for that depot and temporarily locate the equipment at Drogheda. Whilst possibly incurring a cost early, there might be a compensating lower price by avoiding inflation.
- Until such equipment is available, undertake the work at another location such as Inchicore. This would incur operational inconvenience.

- Procure a second set of all the equipment that would be required for the work to be done at Drogheda in addition to that for Maynooth. This would be disproportionally expensive for the number of times it would be used and is therefore not recommended.

6.2.3 Facilities required – light maintenance

Consideration has been given to the locations on the vehicles of equipment fitted on BEMUs, that is different from DMUs, and hence the additional equipment required to carry out light maintenance on BEMUs. For this purpose, as the use of the depot is temporary, it is assumed that an Automatic Visual Inspection System (AVIS) will not be provided, as this will be built into the infrastructure of Maynooth depot. The additional equipment required for access to roof-mounted equipment for light maintenance is assumed not to be included in the Special Tools provided by the train supplier. The following roof-mounted equipment has been considered:

- HVAC module. These are assumed to be similar in concept to those fitted on DMUs, and if well-designed, light maintenance should be possible from inside the vehicles. Therefore, no additional equipment is expected to be required maintain them.
- Pantographs. These require regular inspection, typically at the shortest examination interval, plus carbon strip changes as required.
- Based on comparable vehicles, other equipment that may be located on the roof, depending on the design of the train, may include batteries, battery chargers, air compressors and brake reservoirs.

Therefore, additional roof access equipment is expected to be required. A mobile access platform sometimes called a 'boxing ring' (Figure 6-1 Sample "Boxing Ring" vehicle roof access platform) is recommended. The cost of these is around [redacted] The number of access platforms required depends on the design of the selected unit, the maintenance frequency and duration, which are unknown, and the fleet size (see below), but to avoid moving access platforms between roads in the depot, at least two should be obtained.



Figure 6-1 Sample "Boxing Ring" vehicle roof access platform

Due to the temporary use of the depot for BEMUs, installation of permanent fixed roof access equipment would be disproportionately expensive and is not recommended.

Jacobs understands that shore supply for DMUs is installed in the depot but is disused. The BEMUs will be charged on the roads equipped with overhead line and the energy used moving around the depot will be insignificant compared to the capacity of the traction batteries. Therefore, a shore supply is not required for BEMUs.

Following maintenance, if testing under overhead line is required, this can be undertaken on the roads that are proposed to be electrified. Installation of overhead line in the shed, specifically for testing, is considered to be disproportionally expensive for the additional benefit and also introduces safety risks. It is therefore not recommended.

Storage for spare parts for light maintenance of the BEMUs will be required for the few years of BEMU light maintenance. This might be provided in various ways, for example:

- Review the use of the existing storage spaces, for example for large and non-moving items, and hold BEMU major components and large items that are required infrequently at Inchicore
- Provide a temporary building located on the hard standing in the depot. This could be based on, for example, shipping containers. The cost of renting shipping containers is in the hundreds of Euros per month.
- Rent warehouse space nearby to hold 29000 Class major components and large items that are required infrequently and are currently held at Drogheda. The cost of renting warehouse space is in the order of [redacted] per square foot per month.

6.2.4 Other changes required to the depot

Jacobs has considered other changes that might be required to maintain BEMUs in a DMU depot and the only additional item identified is a possible modification to the train wash. It is assumed that this has roof brushes. If this is correct these should be removed or at the very least switched off before any BEMU is washed due to the risk of pantograph damage and electrical problems. In Jacobs' experience, train washes in depots maintaining vehicles with pantographs do not have roof brushes.

6.3 Depot capacity

From the meeting on 6th November 2020, Jacobs understands that the existing Class 29000 fleet will need to be maintained in Drogheda until 2027 and full electrification is expected to be complete.

RFI0009 describes the 'base case' service and Scenarios 1b and 3.

For the Base Case (current timetable), IÉ has advised that 52 BEMU vehicles (13 HLUs) are specified.

Clause 3.10 of this report shows that TSS 1b requires 54 HLUs and TSS 3 requires 49HLUs.

To estimate at high level whether the DMU maintenance building at Drogheda has sufficient capacity to undertake light maintenance on the BEMU fleet in addition to the Class 29000 DMUs, Jacobs has reviewed the number of units in a sample of DMU and EMU fleets and the number of unit spaces for light maintenance in the maintenance buildings where they are maintained. This showed that DMU depots typically maintain about seven units for each unit space in the maintenance building and EMU depots about twelve.

Drogheda currently maintains a fleet of 29 DMUs and would therefore be expected to require a light maintenance building with 29/7= about four unit spaces and indeed this is the size of the maintenance building at Drogheda. This suggests that there is minimal spare capacity for additional units to be maintained there.

For the Base Case, the proposed BEMU fleet would require a depot with nominally one (13/12) unit space, an increase of 25% in the required capacity of the maintenance building. At the high-level consideration being made here, this might be achievable with some actions, for example:

- Undertake some of the maintenance on the DMUs elsewhere
- Ensure that the maintenance proposed by the BEMU suppliers is optimised, is balanced to suit the needs of the train service, the sequence of work is planned carefully etc.
- Review the staffing level to check whether this is the limiting factor on capacity, rather than maintenance building space
- Review the maintenance of the DMU fleet for potential efficiencies, if this has not been done already
- As the BEMUs are introduced, reduce the size of the DMU fleet

For Scenario 1b, which requires a larger fleet size than Scenario 3, the proposed BEMU fleet would require a depot with four to five (54/12) unit spaces in the shed. It is assumed that by the time either of these scenarios will be implemented, the new depot at Maynooth will be open and therefore no further capacity increase in the maintenance building at Drogheda will be required.

6.4 Recommendations

It is recommended that:

- The exact list of special tools proposed by the possible suppliers should be verified
- To lift the vehicles, they are likely to need to be moved to another location
- The options described above for any additional equipment that is required, and that is not included in the Special Tools provided by the train supplier, should be considered
- At least two mobile access platforms should be obtained
- The options outlined for storage of spare parts for light maintenance of the BEMUs should be considered
- The roof brushes on the train wash should be removed or at the very least switched off before any BEMU is washed.
- For the Base Case, the options described above for increasing the capacity of the maintenance building should be considered.

7. Safety in Design

7.1 APIS and SMS-14

Iarnród Éireann have informed Jacobs that the approval requirements for this project would be dealt with during a later stage as part of the DART + Coastal Programme.

7.2 Jacobs Hazard Evaluation and Risk Reduction Register (HERRR)

This covers the requirements of BS EN 12100 Machinery Safety (Risk Assessments), EU Directives and Construction Regulations. The HERRR is a Jacobs document and provides a means of recording mitigation and risk reductions actions taken. See Appendix K for the HERRR.

The HERRR is a live document and will be updated throughout the duration of the project.

8. Life Cycle Costing Analysis

8.1 Introduction

Life Cycle Costing (LCC) is used to inform decision making by providing an understanding of costs incurred by an organisation over an asset or system lifecycle. It is used to produce comparative assessments of investment options, enabling decisions based on anticipated costs over the period of operation. Analysis incorporates the aggregation of both up-front capital costs (CAPEX) and operational costs (OPEX) and may incorporate multiple renewals of individual Assets over the period of analysis. This following section outlines the methodology used to produce the LCC Analysis.

8.1.1 Note about LCC and Value Added Tax (VAT)

Jacobs note that LCC analysis is intended as a comparative assessment and not as an in-depth accurate predictor of future expenditure. We have followed accepted practice in generating the LCC. VAT is not usually implemented within an LCC Analysis as this is treated in different ways by organisations, most of which are concerned with the cost net of VAT within their accounting practice. In particular please also note that Section 4.1.3 of the Common Appraisal Framework states that VAT should not be included in financial assessments.

8.2 LCC Methodology

The methodology details the processes undertaken to develop the LCC analysis of the options, and is comprised of two sections, CAPEX and OPEX.

8.2.1 CAPEX Development

This Section provides an overview of the principles used in developing the CAPEX for each option. CAPEX summary and breakdown tables for each option can be found in Appendix D.

8.2.1.1 Basis of Cost Estimates

The costs for each of the options proposed in this study are based on the scope outlined in Part 5 of this report. The costs have been prepared in accordance with relevant practice and procedures, including Jacobs internal procedures and those outlined in NTA Cost Management Guidelines.

8.2.1.2 Preliminaries, Overhead and Profit

Main Contractor's preliminaries have been set at a level of 30% of works costs. This accounts for the nature of the works and takes cognisance of the challenges of working in and around an operational railway station with the requirement to programme and phase works to permit continued operations and the need to plan and implement temporary enabling works. The addition for preliminaries also accounts for possession costs which will be significant.

Overhead and profit has been allowed for with an addition of 10% on costs which in our experience is a reasonable level for works of this nature.

8.2.1.3 Professional Fees

An allowance of [redacted] of total works cost has been added to the costs in respect of professional fees, which again is set at a reasonable level for works of this nature.

8.2.1.4 Planning, Environmental Impact Report and Railway Order Fees

Appropriate provisions have been made in respect of anticipated disbursements in connection with Planning, Environmental Impact Report and Railway Order fees.

8.2.1.5 Risk

We have allowed for a construction risk and contingency factor of 35% of overall cost. The risk and contingency factor is based on experience of similar projects at a similar stage in the development process and also takes account of the possibility of planning authorities mandating external aesthetics in keeping with the heritage / listed building status of Drogheda MacBride Station e.g. natural stone finish or similar to external walls of the proposed sub-station. We would expect a more refined level of risk to be determined at a later stage in the development process following a quantitative cost risk analysis with all relevant stakeholders contributing to this process as appropriate.

8.2.1.6 Benchmarking

The costs as compiled have been benchmarked against costs for comparable works in both the Republic of Ireland and the UK.

8.2.1.7 Estimate Base Date

The base date of the estimate is 4Q 2020, and allowance is made in the section below for future inflation.

8.2.1.8 Inflation

[redacted]

8.2.1.9 Range of Accuracy

All estimates are classified in accordance with Jacobs estimating matrix contained within Jacobs Business Management System – Buildings and Infrastructure Europe – Work Instruction WI 3100. Jacobs classify estimates based upon the amount and quality of the information available at the time the estimate is delivered, and this Cost Estimate we consider ranks between a Class 4 and 5 classification and therefore has an expected overall range of accuracy of -30% to +30%.

8.2.1.10 Assumptions and Exclusions

Table 8-1 and 8-2 detail the assumptions and exclusions used in developing the CAPEX estimates.

Table 8-1 CAPEX Assumptions.

CAPEX COST DATA ASSUMPTIONS LIST			
The following assumptions have been made in the preparation of the costs contained in this report			
Element	**Item**	**Description**	**Assumption**
P-Way			
1	Scope of work	Installation of IRJ's	Assumed that existing sleepers and ballast remain (Options 1a and 1b)
OLE			
1	Scope of Work	Testing & Commissioning	Assumed 5% of total OLE cost
SIGNALLING			
1	Scope of Work	Signalling requirements	Assumed scope restricted to general allowance for relocating 2 nr signals for each option, (See below for Navan Line stabling)
ELECTRIC POWER & PLANT			
1	Scope of Work	ESB Connection to Grid (Option 1a)	**We have included an allowance of [redacted] for ESB connection to the sub-station which covers the connection charge and cabling costs** as noted in ESB Networks Statement of Charges Dated Sept 2020. We are advised through informal discussions with ESB that in the case of Option 1a, significant network reinforcement is not likely to be necessary
2	Scope of Work	Cabling	Includes all ducting, troughing or other containment
3	Scope of Work	Battery buffer unit	Assumed not required for Option 1a

4	Scope of Work	Testing & Commissioning	Assumed 5% of total E&P cost
CIVILS			
1	Scope of Work	Piling to OLE supports	Assumed 610mm diameter steel driven piles max depth 5m, subject to confirmation of ground conditions includes making good existing platform 2/3
2	Scope of Work	Excavation	Assumed no existing materials are being reused
3	Scope of Work	Raising existing bridge (Options 1b, 1c and 2a)	Provisional sum allowed of [redacted] include any heritage preservation requirements.
4	Scope of Work	New platform (Option 2b)	The platforms are assumed to be of a typical front wall construction • 665 x 1100mm solid concrete blockwork walls with cope. • Concrete strip foundations 1100 x 470mm, subject to confirmation of ground conditions • Concrete support • Between walls it is assumed that that it will be filled with 6N material. • Typical platform make up; 50mm dense bitumen base and 25mm bitumen wearing. course • 400mm wide concrete tactile slabs to run the length of the platform • Includes Lighting, CCTV, Passenger Information Displays and other Comms

5	Scope of Work	Existing Platform 2/3	Assumed platform will be re-surfaced
BUILDINGS			
1	Scope of Work	Sub-station	Assumed brick-built substation on reinforced concrete raft foundation subject to confirmation of ground conditions
2	Scope of Work	Sub-station	Assumed substation building, transformers and battery buffer unit contained within fenced compound
3	Depot	Mobile roof access platforms	Assumed 2 nr required
4	Depot	Storage	Assumed lightweight metal clad structure, floor area approx 100m2
5	Depot	Existing turntable	Assumed removed to another location in the depot.
Stabling on Navan Line			
1	Scope of Work	P-way	Assumed new switch (trap) required
2	Scope of Work	Signalling	Assumed 2 new signals required
3	Scope of Work	Civils	Assumed new retaining wall required for full length of stabled train to accommodate walking route
4	Scope of Work	Civils	Assumed new walking route required on either side of stabled train
5	Scope of Work	Civils	Assumed acoustic barrier required on top of new retaining wall
6	Scope of Work	Civils	Assumed rail access point and 'Strail' type foot crossing required

7	Scope of Work	M&E	Assumed lighting and CCTV required for stabling area
8	Scope of Work	Landscaping and planting	Assumed some landscaping and semi-mature trees may be required next to some neighbouring properties
Stabling in Adjacent Field			
1	Scope of Work	P-way	Includes 1775m of track, S&C units and buffer stops
2	Scope of Work	Signalling	Assumed no signalling required
3	Scope of Work	Civils	Includes access road, sheet piled retaining wall along access road up to new surface level, bulk upfill to form new levels, car parking, walking routes, Strail type track crossings, palisade security fencing and entrance gates. Acoustic fencing to neighbouring residential properties
4	Scope of Work	Portakabins	Includes services and utility connections
5	Scope of Work	M&E	Includes lighting to stabling area, car park and access road, CCTV and call/help points
6	Scope of Work	Landscaping and planting	Assumed some landscaping and semi-mature trees may be required next to some neighbouring properties
METHODOLOGY			
1	Method of work	Sequence of construction	It is assumed that this work can be carried out as a phased construction utilising Possessions as required

The Table 8.2 below details the exclusions to the CAPEX estimates.

Table 8-2– CAPEX Estimate Exclusions

CAPEX COST EXCLUSIONS & QUALIFICATIONS		
The following Items are EXCLUDED from the reported costs		
Item	**Element**	**Description**
1	VAT	VAT excluded as noted in Section 8.1.1
2	Traffic Management	The cost of any traffic management measures required in relation to the closure of roads, footpaths or car parks is excluded
3	Legal Costs	No allowance has been made for any costs associated with legal fees except as noted below.
4	Land or Property Acquisition	Land acquisition costs are as advised by Irish Rail (Option 1b,and 2b) and are deemed to include any associated legal fees etc.
5	Archaeological works	No allowance has been included in respect of any work associated with Archaeological findings or dealing with uncovered munitions
6	Contaminated land	No allowance has been included for constructing on or remediating any contaminated land which may be uncovered.
7	Ordinance	No allowance has been included in respect of dealing with any unexploded ordinance which may be uncovered
8	Finance costs	No allowance has been made in respect of financing costs
9	Ecological mitigation measures	No allowance has been made in respect of any costs in respect of any ecological mitigation measures which may prove necessary
10	Landowner Interface issues	No allowance has been made for any costs associated with interfaces with adjacent landowners
11	Third Party costs	No allowance has been included for costs in respect of payments to third parties e.g. access consents etc.

8.2.2 OPEX Development

LCC modelling was undertaken in line with the requirements of BS ISO 15686-5:2017[1]. The costs were developed over a 35-year period of analysis. This provides an understanding of the costs that would be incurred during the operational life of the BEMU units. Whilst operation may continue beyond this period, it is possible that with the current rate of change in the rail industry, technological advancement or strategic change may result in alternative infrastructure requirements. This may incorporate systems not yet available and as such analysis beyond this period would introduce greater uncertainty into the assessment.

[1] Buildings and Constructed Assets – Service Life Planning, Part 5 – Life-cycle costing. *British Standards institute*, 2017

The development of the LCC tool was achieved using an understand, build, and calculate approach, as shown in Figure 8.1. The understand phase provides an appreciatation of the proposed options and various lifecycle activities associated with the assets. This key stage is undertaken using a combination of engagement with Subject Matter Experts (SMEs), reference to applicable maintennce and inspection standards, and benchmarking of unit rates and frequencies to comparable railway systems. Within the build phase, the 'infrastructure' of the model is developed, mapping activity profiles to assets and establishing core assumptions wihtin the modelling input. Finally, the calculation stage incorporates the application of unit costs and computes the LCC over the period of analysis.

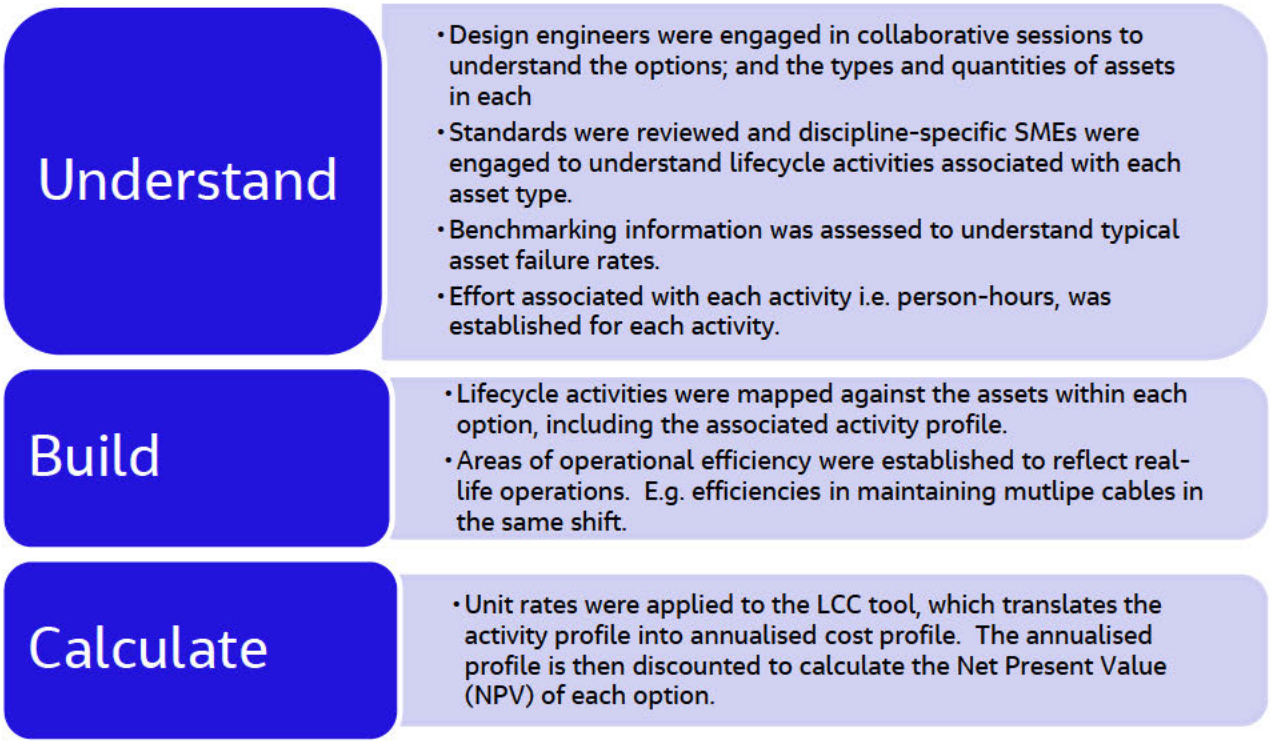


Figure 8-1 OPEX methodology phases

NPV was calculated by discounting the annualised costs using the discount rates shown in Table 8.3 in accordance with the Irish government's common appraisal framework for transport projects[2].

Table 8-3 Discount rates used in LCC Analysis

Project Lifetime (Years)	Discount rate (%)
0-30	[redacted]
31-60	
61-100	

8.2.2.1 Exclusions

Table 8-4 presents the exclusions from LCC modelling.

[2] Common Appraisal Framework for Transport Projects and Programmes. Republic of Ireland Department of transport, Tourism and Sport, 2016.

Table 8-4 LCC Analysis Exclusions

Reference	Asset Type	Comments
E-1	All	Energy usage excluded as this is anticipated to be incorporated in BEMU operational cost in ongoing Irish Rail tender exercise.
E-2	All	Excludes Life Cycle Cost assessment of asset already in situ.
E-3	All	All costs exclude VAT and the impacts of inflation.

8.3 Results

The 35-year discounted LCC of each option is displayed in Table 8-5. The results indicate that Option 1a has an LCC [redacted]. Option 1b has an [redacted] whilst the LCC of Option 2b is a further [redacted] The difference in LCC between Option 1a and the other options is primarily driven by the magnitude of the difference in Total Construction Costs between the options. Options 1b and 2b include the installation of a much greater volume of assets including the battery buffer, additional OLE and additional stabling capacity, thereby incurring much greater up-front expenditure.

Table 8-5 LCC per option.

[redacted]

To inform Irish Rail's strategy of upgrading to an OLE solution in approximately 3.25 years, Table 8-6 displays the cumulative costs incurred to year 3 and 4. This is provided as a guide to the estimated cost prior to installation of a full OLE option. Variations in maintenance timing and scheduling in practice mean that the costs incurred within a single quarter cannot be effectively estimated without significant uncertainty.

Table 8-6 Cumulative costs to year 3 and 4.

[redacted]

Figure 8-2 displays the cumulative discounted cost profile of the three proposed Options. The trends indicate the significance of the Total Construction Cost in the LCC of these options and indicate a similar cost profile across both options 1b and 2b. By comparison the cost profile of Option 1a shows less pronounced increases over the 35 years. This is related to the lesser volume of assets to be installed in this option. The large increases seen in

the cost profile of Options 1b and 2b relate to the requirement to renew the battery buffer a number of times over the period of analysis.



Figure 8-2 Cumulative Cost Profile (Discounted)

The annual cost profile displayed in Figure 8-3 indicates that the through-life costs associated with Option 1a remain broadly consistent across the period of analysis. The through-life costs associated with Options 1b and 2b whilst broadly consistent across much of the period of analysis are of a greater magnitude than those of Option 1b. This is primarily driven by the increased maintenance and inspection requirements as a result of the addition of sidings and the battery buffer in these options. A number of spikes in cost occur across the analysis, the spikes in years 9, 18 and 27 are notable as they occur only in Options 1b and 2b as a result of the renewal requirements of the batter buffer system. The smaller spike in year 26 of the analysis across all options is the result of a number of wiring assets within the system reaching the end of their anticipated design life simultaneously. The cost differs between options as a result of the differing volumes of wiring assets proposed in each option.



Figure 8-3 Discounted annual cost profile.

8.4 Kildare Extrapolation

IE also required the results obtained for Drogheda Station to be extrapolated onto the Kildare line for Hazelhatch station. It was agreed with IE during the development of this exercise that CAPEX costs would be adequate and that Life Cycle Costs and programme were not required in this case.

The logic for extrapolating the operational scenario to be found at Hazelhatch is outlined in Section 3.12.

IE required that costs be provided for a base scenario and for the TSS1b scenario and these are the costs now provided in Appendix D for the Kildare Line extrapolation.

As per the format above for the Northern line and Drogheda station, the assumptions and conclusions are noted here in the following tables.

8.4.1.1 Assumptions and Exclusions

CAPEX COST DATA ASSUMPTIONS LIST			
The following assumptions have been made in the preparation of the costs contained in this report			
Element	**Item**	**Description**	**Assumption**
SIDINGS TRACK & ANCILLIARIES			
1	Scope of Work	P-way	Includes track, S&C units and buffer stops
2	Scope of Work	Signalling requirements	Assumed scope restricted to 2 nr new signals
3	Scope of Work	OLE Testing & Commissioning	Assumed 5% of total OLE cost
4	Scope of Work	Cabling	Includes all ducting, troughing or other containment
5	Scope of Work	Battery buffer unit	2No TB-45-2,466 (2.4MVA) battery units accompanied with a single TB-40-1,644 (1.6MVA) battery unit would provide a combined supply of 6.4MVA. Approximate cost of the battery buffers based on a kWh cost [redacted]
6	Scope of Work	Lighting, CCTV and Comms	Includes lighting to stabling area, car park and access road, CCTV and call/help points
7	Scope of Work	ESB Connection to Grid	12.8MVA grid connection at medium voltage, 3 -Phase 20kV. The approximate connection cost is [redacted]
8	Scope of Work	Testing & Commissioning	Assumed [redacted] of total E&P cost
CIVILS			
1	Scope of Work	Piling to OLE supports	Assumed 610mm steel driven piles max depth 5m, subject to confirmation of ground conditions
2	Scope of Work	Civils	Includes upgrading existing access road, car parking, walking routes, Strail type track crossings, palisade security fencing and entrance gates. Acoustic barrier to neighbouring residential properties
3	Scope of Work	Excavation	Assumed no existing materials are being reused
BUILDINGS			
1	Scope of Work	Sub-station	Assumed brick-built substation on reinforced concrete raft foundation subject to confirmation of ground conditions
2	Scope of Work	Sub-station	Assumed substation building, transformers and battery buffer units contained within fenced compound
3	Scope of Work	Portakabins	Includes services and utility connections
METHODOLGY			
1	Method of work	Sequence of construction	It is assumed that this work can be carried out as a phased construction utilising Possessions as required
CAPEX COST EXCLUSIONS & QUALIFICATIONS			

The following Items are EXCLUDED from the reported costs		
Item	**Element**	**Description**
1	VAT	VAT
2	Traffic Management	The cost of any traffic management measures required in relation to the closure of roads, footpaths or car parks is excluded.
3	Legal Costs	No allowance has been made for any costs associated with legal fees.
4	Land or Property Acquisition	No allowance has been made for any necessary land acquisition costs.
5	Archaeological works	No allowance has been included in respect of any work associated with Archaeological findings.
6	Contaminated land	No allowance has been included for constructing on or remediating any contaminated land which may be uncovered.
7	Ordinance	No allowance has been included in respect of dealing with any unexploded ordinance which may be uncovered.
8	Finance costs	No allowance has been made in respect of financing costs.
9	Ecological mitigation measures	No allowance has been made of any costs in respect of any ecological mitigation measures which may prove necessary.
10	ESB Network enhancement charges	No provision is made for ESB Network enhancements or reinforcement [Connection to site substation is included]
11	Landowner Interface issues	No allowance has been made for any costs associated with interfaces with adjacent landowners.
12	Third Party costs	No allowance has been included for costs in respect of payments to third parties e.g. access consents etc.

9. Implementation Schedule

The high-level schedule has been produced for Options 1a and 1b and 2b to give an overall view of the stages involved from the planning through to construction. See Appendix folder I for Schedules.

Note the schedule has been developed based on traditional Employer's design since this allows development of the design in parallel with preparation of the planning application/ railway order. Design and Build options could be considered for the more specialist items such as the electrical installation, however this would mean planning approval would need to be secured in advance. Also, it is likely that elements of the project would still remain traditional employer's design with works around a live station and so a D&B element would just provide yet another interface that had to be managed.

10. Risk

Throughout the Study Jacobs and IÉ have identified key risks that could impact on each Operational Scenario and the relevant Infrastructure Options. These risks are presented in Appendix J in the form of a spreadsheet complete with scoring system and mitigation actions. In summary, while project risks vary with each Operational Scenario the common thread running through them all is:

- Availability of ESB Grid Power
- Stabling capacity at Drogheda (or elsewhere to serve Drogheda)
- Charging points and interfaces in the Depot

As the train frequency rises from 2tph to 6tph the scale of infrastructure intervention increases such that for example, the new platform on the Navan Line could need new land purchase. This might be mitigated by single tracking a section for the platform (Option 2b as proposed).

The Risk Register will be maintained over the course of the project development.

11. Summary and Conclusions

The purpose of this study is to identify the BEMU infrastructure requirements at Drogheda (including maintenance infrastructure and equipment), with an aim of minimal intervention and operational impact, for 3 different timetable scenarios and to develop Life Cycle Costs accordingly for the resulting requirements.

A long list of infrastructure interventions to provide battery charging infrastructure at Drogheda has been considered, which through a process of multi-criteria analysis was reduced to four key infrastructure options to satisfy the three TSSs provided by IÉ.

The TSS Scenarios have been assessed as shown in *Table 11-1* together with the infrastructure solutions needed for efficient battery charging.

Table 11-1 TSS Scenarios and Infrastructure Options

Scenario	Timetable	DART Train Service Frequency (Trains per hour)	Number of platforms with a charging point	Platform Infrastructure Required	Depot Infrastructure Required
2 and 3 DART trains per hour (the base scenario)	December 2019 timetable	Up to 3	1 (Option 1a)	Platform 3 to have a charging point	Depot Road 4 to have a charging point; Roof Access to be provided in Maintenance Building; Storage to be provided for running spares. Modification to train wash.
			2 (Option 1c)	In addition, a charging point on platform 2 would provide operational contingency and flexibility	Depot Road 4 to have a charging point Roof Access to be provided in Maintenance Building; Storage to be provided for running spares. Modification to train wash.
TSS 1b	Train Service Specification 1b	5 (includes 2tph empty stock between Laytown and Drogheda)	2 (Option 1b)	Charging points on platforms 2 and 3	Depot Road 4 to have a charging point Roof Access to be provided in Maintenance Building; Storage to be provided for running spares. Modification to train wash.
TSS 3	Train Service Specification 3	6	3 (Option 2b)	Platforms 2 and 3 and one new platform to have charging points	Depot Road 4 to have a charging point Roof Access to be provided in Maintenance Building; Storage to be provided for running spares. Modification to train wash.

The conclusion of this study is that it is feasible to install and operate BEMU infrastructure at Drogheda in a manner that will support the existing and proposed future timetables. Relevant considerations are listed below.

- The extent of infrastructure required increases as the timetable scenarios become more demanding in terms of train frequency.
- The cost and impact of the infrastructure required increases in a similar way.
- There are some operational challenges associated with BEMUs, e.g. The requirement for charging will limit their turnaround flexibility in responding to timetable delays. Enhancement of the timetable any further is also somewhat limited by the use of BEMUs vs EMUs. Ability to recover timetable issues today using DMUs will not be an option in future if all services are replaced by EMUs.
- The infrastructure requirements to meet the base scenario of 2/3tph to fulfil the current timetable requires the least investment and would have the least redundant costs. For this scenario we have recommended infrastructure Option 1a. Based on observations of other rail networks and their standard operations and maintenance procedures, it is felt that this option provides an acceptable level of redundancy. [If IE are concerned about a possible breakdown making Platform 3 unavailable and were not satisfied with charging a train for passenger service in depot road 4, and hence even further operational flexibility was required, the addition of a charging station on Platform 2 could be considered (equivalent to Option 1c).]
- Option 1a has a CAPEX estimate of approximately [redacted] an LCC estimate for the 3 to 4-year timescale envisaged before full electrification of approximately [redacted].
- [redacted]
- The additional infrastructure requirements for the two other scenarios (TSS1b and TSS3) and in particular, the increased power requirements and requirement for additional stabling in these scenarios, corresponds to a significant uplift in costs. The requirement for a new platform for the TSS 3 scenario increases these costs yet further.
- Option 1b, recommended for the TSS 1b scenario, has a CAPEX estimate of approximately [redacted] and an LCC estimate for the 3 to 4-year timescale envisaged before full electrification of [redacted]
- Option 2b, recommended for the TSS 3 scenario, has a CAPEX estimate of [redacted] and an LCC estimate for the 3 to 4-year timescale envisaged before full electrification of [redacted]

Note: All costs quoted here as elsewhere, are exclusive of VAT.

We trust that this report provides sufficient information to enable a decision to be made on the provision of necessary infrastructure to suit the TSS and appropriate BEMU fleet.

12. Recommended Next Steps

Following this initial study into the BEMU Infrastructure requirements and their associated costs, we suggest that the next steps for IÉ in this process are as follows:

- Confirmation of preferred option to pursue
- Confirmation from across IÉ departments of all issues being considered
- Finalise proposed timetable to confirm viability of operational assumptions
- Confirm stabling requirements for all scenarios
- Confirm BEMU vehicle details when preferred bidder for new fleet has been chosen
- Confirmation of grid connection capability with the ESB for all scenarios ***[Note this is considered one of the most important next steps]***
- Confirmation of proposed Substation location and ESB access arrangements
- Confirmation of likely ESB incoming cable routing
- Recommended that legal/ planning advice is sought in regard to parallel application for ESB upgrade works and any application for works to McBride Railway Station;
- Recommend that legal advice is sought in regard to any potential Railway Order Application;
- Recommend that any proposed stabling area outside Irish Rail Owned lands is proposed on lands with a favourable zoning objective in both the current Drogheda Borough Council Development Plan 2011-2017 and the emerging Draft Louth County Development Plan 2021- 2027;
- Recommend noise abatement fencing and landscaping around proposed stabling areas in proximity to existing and proposed residential uses;
- Recommended that any separate application submitted by ESB is fully assessed within any environmental report/assessment provided in connection with any application;
- Confirmation of application process and 'consenting route' for the above and timescale involved.
- Submit application (depending on timescale and surety of project proceeding)
- Progressive Engineering Assurance with IÉ to reduce programme timescales.
- Commence early design works including for example:
    - Topographical survey of the proposed works area
    - Geotechnical investigation where required (e.g. Substation area, OLE mast locations)
    - Track condition survey
    - Utilities searches
    - Early Contractor Interface with preferred bidder
- Commence early planning/environmental works for example:
    - Undertake EIA Screening & AA Screening
    - Pre application discussion with Louth County Council and agree application 'route'/ scope of submission
    - Commence early Environmental surveys
    - Engage Architectural Heritage architect
    - Engage with local community to keep them informed of the works and any impact it may have.

    - Undertake Consultation Exercise (could be done at later stage)

- Confirm schedule for potential long lead items and tailor procurement process accordingly
- Development and application of risk-based maintenance prioritisation principles to support performance at most efficient cost.
- Assess potential application of condition monitoring and predictive maintenance regimes for high criticality assets.
- Undertake analysis of economic benefits of increased service volumes to support a business case for investment.
- Undertake systems assurance process to assess the impact of installing current proposed systems within existing infrastructure system and the impact on future further electrification work.

Appendix A. Option 1a Layout

See Appendix A folder for Option 1a layout drawing.

Appendix B. Option 1b Layout

See Appendix B folder for Option 1b layout drawing.

Appendix C. Option 2b Layout

See Appendix C folder for Option 2b layout drawing.

Appendix D. LCC Breakdown

CAPEX Summary

BEMU INFRASTUCTURE STUDY OPTIONS - CAPEX MASTER COST SUMMARY (Rounded to '000's)

	Group Element	Option 1a (Base Scenario)		Option 1b (TSS 1b)		Option 1c (Base Scenario)		Option 2b (TSS 3)		Option 1b Redundant Costs *		Option 2b Redundant Costs *
-												
1	*Track*											
1.1	P-Way											
1.2	Signalling											
1.3	OLE											
1.4	Electric Power & Plant											
2	*Civils*											
2.1	OLE Foundations											
2.2	Platforms											
2.3	Raising of Existing Bridge											
3	*Buildings*											
3.1	New Buildings (Sub-station)											
3.2	Depot (Includes maintenance items and turntable relocation)											
4	*Stabling*											
4.1	P-Way											
4.2	Signalling											
4.3	Civils											

Group Element			Option 1a (Base Scenario)		Option 1b (TSS 1b)		Option 1c (Base Scenario)		Option 2b (TSS 3)		Option 1b Redundant Costs *		Option 2b Redundant Costs *
	4.4a	Acoustic Barrier											
	4.4b	Portakabins											
	4.5	Lighting, CCTV & Comms											
	4.6	Landscaping and Planting											
		Sub Total											
5		General Preliminaries											
6		Overheads & Profit											
		Sub Total											
7		Professional Fees											
		Planning Application											
		Railway Order Application											
		Planning Application & Enviro Impact Report											
		Sub Total											
8		Construction Risk and Contingency											

	Group Element	Option 1a (Base Scenario)		Option 1b (TSS 1b)		Option 1c (Base Scenario)		Option 2b (TSS 3)		Option 1b Redundant Costs *		Option 2b Redundant Costs *
	Sub Total	[redacted]										
9	Inflation (To mid-point of Construction)											
	Total Construction Costs											
	Land Purchase Costs											
	Total Cost											

*Redundant costs - The cost of BEMU infrastructure required that will become redundant and will be surplus to requirements following full electrification of the route.

Note: For Option 1b (which corresponds to TSS1b), this is based on the estimated fleet size requirement of 216 vehicles. For Option 2b (which corresponds to TSS 3), this is based on the estimated fleet size of 196 vehicles.

Note: The use of BEMUs requires extending the turnaround times at Drogheda due to the charging requirement (as opposed to when EMUs are used where no charging is required). This in turn means extra vehicles are required to support the timetable.

Option 1a			
BEMU - OPTION 1 (Rounded to '000's)			
-			*Cost*
-			
1	**Track**		
1.1	P-Way		
1.2	Signalling		
1.3	OLE		
1.4	Electric Power & Plant		
2	**Civils**		
2.1	OLE Piled Foundations		
3	**Buildings**		
3.1	New Buildings (Sub-station)		
3.2	Depot (Associated Works)		
4	**Stabling on Navan Line**		
4.1	P-Way		
4.2	Signalling		
4.3	Civils		
4.4	Acoustic Barrier		
4.5	Lighting and CCTV		
4.6	Landscaping and planting		
	Sub Total		
5	**General Preliminaries**	30.0%	

Option 1a			
BEMU - OPTION 1 (Rounded to '000's)			
6	**Overheads & Profit**	10.0%	[redacted]
	Sub Total		
7	**Professional Fees Planning Application**	10.0%	
	Sub Total		
8	**Construction Risk and Contingency**	35%	
Total Construction Costs			[redacted]

Option 1b	
BEMU - OPTION 1b (Rounded to '000's)	
-	*Cost*
-	
1 Track	
1.1 P-way	
1.2 Signalling	
1.3 OLE	
1.4 Electric Power & Plant	
2 Civils	
2.1 OLE Piled Foundations	
2.2 Platforms	
2.3 Raising of Existing Bridge	
3 Buildings	
3.1 New Buildings (Sub-station)	
3.2 Depot (Associated Works)	
4 Stabling	
4.1 P-Way	
4.2 Signalling	
4.3 Civils	
4.4 Portakabins	
4.5 Lighting, CCTV & Comms	
4.6 Landscaping and planting	
Sub Total	[redacted]

Option 1b			
BEMU - OPTION 1b (Rounded to '000's)			
5	**General Preliminaries**	30%	
6	**Overheads & Profit**	10%	
	Sub Total		
7	**Professional Fees** **Railway Order Application** **Planning Application & Environmental Impact Report**	10%	
	Sub Total		
8	**Construction Risk and Contingency**	35%	
	Total Construction Costs		

Option 1c	
BEMU - OPTION 1c (Rounded to '000's)	
-	*Cost*
-	
1 Track	
1.1 P-Way	
1.2 Signalling	
1.3 OLE	
1.4 Electric Power & Plant	
2 Civils	
2.1 OLE Piled Foundations	
2.2 Platforms	
2.3 Raising of Existing Bridge	
3 Buildings	
3.1 New Buildings (Sub-station)	
3.2 Depot (includes maintenance equipment and turntable relocations)	
4 Stabling on Navan Line	
4.1 P-Way	
4.2 Signalling	
4.3 Civils	
4.4 Acoustic Barrier	
4.5 Lighting and CCTV	
4.6 Landscaping and planting	
Sub Total	[redacted]

Option 1c			
BEMU - OPTION 1c (Rounded to '000's)			
5	**General Preliminaries**	30%	
6	**Overheads & Profit**	10%	
	Sub Total		
7	**Professional Fees Planning Application**	10%	
	Sub Total		
8	**Construction Risk and Contingency**	35%	
	Total Construction Costs		[redacted]

Option 2b			
BEMU - OPTION 2b (Rounded to '000's)			
-			*Cost*
-			
1	**Track**		
1.1	P-way		
1.2	Signalling		
1.3	OLE		
1.4	Electric Power & Plant		
2	**Civils**		
2.1	OLE Piled Foundations		
2.2	Platforms		
2.3	Raising of Existing Bridge		
3	**Buildings**		
3.1	New Buildings (Sub-station)		
3.2	Depot (includes maintenance equipment and turntable relocation)		
4	**Stabling**		
4.1	P-Way		
4.2	Signalling		
4.3	Civils		
4.4	Portakabins		
4.5	Lighting, CCTV & Comms		
4.6	Landscaping and planting		
	Sub Total		
5	**General Preliminaries**	30%	

Option 2b			
BEMU - OPTION 2b (Rounded to '000's)			
6	**Overheads & Profit**	10%	[redacted]
	Sub Total		
7	**Professional Fees** **Railway Order Application** **Planning Application & Environmental Impact Report**	10%	
	Sub Total		
8	**Construction Risk and Contingency**	35%	
	Total Construction Costs		[redacted]



BEMU Infrastructure Study - Hazelhatch Sidings CAPEX				
	Group Element	Base Scenario (2 Sidings)		TSS 1b (5 Sidings)
		Cost		*Cost*
1	**Sidings Track and Ancillaries**	[redacted]		
1.1	P-Way			
1.2	Signalling			
1.3	OLE			
1.4	Electric Power & Plant (Inc ESB Connection)			
1.5	Lighting, CCTV & Comms			
2	**Civils**			
2.1	OLE Piled Foundations			
2.2	Upgrade Existing Access Road			
2.3	Car Parking Area			
2.4	Security Fencing			
2.5	Acoustic Barrier			
2.6	Trackside Walking Routes			
3	**Buildings**			
3.1	New Sub-station Building			
3.2	Sub-station Compound and Fencing			
3.2	Portakabins			
	Sub Total			

	Group Element		
4	**General Preliminaries**	30.0%	[redacted]
5	**Overheads & Profit**	10.0%	
	Sub Total		
6	**Professional Fees** **Railway Order Application** **Planning Application & Environmental Impact Report**	10.0%	
	Sub Total		
7	**Construction Risk and Contingency**	35%	
	Sub Total		
8	**Inflation (To mid-point of Construction)**	10%	
	Total Construction Costs		

Appendix E. Relevant Planning information.

Extracts form the current Drogheda Borough Council Development Plan (DBCDP) 2011-2017 & the emerging Draft Louth County Development Plan (DLCDP) 2021 - 2027

E.1 DBCDP 2011 - 2017 - Drogheda Transport Development Area (DTDA)



Brown Hatched lands = DTDA – Drogheda Transport Development Area

"The wider area surrounding the DTDA within the Borough, together with a larger contiguous area lying within County Meath and referred to as the Mill Road / Marsh Road character area within the Local Area Plan for the Southern Environs of Drogheda 2009-2015, will be subject to the preparation of a Master Plan during the lifetime of the Plan in conjunction with Meath County Council."

"In the case of Drogheda, Mc Bride Railway Station has been identified in both the Drogheda Transportation Study and the Planning Strategy for the Greater Drogheda Area as being the main public transport hub for the Borough. This transportation hub revolves primarily around the provision of rail services but also attracts significant car borne traffic, cyclists and pedestrians. Due to the fixed route nature of railways, it is vital that the rail service continues to have sufficient critical mass of potential patrons in order to ensure the continued viability of services. In practice this involves the careful siting of major employment generating attractors in close proximity to the rail station. Ease of access by all modes of transport to the station site from more distant locations within the Borough and its environs is also a pre-requisite for the success of a transport hub. Thus, a latent demand for transport services is created and the rail passenger ***market*** *in particular is strengthened by the close spatial matching of origins with destinations and as such, further investment in improving the quality of the rail service itself can be justified."*

DLCDP 2021 – 2027 – J1 ' Transport Development Hub'



The lands in grey are J1 'Transport Development Hub' (which is the current Drogheda Development Transport Area (DDTA) objective).

E.2 Appendix E2. DBCDP 2011 – 2017 Transport Related Policies

Policy TR 9
"To implement the general principles outlined above associated with the Drogheda Transport Development Area. To explore the feasibility in conjunction with Meath County Council, to producing a Master Plan for those lands east of McBride Station bounded to the south by the rail line, to the north by the River Boyne and to the east by the Borough boundary."

Policy TR 12
"Work in partnership with Iarnród Éireann in the provision of upgraded rail facilities at McBride station including extension of the DART service to Drogheda and the provision, in time, of a further rail station and park and ride facility in the northern sector of the town (within County Louth). Co-operate with the railway operator and neighbouring Local Authorities in the event of the proposed re-opening of the Drogheda to Navan rail line to regular passenger traffic. Maintain the abandoned Drogheda Port Rail Link ("Cement Branch") rail alignment for future rail-based use."

Policy TR 13

"Promote and facilitate the development of an Integrated Public Transport Hub (IPTH) at McBride Railway station and facilitate the development of integrated and co-ordinated bus and rail services within the Railway station site."

E.3 Appendix E3. DBCDP 2011 – 2017 Rail

"At present the Borough is served by up to 38 trains per day towards Dublin with an equal number of return services. Drogheda is also a major station on the cross border, Dublin to Belfast intercity route linking the two largest cities on the Island of Ireland. The Dublin to Belfast rail service is due to be upgraded during the course of the Plan, to permit an hourly service on the route. The existing railway station on the southern side of the river is heavily utilised, primarily by commuters to Greater Dublin. In recent years there have been significant capacity constraints in the railway station car park despite a significant expansion of parking on the site. The Planning Authority is presently considering an application to construct a car park along the Marsh Road this will serve Mc Bride Station. The rail station is not served by connecting bus services from other parts of the Borough which only serves to increase pressure on car parking. Many commuters travel from the northern suburbs of the town causing unnecessary vehicle flows at peak hours over the limited amount of river crossings by other means of transport to access the rail station."

1. Drogheda North Railway Station

"*The North Drogheda Environs Master Plan 2005 and the Planning Strategy for the Greater Drogheda Area 2007 both propose the establishment of a second commuter station in Drogheda, serving the expanding Northern Environs area in County Louth on the north side of the river. This would eliminate the need for commuters to travel across the town at peak hours. The proposed station would incorporate park and ride facilities. The creation of this station may necessitate the extension of some services from the Borough including road and pedestrian links. Drogheda Borough Council will co-operate with the railway operator and adjacent Local Authority in order to realise the establishment of a Drogheda North Railway Station."*

2. Drogheda to Navan Railway Line

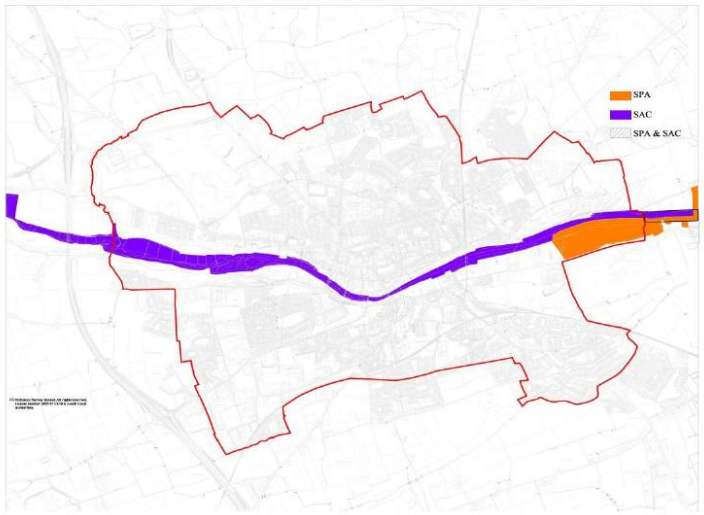
"Drogheda Borough is linked to Navan in County Meath by a freight only rail link. Whilst this line is rarely used by passenger trains, there may be potential in the future for passenger utilisation of sections of this line. The town of Navan is one of three designated Primary Development Centres in the Greater Dublin Hinterland Area. It is not connected directly to Greater Dublin by a rail link at present. However, the town is likely to be reconnected by rail during the course of the Plan. In the interim there is the possibility that a commuter service could be provided from Navan to Dublin via Drogheda."

3. Drogheda Port Rail Link ("Cement Branch")

"A disused but largely intact railway line ("Cement Branch") links the environs of Tom Roe's Point (Cement Factory) to the main rail line north of Drogheda. This link is approximately 1.0 km in length and has remained largely free from development over the course of previous Plans. It has the potential to provide a direct rail-based connection to the Drogheda Port container terminal at Tom Roe's Point in County Louth. This would accord with international policy on encouraging modal shift to environmentally sustainable forms of transport for freight movements, in this case sea and rail. As such, the rail link is of strategic significance. It is the policy of Drogheda Borough Council to maintain this rail alignment for future rail-based use. Whereas the rail service in Drogheda is of strategic importance in economic and transportation terms, the railway line itself can provide a barrier to connectivity between communities and services located on either side of the line. It is therefore important that arrangements are put in place to provide for greater permeability and connectivity across this barrier. Consequently, where development is proposed adjacent to the railway line, the council may require developers to investigate the provision of and where feasible provide, new connections across the line."

E.4 Appendix E4. Nearby SPA/SAC

Map 8.1: Special Protection Area and Special Area of Conservation.

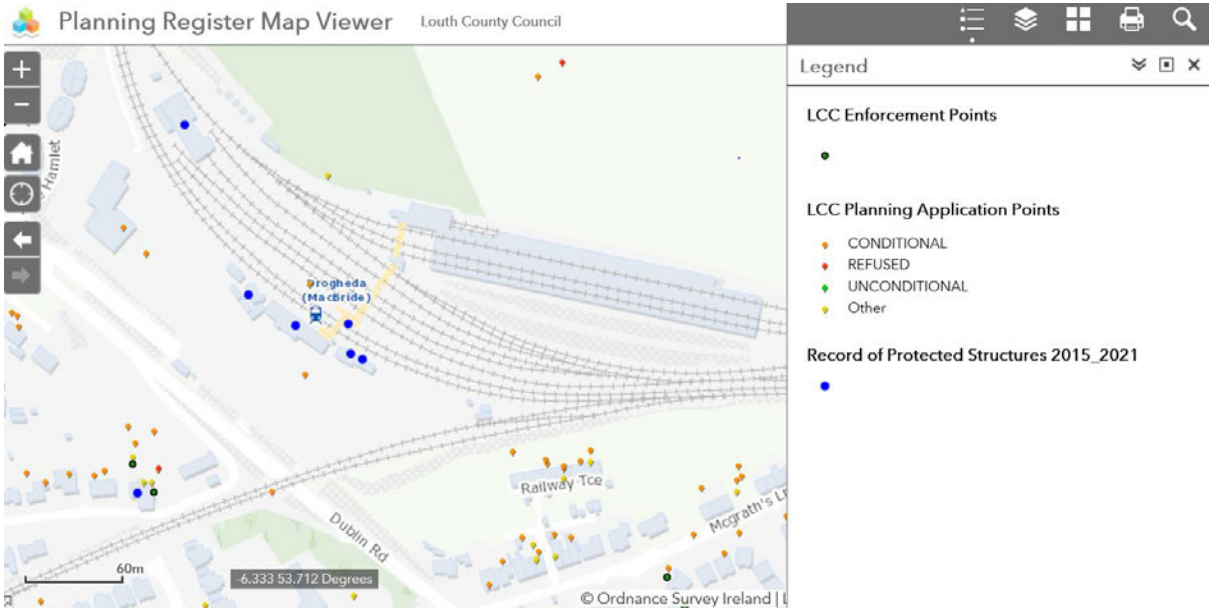


E.5 Appendix E5. Protected Trees

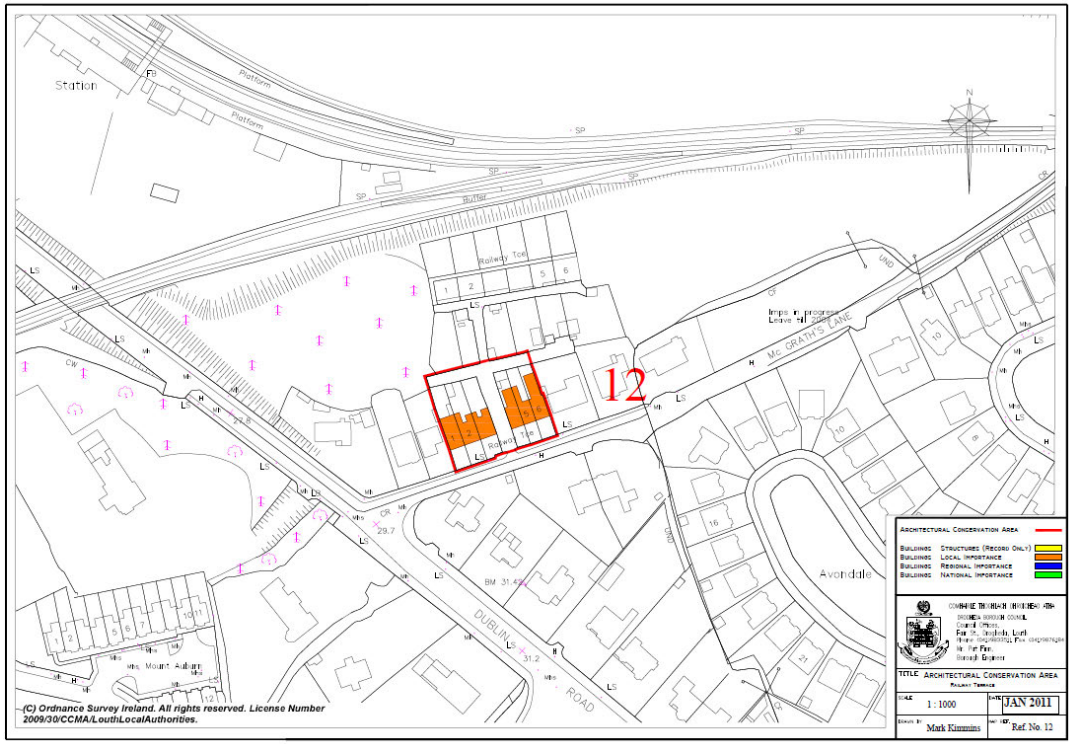
Map 8.4: Areas covered by Tree Survey



E.6 Appendix E6. Record of Protected Structures Buildings



E.7 Appendix E7. Architectural Conservation Areas (ACA)



E.8 Appendix E8. Relevant Planning History

Ref 10510055 (May 2010)
"Development at McBride Railway Station, which is a Protected Structure. Development consists of removal of glass screens and counter to Ticker Office and Waiting Room, introduction of new glass double door to Waiting Room, re-instatement of original arch to Ticket Office, demolition of existing partition wall in Ticket Office & construction of new partition walls in new positions, installations of 5nr automatic ticket gates with associated screens and all associated works."

Required the submission of an "Assessment of the works on the McBride Station" It was considered that the works are minor and will not undermine the character or architectural merit of the building.

Decision: Permission Granted July 2010

Ref 00510255 (November 2000)
ABP Ref PL54.123480
"Construction and operation of an Arrow Fleet Train Servicing Centre, Maintenance Workshop, Administration Building, Single Storey Train Wash Building, workshop, together with associated works and EIS Statement."
Appealed by third parties including the Preservation Society of Ireland (PSOI)
The PSOI were primarily concerned with a proposed relocation and use of the existing turn table on site.

The Inspectors Report sets out that: "*The society's appeal is concerned exclusively with the proposed relocation and use of the existing turn table on site. The society notes that although it is listed as a protected structure in the Drogheda Development Plan it is not "of great heritage value" having been built and installed as recently as the 1940's. Its location in the middle of a car park divorced from any relevant railway infrastructure makes a nonsense of its functional origins and unnecessarily reduces the available car parking area. The society states therefore that the turn table would be better utilised in both heritage and practical terms by relocation and restoration at another site served regularly by steam locomotives where it will be open to view by the public in a working environment.*

In regard to the above, the Inspector stated at paragraph 13.14 " However, as the turntable is a listed structure its relocation off site will require it first to be delisted in accordance with the procedures indicated at Section 6 of the 1999 Local Government (Planning & Development) Act. As the Board does not have any role in such procedures it is unable to acquiesce with any request of the RPSI involving relocation of the turntable to any place outside the boundaries of the site. In that content therefore I am satisfied that the relocation of the turntable to the car park is acceptable."

The inspector continued at paragraph 15.5 to set out that: "With regard to the appeal submission by the RPSI, I note their informed comments on the age, structural integrity and operational potential of the turn table would appear to undermine its status as a listed structure in the current Drogheda Development Plan. However, as the structure is currently a protected structure in the Drogheda Development Plan, and as the Board under the provisions of the 1999 Local Government (Planning & Development) Act does not have any role in the de-listing procedures referred to therein, the relocation of the turntable to an off-site location as suggested by the RPSI is not one which can be acceded to by An Bord Pleanala by way of attached condition. The onsite relocation of the turntable as proposed by the developer is however acceptable. "

The An Bord Pleanala Order sets out at the Second Schedule that 1. "The proposed relocation of the turntable to the car parking area is not permitted. The turntable may be relocated within the site to an alternative location on the rail side of the station building, details to be agreed with the planning authority prior to relocation." Reason: "Having regard to the status of the turntable as a protected structure and to its function, it is considered that its relocation to a car parking area would be contrary to the proper planning and development of the area."

Additional Issues Raised:

- *Dispute over property ownership*
- *Visual Impact*
- *Traffic Impact*
- *Noise Impact*
- *Impact upon Trees*
- *Vermin*

Decision: Permission Granted by ABP September 2001

Appendix F. E&P Details

See Appendix F folder for additional Electrification & Plant details.

Appendix G. OLE Current Calculation

Selection of contact wire and catenary wire

As per standard BS EN 50119 2013, table A.1 - Continuous current-carrying capacity of conductors and contact wires.

The current (AC) carrying capacity for a Cu 107mm^2 is 469A at 30^o C and,

The current (AC) carrying capacity for a Cu 150mm^2 is 583A at 30^o C

To find out the DC equivalent as per standard IEIEC 60287-1-1,

IDC = 2 x IAC

So, for copper wire of107mm^2 the DC current carrying capacity will be 938A at 30^o C

Similarly,

For copper wire of 150mm^2 the DC current carrying capacity will be 1166A 30^o C

So, the total current will be = 2104A

The current required to charge a FLU is 2109.3A (current rating based on E&P calculation).

To get the current of 2109.3A, will have to propose 2nos. of contact wire (2x107mm^2) and 1no. catenary wire(1x150mm^2)

So, total current for a 2 x 107mm^2 + 1x 150mm^2 will be:

Total current = 2x938 + 1166

Total current = 3042A

Appendix H. Bridge Clearance Assessment for OLE

Bridge Clearance Assessment

There are two footbridges within the limit of works, OBB81 on platform area and OBB81C on the depot road. The soffit height for Drogheda Station Footbridge (over platforms 1 & 2)- OBB81 is 4.394m and for Staff Access Footbridge to Depot (over platform 3 and service slabs/sidings)- OBB81C is 5.765m.

As per standard I-ETR-4005 'Clearance Requirement for 1500V DC Electrified line', section 6.1.5, 6.1.6 and 6.1.7 and as per standard I-PWY-1101 'Requirement for track and Structures Clearance', section 7.1.2.2. it has been noted that the minimum contact wire height shall be 4200mm and the maximum permitted height of DART vehicles and all other rolling stock at the centre of the track is 4064mm giving a minimum passing clearance between the vehicle and contact wire of 136mm.

As per standard GL/RT 1210 and BS EN 50119 2013 section 5.1.3, the minimum clearance between live part and earth shown below (extract from BE EN 50119 2013):

Dimensions in millimetres

Voltage	Recommended clearances	
	Static	Dynamic
d.c. 600 V [a]	100	50
d.c. 750 V	100	50
d.c. 1,5 kV	100	50
d.c. 3,0 kV	150	50
a.c. 15 kV	150	100
a.c. 25 kV	270	150

[a] Only for existing systems.

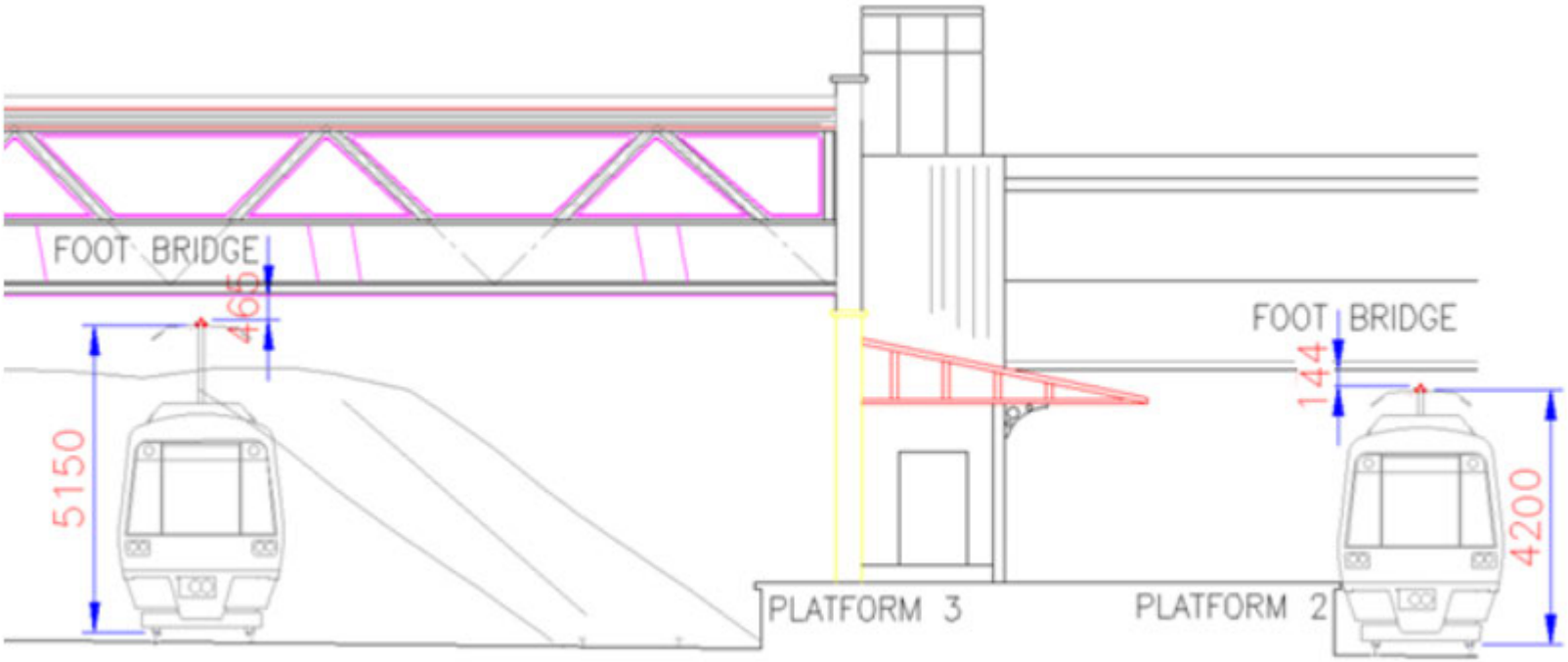
Also, as per standard I-ETR-4005 'Clearance Requirement for 1500V DC Electrified line', section 6.1.13 and 7.1.3 and as per standard I-PWY-1101 'Requirement for track and Structures Clearance', section 7.1.3 and 7.1.4, the static clearance and passing clearance are 150mm and 100mm respectively. The special reduced Static clearance and Passing clearance of 100mm and 80mm limit may only be used in cases of difficulty, the Chief Engineer's written authority must be obtained following notification to the Chief Railway Inspecting Officer.

All bridges which are within contact line zone (as per standard BS EN 50119-2020, BE EN 50122-1 and BS EN 50122-2) are bonded to main earth terminal of the station area to allow a robust earthing system. Detailed Bridge bonding assessment to undertaken at later stages.

All bridges with below 150mm static clearance are bonded to the traction return to allow for a robust earthing system.

Bridge clearance assessment show below at Drogheda station:

The values of the soffit height for the OBB 81 were taken on site on November 2020. By reducing the nominal height of the system and the encumbrance the following electrical clearance can be achieved:



BEMU Station Foot Bridge	Soffit Height (mm)	Contact Wire (mm)	Catenary wire (mm)	Encumbrance (mm)	Static Clearance (mm)
Drogheda Station Footbridge (over platforms 1 & 2)- OBB81	4394	4200	4250	50	144
Staff Access Footbridge to Depot (over platform 3 and service slabs/sidings)- OBB81C	5765	5150	5300	150	465

It can be observed that for the Drogheda Station Footbridge the static clearance is 144mm which is less than the 150mm recommended in the standard. The recommendation is to study the raising of the Station footbridge at the next stage in order that the OLE system can be in compliance.

Note if necessary, for clearance purposes, it would be possible to reduce the encumbrance even further such that the catenary wire will sit just above the two contact wires. (This arrangement would then avoid the installation of rigid droppers.)

Note: the soffit height data considered may not be fully accurate. Different soffit heights will have different solutions to achieved electrical clearances. These are to be undertaken at detailed design stage.

Appendix I. High Level Schedules

See Appendix folder I for high level schedules.

Appendix J. Project Risk Register

See Appendix folder J for Risk Register.

Appendix K. Hazard Elimination and Risk Reduction Register (HERRR)

See Appendix folder K for HERRR document.

Appendix L. Options Matrix

See Appendix folder L for Options Matrix and location sketch.

Appendix M. CAF Matrix

See Appendix folder M for CAF Matrix.

Appendix N. December 2019 Timetable Platform Workings at Drogheda

This Table shows the December 2019 platforming arrangements at Drogheda and the changes required to the rolling stock diagrams if BEMUs replace DMUs on some existing services.

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Use BEMU Stock?	BEMU Diagram	Suggested Change 1	Suggested Change 2	Note
05:40 Dundalk	06:03	2	06:04	Pearse	8 x 29000					
Depot		3	06:28	Pearse	4 x 29000	Yes	1,2	07:55 Pearse – Dundalk terminates Drogheda at 09:03 and forms 09:40 to Pearse	08:40 Connolly – Drogheda empty stock advertised and extended to Dundalk	
Depot		3	06:45	Pearse	7 x 22000	Yes	3,4	07:45 Maynooth - Connolly works 08:23 Pearse - Maynooth (retimed, starts Connolly)	Empty stock stabled at Pearse via 10:19 ex Bray? Return empty stock to Drogheda?	
06:30 Dundalk	06:54	2	06:55	Bray	8 x 29000					
Depot		2	07:05	Bray	8 x 29000	Yes	5,6	Swap Bray departures at16:50 and 17:30 to keep Drogheda diagram self-contained		Use platform 3 at Drogheda
06:30 Newry	07:19	1	07:21	Connolly	7 x 22000					
07:10 Dundalk	07:34	1	07:36	Pearse	8 x 29000					
Depot		3	07:58	Bray	8 x 29000	Yes	7,8	Terminate Connolly 08:58	Forms 09:10 Connolly - Drogheda	
07:35 Connolly	08:09	1	08:11	Belfast	Enterprise					
06:45 Belfast	08:22	1	08:24	Connolly	Enterprise					
07:09 Pearse	08:05	1	08:30	Pearse	8 x 29000					Should be platform 3

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Use BEMU Stock?	BEMU Diagram	Suggested Change 1	Suggested Change 2	Note
07:50 Connolly	08:49	1	09:00	Connolly	4 x 29000	Yes	9,10	Outstabled at Connolly and unable to act as Enterprise standby set if a BEMU	11 minute turnaround time at Drogheda – minor retiming required	Use platform 3 at Drogheda
07:54 Pearse	09:03	1	09:04	Dundalk	4 x 29000					
08+40 Connolly	09+23	2	09:40	Pearse	7 x 22000	Yes	1,2	PM work as booked		
05:35 Rosslare	09:51	1	09:53	Dundalk	4 x 29000					
09:10 Connolly	09:59	2	10:10	Connolly	3 x 22000	Yes	7,8		11 minute turnaround time at Drogheda – minor retiming required	Use platform 3 at Drogheda
09:30 Connolly	10:07	1	10:08	Belfast	Enterprise					
10:15 Dundalk	10:38	2	10:40	Connolly	4 x 29000					
10:50 Dundalk	11:13	2	11:14	Connolly	4 x 29000					
11:20 Connolly	11:54	1	11:55	Belfast	Enterprise					
10:35 Belfast	12:08	2	12:09	Connolly	Enterprise					
11:07 Connolly	12:07	1	12:10	Dundalk	4 x 29000					
10:30 Connolly	11:32	3	12:20	Connolly	4 x 29000	Yes	9,10	09:00 Drogheda – Connolly forms 10:30 Connolly – Drogheda		
12:45 Dundalk	13:08	2	13:10	Connolly	4 x 29000					
11:50 Connolly	12:45	3	13:40	Connolly	8 x 29000	Yes	7,8	10:10 Drogheda – Connolly forms 11:50 Connolly – Drogheda		
13:20 Connolly	13:56	1	13:58	Belfast	Enterprise					
12:35 Belfast	14:08	1	14:09	Connolly	Enterprise					

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Use BEMU Stock?	BEMU Diagram	Suggested Change 1	Suggested Change 2	Note
12:50 Connolly	13:44	2	14:20	Connolly	4 x 29000					
Depot		3	14:50	Bray	8 x 29000	Yes	3,4	Terminate Grand Canal Dock and then work 16:21 Pearse – Drogheda		
13:50 Connolly	14:44	2	15:10	Connolly	8 x 29000	Yes	9,10	formed off 12:20 Drogheda – Connolly	cannot work to Maynooth	
14:05 Belfast	15:41	1	15:43	Connolly	Enterprise					
14:50 Connolly	15:43	2	15:50	Connolly	4 x 29000	Yes	7,8	swaps with 14:47 Connolly – Maynooth at Connolly	works 17:12 Connolly to Ballbriggan – extend to Drogheda? Another set required to work 19:00 Pearse - Maynooth	
15:20 Connolly	15:54	1	15:55	Belfast	Enterprise					
Depot		3	16:02	Pearse	8 x 29000			Cannot then form next working at 18:00 to Dundalk		
15:22 Connolly	16:23	2	16:28	Connolly	4 x 22000					
15:43 Pearse	16:47	2	17:00	Pearse	8 x 29000					
16:50 Connolly		1	*17/28*	Belfast	Enterprise					
16:23 Pearse	17:24	2	17:30	Pearse	8 x 29000	Yes	3,4	very short turnaround at Drogheda		Use platform 3 at Drogheda
16:05 Belfast	17:41	1	17:43	Connolly	Enterprise					
16:53 Pearse	17:56	1	18:02	Pearse	7 x 22000	Yes	1,2	very short turnaround at Drogheda		Use platform 3 at Drogheda
17:13 Pearse	18:21	1	18:22	Newry	8 x 29000					
16:50 Bray	18:38	2	18:50	Pearse	8 x 29000	Yes	5,6			Use platform 3 at Drogheda

Inbound	Arrive	Platform	Depart	Outbound	Rolling Stock	Use BEMU Stock?	BEMU Diagram	Suggested Change 1	Suggested Change 2	Note
16:50 Bray	19:06	1	19:08	Dundalk	8 x 29000					
19:00 Connolly	19:33	1	19:35	Belfast	Enterprise					
18:05 Belfast	19:41	1	19:43	Connolly	Enterprise					
18:50 Connolly	19:44	2	20:00	Pearse	8 x 29000					
19:23 Pearse	20:25	2		Depot	7 x 22000		1,2			Use platform 3 at Drogheda
20:40 Dundalk	21:03	1	21:05	Pearse	8 x 29000					
20:15 Pearse	21:21	2		Depot	8 x 29000					
20:50 Connolly	21:29	1	21:30	Belfast	Enterprise					
20:05 Belfast	21:41	1	21:43	Connolly	Enterprise					
20:46 Pearse	21:50	2		Depot	8 x 29000					
18:24 Pearse	19:24	2	22:05	Connolly	8 x 29000					
21:40 Pearse	22:47	2		Depot	8 x 29000					
22:40 Pearse	00:07	3		Depot	8 x 29000					
23:35 Pearse	01:10	3		Depot	7 x 22000					

Appendix O. Indicative Timetable for TSS 1b Fleet Size Calculation

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	2	21
Drogheda	06:10	06:17		06:41	06:46	06:50		07:10	07:17		07:41	07:46	07:50		08:10	08:17		08:41	08:46	08:50		09:10
Clongriffin			07:01				07:29			08:01				08:29			09:01				09:29	
Bray	07:43	07:51	08:02	08:15	08:18	08:23	08:30	08:43	08:51	09:02	09:15	09:18	09:23	09:30	09:43	09:51	10:02	10:15	10:19	10:23	10:30	10:43
	16	15	10	19	20	18	14	22	21	17	23	24	1	2	3	4	5	6	7	8	9	10
Bray	06:14	06:22	06:34	06:42	06:50	06:54	07:02	07:14	07:22	07:34	07:42	07:50	07:54	08:02	08:14	08:22	08:34	08:42	08:50	08:54	09:02	09:14
Clongriffin			07:32				08:00			08:32				09:00			09:32				10:00	
Drogheda	07:45	07:53		08:13	08:23	08:25		08:45	08:53		09:13	09:23	09:25		09:45	09:53		10:13	10:23	10:25		10:45
forms	*08:17*	*08:10*	*08:01*	*08:46*	*08:50*	*08:41*	*08:29*	*09:17*	*09:10*	*09:01*	*09:46*	*09:50*	*09:41*	*09:29*								

Appendix P. Indicative Diagrams for TSS 3

	1	2	3	4	5	6	7	8	9	10	11	3	4	12	13	14	15	16	18	11	3	17	19	20
Drogheda	06:07	06:23	06:27			06:35	06:51	06:55	07:07	07:23	07:27			07:35	07:51	07:55	08:07	08:23	08:27			08:35	08:51	08:55
Clongriffin				07:04	07:12							08:04	08:12							09:04	09:12			
Connolly			07:16	07:20	07:28			07:45			08:16	08:20	08:28			08:45			09:16	09:20	09:28			09:45
Connolly																								
Bray	07:41	07:58				08:10	08:25		08:41	08:58				09:10	09:25		09:41	09:58				10:10	10:25	
	16	17	3	4	18	19	20	5	21	8	11	3	22	1	2	4	6	14	18	11	7	9	10	3
Bray	06:27				06:39	06:55	07:11		07:27				07:39	07:55	08:11		08:27				08:39	08:55	09:11	
Connolly																								
Connolly		07:15	07:35	07:42				07:58		08:15	08:35	08:42				08:58		09:15	09:35	09:42				09:58
Clongriffin			07:51	08:00							08:51	09:00							09:51	10:00				
Drogheda	07:59	08:05			08:11	08:30	08:43	08:46	08:59	09:05			09:11	09:30	09:43	09:46	09:59	10:05			10:11	10:30	10:43	10:46
forms	*08:23*	*08:35*			*08:27*	*08:51*	*08:55*	*09:07*	*09:23*	*09:35*			*09:27*	*09:51*										

Appendix Q. RFIs and TQs

See Appendix folder Q for RFIs and TQs raised on the project.

Appendix R. Manufacturer / Installers

Discipline	Manufacturer/ Installer
E&P- HV Switchgear	ABB
E&P- Transformer	ABB, Secheron
E&P- Rectifiers	ABB, Secheron
E&P- DC High speed circuit breaker	ABB, Secheron
E&P- DC Switchgear	ABB, Secheron
E&P- cables	Caledonian Cables
E&P- Battery Buffer	Centrica, Anesco
E&P- Lighting	DesignPlan, DW Windsor
Telecoms-CCTV	Bosch
OLE	Supplier homologated by ADIF/ Irish Rail Surgremin, Elecnor, Siemens Approved installer by Irish Rail

Appendix S. Assumptions

Discipline	Assumption	Relevant Scenarios
E&P	ESB can supply the base option from Mornington Road without Grid reinforcement.	Base Scenario
E&P	Mornington Road is assumed to provide 10KV 3-phase supplies	All Scenarios
E&P	20% spare capacity is not required to be applied to the substation capacity as due to the high capacities.	All Scenarios
E&P	All costings are approximate or based on liaison and need to be confirmed at the subsequent design stage.	All Scenarios
E&P	Under the proposals outlined on Option 2b, supply cables will be routed through the new platform.	TSS 3
E&P	For the sizing and specification of the proposed transformers, unity power factor is assumed.	All Scenarios
E&P	The battery buffer is assumed to operate in tandem with the grid connection and smooth the supply peaks. It assumed the battery buffer will be charged during operation.	TSS1b and TSS3
E&P	Lighting and CCTV for the Navan Stabling is serviced by the Station supply.	Base Scenario
E&P	The stabling in the field will require a new supply for lighting, building domestic and telecoms power.	TSS1b and TSS3
E&P	The Existing signalling power has the capacity to service the new stabling in the field.	TSS1b and TSS3
Environment	Assumed that a Railway Order is only required for Options 1b & 2b as they require third party lands for additional stabling. Option 1a (or 1c) does not require third party lands and a planning application to Louth	TSS1b and TSS3

	County Council is considered the most appropriate mechanism. Assumed that and EIA will be screened out for Option 1a and that an environmental report to support any application is sufficient. However, an EIA will be required for Options 1b & 2b as they trigger Railway Order; Assumed there will be no impacts upon the SPA/SAC; Assumed that further development can be accommodated in close proximity to existing Protected Structures; Assumed that the relocation of the turntable can be accommodated; Assumed that the proposed development taken forward is fully compliant with the aims/objectives of the current Drogheda Borough Council Development Plan (DBCDP) 2011 – 2017 and the emerging Draft Louth County Development Plan 2021 – 2027; Assumed that the principle of works on the Navan Line is acceptable and will not compromise the objectives of the Drogheda Borough Council Development Plan (DBCDP) 2011 – 2017 or the emerging Draft Louth County Development Plan 2021 – 2027.	Base Scenario All Scenarios All Scenarios All Scenarios All Scenarios TSS3
Depot	BEMU servicing and light maintenance will be undertaken at Drogheda for a period of about three years, until the new depot at Maynooth opens. Thereafter, servicing of BEMUs will be undertaken at Maynooth. The additional equipment that is required for both light and heavy maintenance and major component changes on the new fleet is included in the Special Tools provided by the train supplier. During the first three years, no overhauls or changes of major	All Scenarios All Scenarios

	components (heavy maintenance) on the BEMUs will be scheduled. Due to the range of vehicles lifted at Inchicore, this work on the BEMUs will be possible there. An Automatic Visual Inspection System (AVIS) will not be provided at Drogheda as this will be built into the infrastructure of Maynooth depot. The additional equipment required for access to roof-mounted equipment for light maintenance is assumed not to be included in the Special Tools provided by the train supplier. The HVAC modules on the BEMUs are similar in concept to those fitted on DMUs. The train wash at Drogheda has roof brushes. By the time either of scenarios 1b or 3 will be implemented, the new depot at Maynooth will be open.	All Scenarios All Scenarios All Scenarios All Scenarios All Scenarios TSS1b and TSS3
QS - OPEX	Inspection of similar components completed simultaneously rather than separately to provide operational efficiency. E.g. wiring assets.	All Scenarios
	Visual inspection to OLE wiring assumes visual inspection of structures completed at the same time to provide operational efficiency.	All Scenarios
	OLE Ground Inspection conducted 7 times a year based on a 7-weekly interval.	All Scenarios
	Height and Stagger survey assumes half a day to inspect up to 16 structures to account for site induction and access.	All Scenarios

	Assumes installation of ballasted track to new sidings requiring tamping on a 5-yearly frequency with all switches and track treated together for operational efficiency.	TSS 1b and TSS 3
	Battery Buffer renewal assumed a every 9 years.	TSS1b and TSS3
	Assumes Lighting and CCTV installation inspection requirement is approximately 2.5 times greater in options 1b and 2b than Option 1a due to greater volume and size of installation area.	TSS1b and TSS3
	It is assumed that there are no catastrophic failures requiring full asset renewal before the end of design life i.e. assets last entire lifetime.	All Scenarios
	It is assumed that maintenance activities occur in half, or full day increments to account for induction, and site access requirements.	All Scenarios
	Structures renewal assumed at 41 years and every 40 years thereafter based on estimated design life of 40-45 years. As such no renewal is incurred within the period of analysis.	All Scenarios
	Wire renewal frequency assumed at 26 years and every 25 years thereafter based on estimated design life of 20 -30 years.	All Scenarios
	OLE Switches renewal assumed at 41 years and every 40 years thereafter based on estimated design life of 40-45 years. As such no renewal is incurred within the period of analysis.	All Scenarios
	Traction substation renewal frequency assumed in year 36 and every 35 years thereafter based on estimated design life of 35 years. As such no renewal is incurred within the period of analysis.	All Scenarios
	Track and switching assets assume a design life of 40 years. As such no renewal is incurred within the period of analysis	All Scenarios

	Hourly rate for engineers assumed at [redacted]/ hour based on benchmarking for comparable works in the UK and Republic of Ireland.	All Scenarios
	Asset renewals costs are assumed to be the same as initial installation.	All Scenarios
	Assumes additional car parking and access road are subject to annual visual inspection.	TSS1b and TSS3
	OLE Wiring elements accounts for 40% of overall OLE installation cost.	All Scenarios
	Inspection of similar components completed simultaneously rather than separately to provide operational efficiency. E.g. wiring assets.	All Scenarios
	Visual inspection to OLE wiring assumes visual inspection of structures completed at the same time to provide operational efficiency.	All Scenarios

Appendix T. Additional Stabling Layout

See Appendix folder T for drawing showing the possible additional stabling layout.

Appendix U. Planning Consideration of Additional Stabling Lands (Outside Irish Rail Ownership)

Both the DLCDP and the current DBCDP support the principle of public transport uses as well as other mixed uses in the DTDA Zoning objective under the current Plan and the J1 Transport Development Hub under the emerging plan. The DTDA and J1 objectives appear to encompass the existing Railway Station lands as well as those further to the north (See Appendix E).

However, the subject lands currently selected for the new stabling are on residential zoned lands under both the current and emerging Plans. The provision of rail or transport infrastructure as the main use on these lands is contrary to the zoning objective. Furthermore, there appears to be two separate planning permissions under references 17387 and 12510037 on these lands as well as approval for a Strategic Housing Development (SHD) to the immediate west of same (see additional planning history section further below).

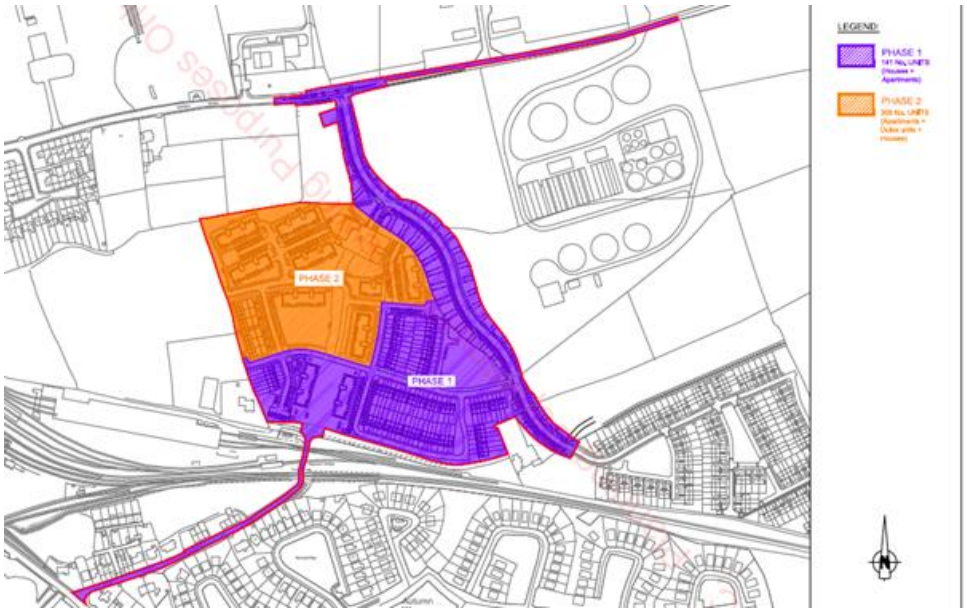
As the proposed stabling is on lands is outside Irish Rail ownership it may require the submission of a Railway Order Application to An Bord Pleanala which would trigger the need for an Environmental Impact Assessment Report (EIAR). Before taking this site forward, Irish Rail would need to have undertaken a very robust options assessment where all other sites adjoining and within lands zoned favourably for such uses has been discounted. However, given the non-favourable zoning objective and the existing permission for Housing Development, in our view this site should not be taken forward.

However, if a similar sized site was taken forward in the DTDA or emerging J1 zoning objective lands it's likely to meet with less objection in regard to the principle of the proposed use. Pre-Application Consultation with An Bord Pleanala as well as Louth County Council should be undertaken at an early stage and well in advance of any application or preparation of EIAR. It is further noted that existing residential lands are to the immediate north and an existing SHD permission for residential development to the immediate east of the DTDA/J1 zonings. If the principle of the stabling is accepted by An Bord Pleanala/Louth County Council then any application would need to be cognisant of potential impacts upon residential amenity. Boundary planting and a buffer between the use any existing or proposed residential uses should be included in the layout. The EIAR would also need to consider noise, air, dust, and visual impacts among others.

Planning History (Lands to North & North East of McBride Station)

ABP Reference: PL15.305110 (Strategic Housing Development)
Description: 450 residential units, creche and associated site works.
Location: Newtown, Marsh Road & McGraths Lane Railway Terrace, Drogheda.
Decision: Grant with conditions 2019





Planning Ref: 17387
Description: Construction of 133 houses and vehicular access from the Marsh Road.
Location: Marsh Road, Newtown, Lagavooren
Decision: Conditional 2017



Planning Ref: 12510037
Description: Extension of Duration of Permission for 260 residential units, creche and new access road.
Location: Newtown/Lagavooren, Drogheda
Decision: Conditional 2012

