DART+ West

Iarnród Éireann

Capacity enhancement options analysis with preliminary Train Services Specifications

MAY-MDC-OPS-DART-RP-Y-0002

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Table of contents

Executive Summary vi
1. Introduction 1
1.1 Scope and purpose of the report 1
1.2 Interaction with other documents 1
2. Abbreviations 2
3. Analysed options – infrastructure 3
3.1 Initial assumptions 3
3.1.1 Geometry and speed profiles 3
3.1.2 Stations and sidings 5
3.2 Connolly station 5
3.2.1 “Do minimum” option 5
3.2.2 Investment option IDOM 1 5
3.2.3 Investment option IDOM 2 7
3.2.4 Investment option IDOM 3 7
3.3 Docklands station 8
3.4 Other city lines and junctions in the city centre area 9
3.4.1 Line 1: Connolly - East Wall Junction 9
3.4.2 Line 2 and North Strand Junction 9
3.4.3 Line 3 (Docklands – Newcomen Junction) 9
3.4.4 Line 3a and Newcomen Junction 9
3.4.5 Line 7 (Connolly – Pearse section) 15
3.4.6 Line 9 and 9a (East Wall Yard – East Wall Junction and North Strand Junction) 15
3.5 Lines to Maynooth and M3 Parkway 15
3.5.1 Kinematic parameters and speed profiles 15
3.5.2 Line 2 North Strand Jct. – Glasnevin Jct. and Glasnevin Jct. 15
3.5.3 Line 3 Newcomen Jct. – Maynooth 17
3.5.4 Line 4 Clonsilla – M3 Parkway 18
3.6 Other lines and stations 18
3.6.1 Line 1 (East Wall Junction – Malahide – Drogheda) 19
3.6.2 Line 1a (Howth Junction – Howth) 21
3.6.3 Line 2 (Glasnevin – Islandbridge Junction) 21
3.6.4 Line 5 (fast; Heuston – Park West – Hazelhatch – Kildare) and line 6 (slow; Heuston – Park West – Hazelhatch) 21
3.6.5 Line 7 (Pearse – Greystones) 23
4. Analysed options – operations 25
4.1 Initial assumptions 25
4.2 The capacity of lines and stations 25
4.3 Preparation of train services specifications 25
4.3.2 Initial basic traffic scenarios (TSS) 27

4.4 Adjustment of TSS 36
4.4.1 Initial assessment of train paths conflicts 36
4.4.2 Comparison of initial TSS 48
4.4.3 Adjustment of TSS 48
5. Preselection of modelling options 51
6. Modelling results 54
6.1 Modelling assumptions 54
6.1.1 Infrastructure 54
6.1.2 Rolling stock 55
6.1.3 Traffic conditions 59
6.1.4 Capacity calculation 59
6.2 Modelling of traffic – scenarios 60
6.2.1 Scenario 1: “do minimum” infrastructure – mixed traffic at Connolly, services from all directions both terminate or continue to the south 60
6.2.2 Scenario 2 – “do minimum” infrastructure – change of traffic pattern at Connolly, northern services terminating 67
6.2.3 Scenario 3 – reconstruction of the Connolly northern throat - mixed traffic with Maynooth trains terminating at Connolly 75
6.3 Modelling conclusions 82
7. Multi-criteria analysis 86
7.1 Selection of criteria 86
7.2 Assessment of options 86
7.3 Comparison of options 90
8. Conclusions and recommendations 92
8.1 Summary of findings 92
8.1.1 Operations – Train services specification 92
8.1.2 Infrastructure 93
8.2 Recommendations 93
8.3 Further steps 93

Executive Summary

In recent years the number of passengers using DART services increases significantly. With the planned infrastructure improvements on the Maynooth line and the other lines, the demand for the train services will increase even further in upcoming years. The modern urban transit system must provide high quality and high capacity service.

The **principal objective** of the study is to design the potentially most efficient system. The system in which each element of the infrastructure can be used efficiently, providing the necessary capacity. Proposed solutions for the system improvement can have a different character, different effects and different costs. The Operation enhancement option analysis presents different Scenarios of the transit system improvements, but only one scenario will be implemented. Base on the analysis of proposed scenarios and the parameters of those scenarios, the decision on the future shape of DART will be taken.

The purposes of this report are to:

- present the different Scenarios of the infrastructure upgrade analysed along with Train Service Specifications (TSS) proposals adjusted to infrastructure upgrades in each Scenario;

- evaluate the proposed scenarios and describe the main advantages and disadvantages for each scenario;

The evaluation presented in this report should be the base for the selection of the Scenario that will be developed in detail by the Consultant at the next stages of Project elaboration, including the preliminary design of the needed infrastructure enhancements.

A main and crucial aspect of this study is that it has a preliminary character. Its purpose is not to present a detailed future TSS and timetable as well as an answer to all questions related to the future shape of infrastructure, but to direct a decision process as regards the choice of the target shape of train services and adequately modelled infrastructure to meet that target TSS.

Because the focal point of the whole DART System is Connolly Station with its adjacent line section where all the lines connect, the scenarios presented in this report were especially carefully elaborated for this area. Certain assumptions for all the lines were made, as well as a general assumption for the parameters of the future system, for example, train traffic control system. These assumptions for the rest of the DART network are the same in each scenario. It allows us to compare Scenarios with each other.

The operation efficiency depends on the infrastructure and operational skim.

- Regarding the first, IDOM had analysed a wider range of infrastructure changes before the definition of the Scenarios that were evaluated. Those infrastructure Investments options are presented in Chapter 2, especially within the subchapter *2.2. Conolly Station*.

- For the second, a similar analysis of the operational skim (TSS) adjustment is carried out to assess the TSS change on the capacity of the infrastructure. The final step in Scenarios definition was the adjustment of the TSS to the infrastructure layout.

Taking all of that into account, the scenarios defined and analysed in this study are:

1) Scenario 1:

    a) Infrastructure: Do minimum (corrections of geometry, adjustment of switches if possible, SET)

    b) TSS: Trains from north line continue south toward Bray/Greystones, Trains from Maynooth line terminate at Connolly

2) Scenario 2:

   a) Infrastructure: Do minimum (corrections of geometry, adjustment of switches if possible, SET)

   b) TSS: Trains from north line terminate at Connolly, Trains from Maynooth line go Southbound to Bray/Greystones

3) Scenario 3:

   a) Infrastructure: Remodelling of the Northern throat of Connolly (1 option to be chosen for detailed analyses from 3 options initially proposed) assuming the reconstruction of the one double-track overbridge that eliminates the conflict generated by trains from Maynooth line end at Connolly and trains from the norther line run further south

   b) TSS: Mixed train service. Generally, northern trains go south, but some trains terminate at Connolly. Generally, western trains terminate at Connolly, but some trains go south

Railsys models for such defined Scenarios were built and 4-hour simulations were run.

After the modelling and the MCA developed, the main conclusions (included in section 8) are the following:

- It is not possible to significantly increase the capacity of the system without TSS adjustment or significant infrastructure upgrade.

- Change of TSS has a slightly higher increase in the capacity than the infrastructure improvements.

1. Introduction

1.1 Scope and purpose of the report

The scope of the report covers the train movements at the railway infrastructure of the whole DART System.

The main purposes of this report (with the aim of finding the potentially most efficient system) are to:

- present different Scenarios of the infrastructure upgrade along with Train Service Specifications (TSS) proposals adjusted to infrastructure upgrades in each Scenario;
- evaluate the proposed scenarios and describe the main advantages and disadvantages for each scenario;

The evaluation mentioned above that is included in this report should be the base for the selection of the Scenario that will be developed in detail by the Consultant at the next stages of Project elaboration. The information present in the Report will be used by the decision-makers to select the preferred scenario.

The Report consists of Multicriteria Analysis (MCA) that compares different operation scenarios considering different criteria (parameters). The data presented in the MCA (chapter 7) summarizes the analysis that was carried out on the purpose of this report.

1.2 Interaction with other documents

The document is elaborated according to the methodology presented in the Design Review Report. It is also the continuation of the document "Current capacity and traffic analyse report" presented 6th March 2020 (MAY-MDC-OPS-DART-RP-Y-0001).

2. Abbreviations

Table 1 documents a list of the abbreviations that may be found in this report and the explanation of their meaning:

Table 1. Abbreviations

Abbreviation	Meaning
CWR	Continuous Welded Rail
DART	Dublin Area Rapid Transport (IÉ's Electrified Network)
DART-E	DART-Expansion
DMU	Diesel Multiple Unit
EMU	Electric Multiple Unit
GCD	Grand Canal Dock
GDA	Great Dublin Area
IÉ	Iarnród Éireann/Irish Rail
Jct.	Junction
MCA	Multicriteria Analysis
NTA	National Transport Authority
PPT	Phoenix Park Tunnel
SET	Signalling, Electrical, Telecommunication
TPHPD	Trains Per Hour Per Direction
TSS	Train Service Specification
UIC	International Union of Railways
WTT	Working Timetable

Station names:

For clarity when this document mentions:

- Park West – it is referred to Park West & Cherry Orchard Station
- Hazelhatch – it is referred to Hazelhatch & Celbridge station
- Bray – it is referred to Bray (Daly)
- Pearse, Connolly, Heuston – it is referred to Dublin Pearse, Dublin Connolly and Dublin Heuston stations.

3. Analysed options – infrastructure

3.1 Initial assumptions

On this stage of the documentation, all solutions have feasible detail level. Detailed solutions are not designed nor described - especially bridges, signalling, construction technologies, etc. This will be included in further reports.

This solution aims to show options that may fit into existing railway terrain without interfering with adjoining properties and is possible according to horizontal and vertical parameters of the track.

All design calculations are calculated on a nominal track gauge of 1600 mm, and for CWR track on a gauge of 1602 mm.

The track design parameters meet requirements with the following standards:

- EN 13803-1:2010 – Railway applications. Track. Track alignment design parameters
- EN 13803-2: 2006+ A1:2009 Railway applications – Track – Track Alignment design parameters – Track Gauge 1435 mm and wider – Part 2: switches and crossings and comparable alignment design situations with abrupt changes of curvature
- CCE-TMS-300 Track Construction Requirements and Tolerance
- CCE-TMS-321 Track Maintenance Requirements and Tolerance
- CCE-TMS-340 Horizontal Curvature Design
- CCE-TMS 341 Vertical Curvature Design
- EN 15273-1 Railway applications Gauges. General. Standard rules for infrastructure and rolling stock

3.1.1 Geometry and speed profiles

For most design parameters, three types of limits are specified:

- Design Value and Desirable Limit – the recommended actual limit design value
- Normal Limit – These values ensure maintenance costs of the track are kept at a reasonable level
- Exceptional Limit - their use is as infrequent as possible and has the permission of the Technical Manager, CCE

The following parameters are used:

Table 2 Limits of kinematic parameters

Parameters	Desirable limit	Normal Limit	Exceptional limit
Radius [R]	200 metres	150 metres	120 metres
Cant [D]	165 mm	165mm	185 mm
Cant Deficiency – CWR Track [I]	110 mm	130 mm	150 mm
Cant Deficiency – Turnouts and Crossovers [I]	90 mm		110 mm
Cant Excess [E]	90 mm	110 mm	
Cant Gradient [dD/ds]	2,50 mm/m	2,70 mm/m	
Rate of Change of Cant [dD/dt]	40 mm/s		60 mm/s
Rate of Change of Cant Deficiency dI/dt	40 mm/s		60 mm/s

Parameters	Desirable limit	Normal Limit	Exceptional limit
Abrupt Change of Cant Deficiency for Points and Crossings ΔI V ≤ 100 km/h	100 mm	120mm	
Abrupt Change of Cant Deficiency for Points and Crossings ΔI 100 < V ≤ 170 km/h	133-0,33V mm	141-0,21V mm	
Abrupt Change of Cant Deficiency for Plain Line ΔI V ≤ 70 km/h	50 mm		
Abrupt Change of Cant Deficiency for Plain Line ΔI 70 < V ≤ 70 km/h	40 mm		

The project on lines 2 and 3 was divided into sections as below:

Figure 1 Project Sections

Table 3 Project Sections

Route Section	Location	Length
Section 1	Docklands – Newcomen Junction (line 3)	1,7 km
Section 2	Connolly – Newcomen Junction (line 3a)	1,5 km
Section 3	Newcomen Junction – Glasnevin Junction (line 3)	1,1 km
Section 4	Connolly – Glasnevin Junction (line 2)	3,4 km
Section 5	Glasnevin Junction – Clonsilla (line 3)	10,0 km
Section 6	Clonsilla – Maynooth (line 3)	12,4 km
Section 7	Maynooth – New Depot (line 3 and new spurs)	2,0 km
Section 8	Clonsilla – M3 Parkway (line 4)	7,0 km

3.1.2 Stations and sidings

Since detailed investment options are not yet determined and thus, designs are not yet prepared, all described investment options are to be treated as early assumptions that were initially checked for their feasibility. This relates to track alignment and design of the station, including sidings, crossovers and other elements of permanent way infrastructure, signalling etc.

This document is aimed at choosing the general scenario, which will subsequently lead to shaping that infrastructure in a desirable direction.

Expected future TSS provide for the significant growth of train frequency and, subsequently, the number of trains in service on each of the lines. Stabling of that rolling stock for off-peak times and nights will require significantly more stabling sidings. This report includes some proposals about their locations, based on early assumptions. However, since the service pattern is still a matter of future choice, it will be proposed in more detailed form concerning the chosen scenario.

3.2 Connolly station

There are four basic infrastructure remodelling options for Connolly station. They have a preliminary character and will be further developed in strict connection with the architecture of the station (particularly – functionalities of platforms and the possibility of creation of additional underpass with staircases and elevators).

3.2.1 "Do minimum" option

Option "do minimum" provides for investment in fields of SET. Electrification of all main track is envisaged, and the new signalling system is installed. Track works have main the character of repairs, although some minor improvements (like crossovers modifications) are possible.

In case the decision is made about the discontinuation of line 3a (Connolly – Newcomen Jct.), on the segment between Connolly and the Royal Canal construction of stabling tracks may be considered (with the change of geometry).

3.2.2 Investment option IDOM 1

This option provides for a one-track overbridge, allowing Connolly-bound trains from line 2 to arrive at the station without conflicts with traffic linking platforms 6 and 7 with line 1 (north). In this option conflicts still exist between trains originating at Connolly and heading to lines 1 and 2 (conflicts with through traffic to/from line 1 and southbound traffic from line 2).

Functional scheme of the option may be found here:

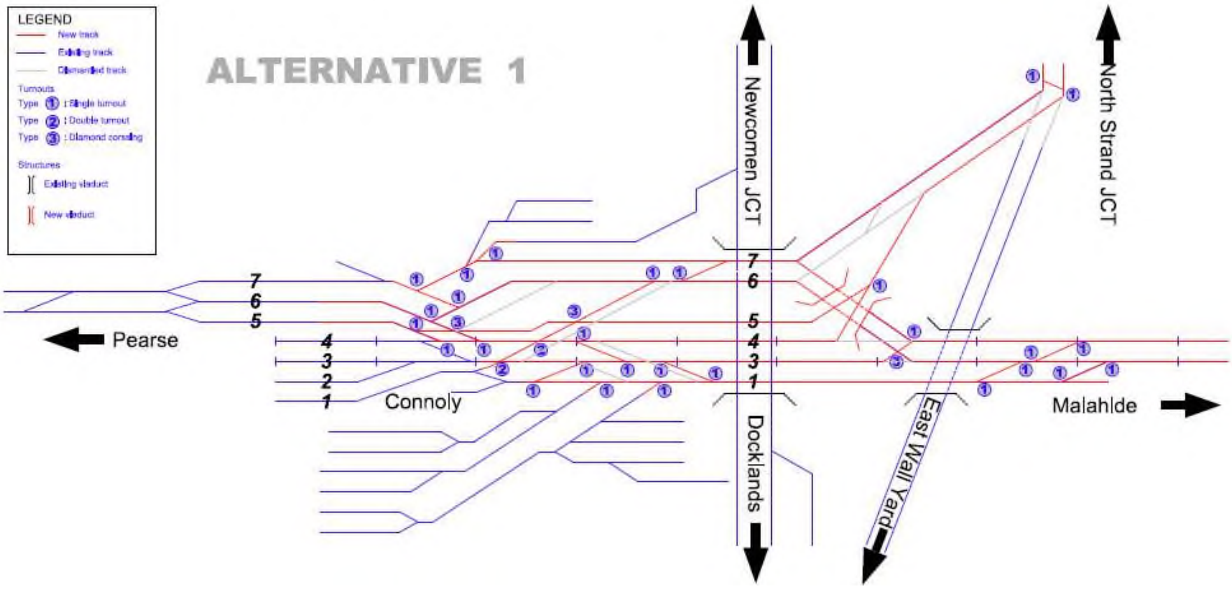


Figure 2 Connolly station – option 1 – functional scheme

A detailed drawing is found in Appendix B.

Vertical alignment of the proposed overbridge is shown on the scheme:

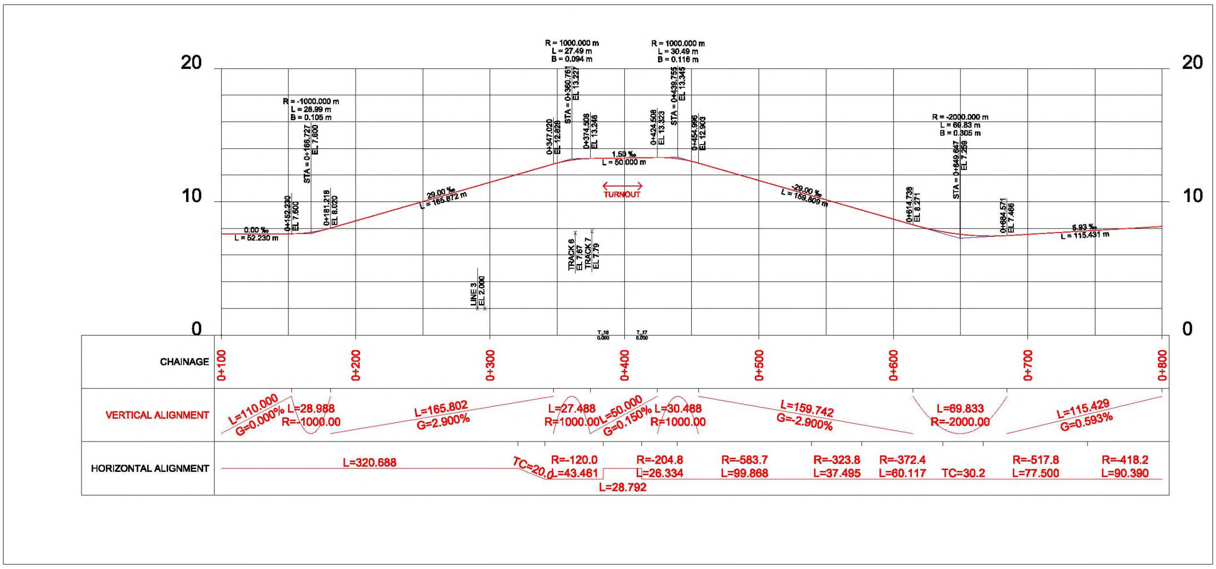


Figure 3 Connolly station – option 1 – vertical alignment

Maximum applied gradients are 2.9 %. Vertical clearance over the line 1 tracks is 4,70 m (5,45 m between rail surface of the track on the overbridge and under it). It is envisaged that in the course of detailed design, the gradient may be reduced. Length of the overbridge – approximately 500 m. It is expected that the option will require a reconstruction of approximately 1000 m of line 1 and 550 m of line 2.

This option, in general, may be located on existing railway property.

In case the decision is made about the discontinuation of line 3a (Connolly – Newcomen Jct.), on the segment between Connolly and the Royal Canal construction of stabling tracks may be considered (with the change of geometry).

3.2.3 Investment option IDOM 2

This option provides for a 2-track overbridge towards line 2. It allows reducing the number of conflicts between trains going to line 2 and trains going between line 1 and 7 (north-south coastal services). This option would work the best for a clear distinction of traffic with all services arriving from line 2 terminate at Connolly. Conflicts between northbound line 1 services originating at Connolly and southbound services from the north remains.

Functional scheme of the option may be found here:

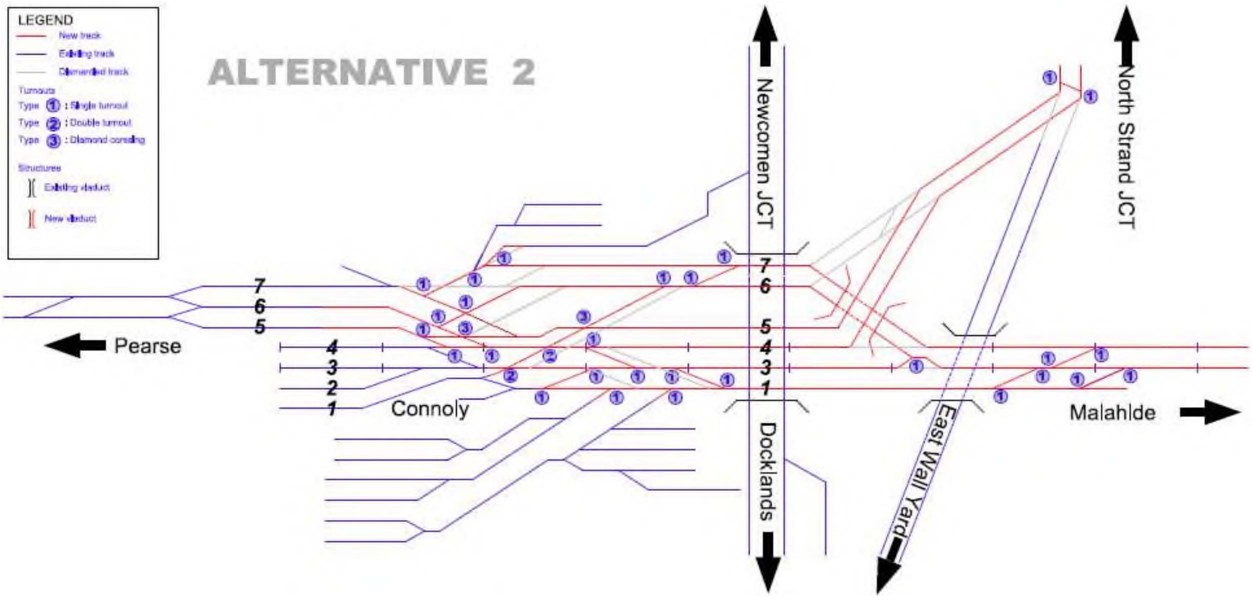


Figure 4 Connolly station – option 2 – functional scheme

A detailed drawing is found in Appendix B.

Maximum applied gradients are 2.9 %. Vertical clearance over the line 1 tracks is 4,70 m (5,45 m between rail surface of the track on the overbridge and under it). It is envisaged that in the course of detailed design, the gradient may be reduced. Length of the overbridge – approximately 460 m (but the structure is wider compared to option 1 as there is a double track on the whole overbridge). Same as in case of option 1, it is expected that the option will require a reconstruction of approximately 1000 m of line 1 and 550 m of line 2.

This option, in general, may be located on existing railway property.

In case the decision is made about the discontinuation of line 3a (Connolly – Newcomen Jct.), on the segment between Connolly and the Royal Canal construction of stabling tracks may be considered (with the change of geometry).

3.2.4 Investment option IDOM 3

This most complicated investment option envisages two separate overbridges between Connolly and North Strand Jct. First, with one track (similar to option 1) plays its role for trains from line 2 directing south towards line 7.

The other overbridge is aimed at serving the traffic from line 2 terminating at Connolly and trains originating at Connolly, going to line 2. Southbound services from line 1 are redirected within the station. Conflicts between northbound line 1 services originating at Connolly and southbound services from the north remains.

Functional scheme of the option may be found here:

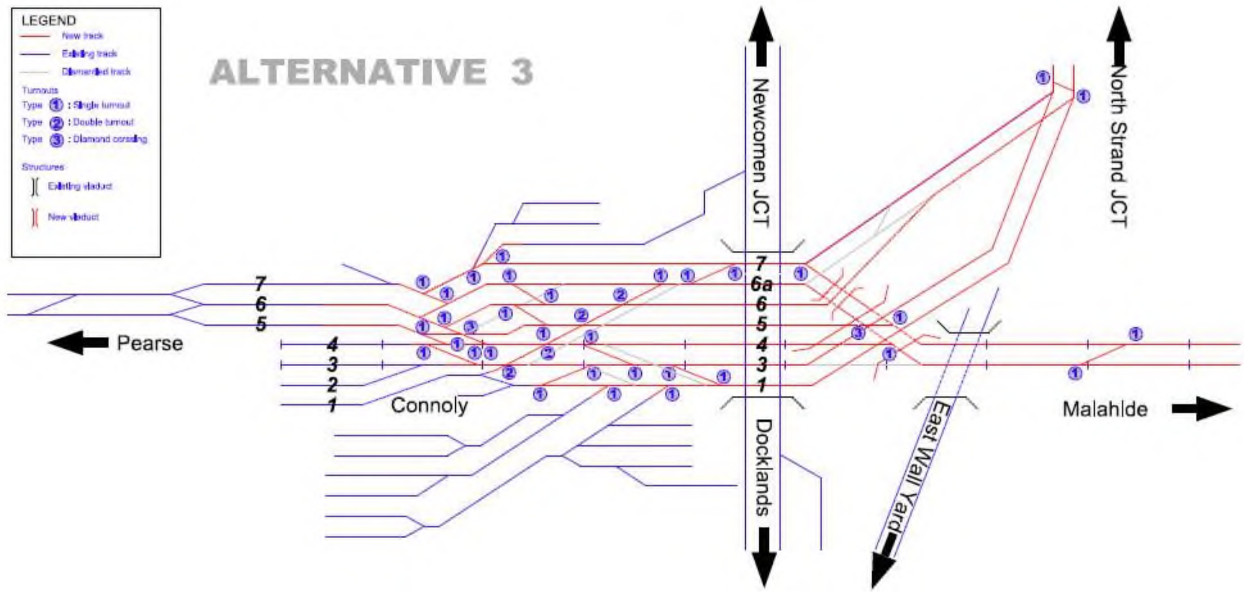


Figure 5 Connolly station – option 3 – functional scheme

A detailed drawing is found in Appendix B.

This option envisages discontinuation of the current line 9a (East Wall Yard – North Strand Jct.). Freight traffic between line 2 and East Wall Yard is redirected through Glasnevin Jct. (new crossover provided for in the Metrolink project), line 3 and a rebuilt connection between line 3 (Ossory Road Jct.) and East Wall Yard.

Maximum applied gradients are 2.9 %. Vertical clearance over the line 1 tracks is 4,70 m (5,45 m between rail surface of the track on the overbridge and under it). Length of the single track overbridge – approximately 500 m, double-track – approximately 600 meters. It is expected that the option will require a reconstruction of approximately 1000 m of line 1 and 550 m of line 2 and 200 m of line 9a. There will be 7 tracks on the bridge above the Royal Canal, line 3 and Ossory Road – minimum horizontal distance between tracks is going to be 3,65 m. There is an option to reroute line 1 on this section, which would allow reducing the number of tracks on the bridge to 6.

Because of vertical clearance under overbridges and limited gradients on access ramps to it, existing geometry of the segment of line 1 will have to be adjusted – generally lowered (approximately 0,5 m). It will be associated with discontinuation of line 9a (lowering of the overbridge) and with the potential lowering of the bridge over line 3, the Royal Canal and Ossory Road. That will require lowering of the line 3 tracks (approximately 0,5 m), which might also be envisaged due to vertical clearance constraints in the area of Newcomen Jct.

Because of the overbridge geometry, this option interferes with several properties that would need to be taken over (end of Bessborough Avenue).

In case the decision is made about the discontinuation of line 3a (Connolly – Newcomen Jct.), on the segment between Connolly and the Royal Canal construction of stabling tracks may be considered (with the change of geometry).

3.3 Docklands station

In analysed options, Docklands station is a modified option A according to the Arup Docklands Station Options Study Sift 2 Report, February 2019. Modification entails access from all lines (lines 3, 9, 9a) to all 5 platforms.

Since there is no traffic envisaged in analysed TSS through lines 9 (East Wall Jct.) and 9a (North Strand Jct.) the station serves practically only line 3 as a terminus.

Infrastructure option 3 envisages reconstruction of a once existing connection between line 3 and East Wall Yard to enable freight traffic which currently uses line 9a, expected to be dismantled in that option.

3.4 Other city lines and junctions in the city centre area

3.4.1 Line 1: Connolly - East Wall Junction

Several investment options related to Connolly station affect that segment of the line. In particular, the train wash track is rebuilt into a regular line, serving trains mostly from the northern line originating and terminating at Connolly. Bridges over the Royal Canal, line 2 and Ossory Road are reconstructed.

3.4.2 Line 2 and North Strand Junction

Investment options provide for severe different reconstruction of this segment.

Option IDOM 1 envisages an overbridge of the Connolly-bound track over tracks of line 1. North Strand-bound track remains on the same level.

Option IDOM 2 envisages a double-track overbridge between Connolly and North Strand.

Option IDOM 3 envisages solutions similar to option IDOM 1 on this section. At the same time, double-track overbridge, intended for trains terminating and originating at Connolly, is located further north, connecting Connolly with the trackbed of line 9a (East Wall Yard – North Strand Jct.), which is discontinued in its current shape.

3.4.3 Line 3 (Docklands – Newcomen Junction)

This line is likely to undergo several adjustments:

- reconstruction of the Docklands station throat;
- in some variants – reconstruction of the spur between Ossory Road Jct. Lower (former) and the tracks leading to East Wall Yard;
- lowering of the track level in the Ossory Road Jct. Lower (former) area (see chapter 3.2.4);
- possible lowering of the track level in the Newcomen Jct. area;
- remodelling or liquidation of the Newcomen Jct.

For the latter two aspects, explanations may be found in chapter 3.4.4.

3.4.4 Line 3a and Newcomen Junction

None of analysed TSS envisages traffic through line 3a. For several reasons, this line may be considered of limited functionality and cause several severe engineering and subsequently, financial concerns.

3.4.4.1 Functional constraints

Line 3a is connected solely with track 7 of the Connolly station. Track 7 is usually occupied with northbound traffic from line 7 (south). Although it would permit for south-west connections, where trains arrive from the south in a sequence, the traffic in the opposite direction is heavily constrained and would mean serious disturbance in south-north traffic.

Although some of the previous studies (Systra&Jacobs DART Expansion Programme Options Assessment, October 2018 with Addendum Report of August 2018) envisaged bidirectional traffic on line 3a and – in some cases – a limited scale of continuation of that traffic to the south, it needs to be noted that:

- Terminating trains on track 7 (or southbound traffic through track 7) means that all northbound traffic goes through track 6. Currently, track 6 is used in both directions, with a substantial role as a "buffer", together with track 5, for southbound trains. Since trains arrive at Connolly from different directions and several of them, need to be directed further south it is necessary that in case of any delay there is the possibility of "buffering" trains at least at one platform there, without blocking the line. Geometry constraints the possibility of connection of line 3a with other tracks (for instance track 6) at Connolly;

- Remodelling the line into 2-tracks: as per Jacobs Connolly Station Enhancement Options Study, March 2019 – in case both tracks are functional; that does not solve the issue of arriving at track 7 of Connolly station. Following the Jacobs study (drawing 8B), remodelling the line into 2-tracks with bidirectional traffic on each of tracks and one of them serving only as access to terminus platform 8 means a very limited capacity of that terminus track (in reality 3 tphpd);
- Creation of a new terminus platform 8 connected with single-track line 3a means the very limited capacity of that terminus track;
- A substantial number of train path conflicts at Newcomen Junction;
- The low speed on the section (15 km/h) means that its capacity is very limited;
- The line is of very limited use now; despite scheduling of a very limited number of trains (2 per weekday) through line 3a, it is practically unused.

3.4.4.2 Technical constraints

Please note the preliminary character of technical constraints enumerated in this document; they will be subject to further detailed technical analyses.

- Increase of line functionality through adding platform 8 at Connolly means substantial investment costs and demolition of at least 2 buildings (incl. protected, historic edifice), as indicated on drawings.

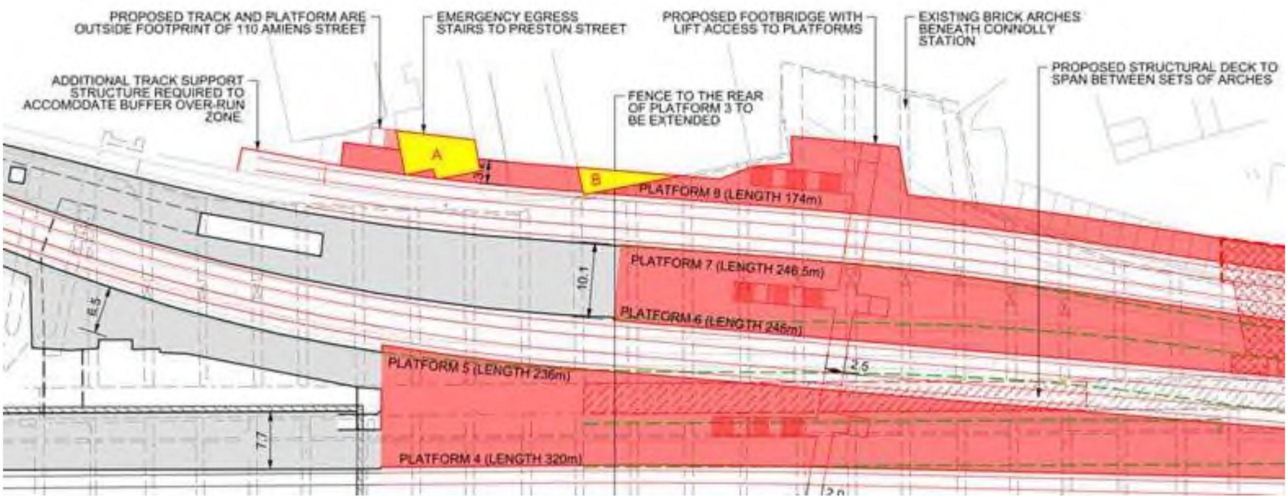


Figure 6 Connolly station – potential platform 8 layout and conflicts with existing structures

Figure 7 Connolly station – potential platform 8 conflicts with existing structures

- Remodelling a line into 2-tracks (Jacobs option 8B) is not envisaged in the process of construction of the new pedestrian and cycling bridge, currently (as of Mar 2020) built over line 3a. Also, in case of double track, it will be challenging to meet the geometry criteria since the existing single track has curves with a radius of 125 m, which places it in close to “exceptional case” allowance according to CCE-TMS-340 Horizontal Curvature Design (NNTR) Standards. The speed on the section is also limited to 15 km/h;

Figure 8 Line 3a – Construction of the new pedestrian and cycle overbridge near the Royal Canal (Feb 2020)

- Vertical clearance issues at Newcomen Junction:

Newcomen Junction switches are located right under the existing overbridge (OBD226 / North Strand Road). OBD 226 is approximately 19.53 m wide flat deck bridge. The worse vertical clearance from TOR to soffit is 4.22 m, and it does represent a significant challenge for the OHLE since there is not enough clearance for any OHLE solution as the clearance is even smaller than the minimum contact wire height (4.2 m) plus the 150 mm for electrical clearance as shown in the following figure.

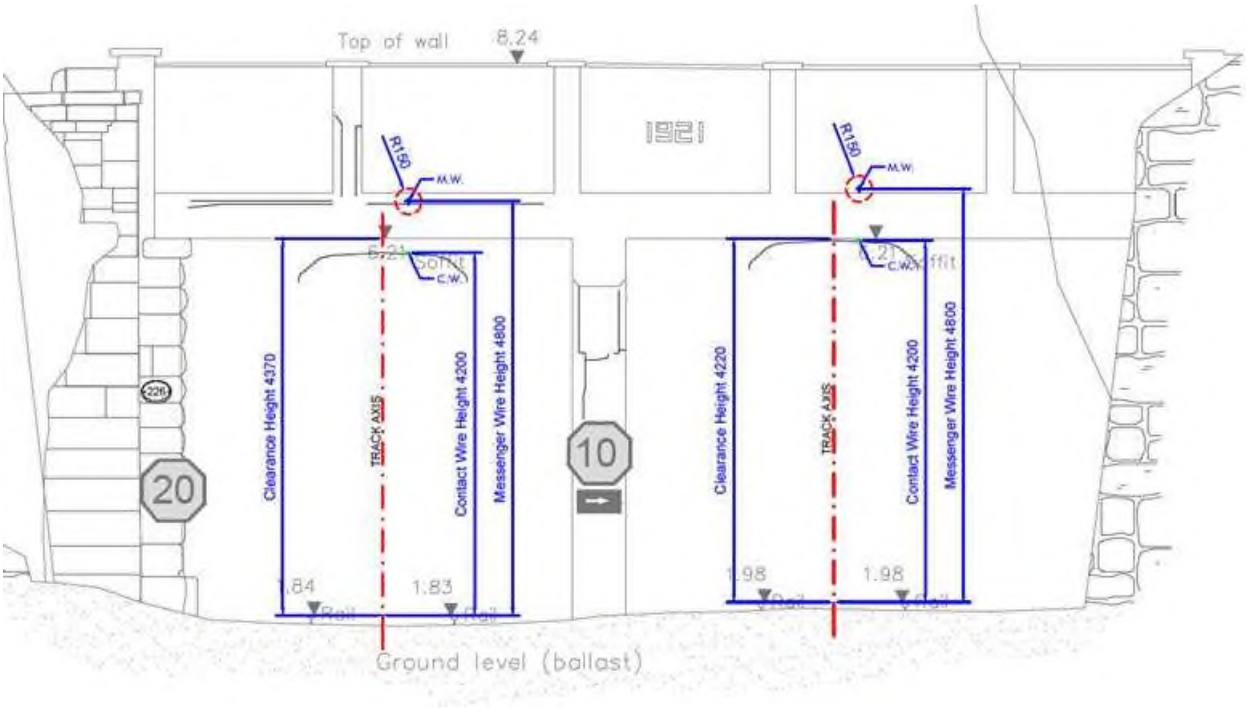


Figure 9 Vertical clearance for the OHLE under the existing bridge

This is a significant engineering challenge even just considering the main tracks towards Docklands since even designing a special OHLE arrangement with just contact wire(s) there is still not enough clearance with the minimum 4.2 m contact wire height. However, if line 3a has also to be electrified, and therefore an OHLE switching arrangement has to be installed, the required clearance to build it will increase dramatically to allow space for the OHLE in the main tracks and the track for line 3a, requiring massive works at the canal.

Since switches are under the bridge, as might be seen on a figure below, the needed vertical clearance might need to be increased by approximately 90 – 100 cm.

Figure 10 Newcomen Jct. – View from the east

In case no switches of Newcomen Jct. are required; additional vertical clearance need is substantially lower (approximately 25 – 30 cm). Those factors constitute a significant obstacle as regards the possibility of keeping the junction of line 3 with line 3a in this area. The existing line 3a bridge over the Royal Canal (see figure) is a lifting one due to low vertical clearance on the waterway. It is lifted for boat traffic only several times a year (8 times in the navigational season 2020, between April and September). Since lifting the bridge (for 2 hours) means a significant obstacle in rail traffic, it is not possible to schedule frequent daily services in case the current solution is maintained. In previous studies, it was proposed to replace the existing bridge with a permanent bridge and build the pair of locks on the canal (so-called ”drop locks”). However, a permanent bridge does not solve problems with vertical clearance under the OBD226, and in case of lowering the track level, the permanent bridge will also have to be lowered.

Lowering of the bridge level would also impact the technology of a drop lock solution on the canal. According to early assessment of the drop – lock issue the canal lock gates will have to be remodelled, and it may cause causes needs to seriously remodel a long section (even 900 m) of the Royal Canal, which is a protected structure, constructed in the 18th century. Associated costs of canal remodelling, drop lock construction and further maintenance are also supposed to be substantial.

Since lowering the track level on line 3 is taken under consideration because of the vertical clearance, the potential bridge would also need to be lowered compared to the current level of the lifted bridge. Lowering the bridge also means a steeper gradient in approach to Connolly and possibly changed the geometry of the entire line.

Figure 11 Newcomen lifting bridge on line 3a

3.4.5 Line 7 (Connolly – Pearse section)

At this stage, no assumptions were made for this section.

3.4.6 Line 9 and 9a (East Wall Yard – East Wall Junction and North Strand Junction)

For some of Connolly investment options, (see chapter 3.2.4) line 9a is discontinued as regards connections to East Wall Yard and serves trains coming from Glasnevin Jct. direction and terminating at Connolly station. Freight traffic to East Wall Yard is rerouted through Glasnevin Jct. (new crossover), line 3 and a new spur, connecting Ossory Rd. Jct (former) with East Wall Yard.

Line 9 is envisaged as the connection of East Wall Junction with both East Wall Yard (for freight traffic purposes only) and with Docklands Station. However, no TSS provides for passenger traffic on this section.

3.5 Lines to Maynooth and M3 Parkway

3.5.1 Kinematic parameters and speed profiles

Kinematic parameters and speed profiles of lines 2 (Connolly – Glasnevin), 3 (Docklands – Maynooth) and 4 (Clonsilla – M3 Parkway) are contained in APPENDIX A.

3.5.2 Line 2 North Strand Jct. – Glasnevin Jct. and Glasnevin Jct.

Assumptions as regards line 2 on Glasnevin – North Strand Jct. section are in chapter 3.4.2.

No specific changes are envisaged on line 2 between North Strand Jct. and Glasnevin Jct., although (depending on the chosen scenario for Connolly station) some crossovers may need to be installed in case of North Strand Jct. reconstruction.

As regards Glasnevin Jct. (which is not in the scope of this report) solutions envisaged in Metrolink – Preferred Route Design Development Report – Jacobs and IDOM, March 2019) are treated as assumptions. In particular, construction of the new passenger station and important interchange is planned, following the study mentioned above. Proposed solutions are shown on the figure:

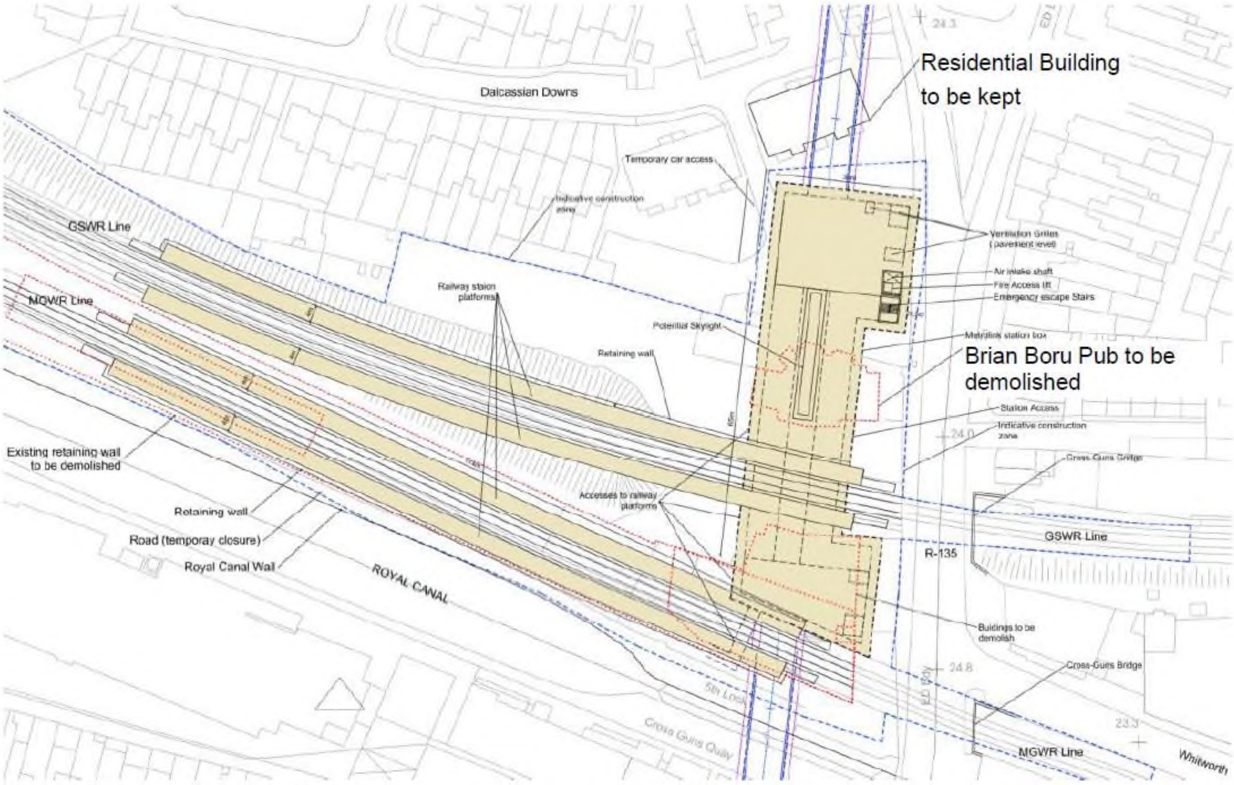


Figure 12 Plan of proposed interchange station at Glasnevin (Jacobs and IDOM Metrolink study)

Remodelled Glasnevin Jct. is to be equipped with double crossovers, allowing for traffic in all directions. Sections of line 2 and 3 are to be remodelled in terms of vertical and horizontal alignment. High-level details are shown on the figure:

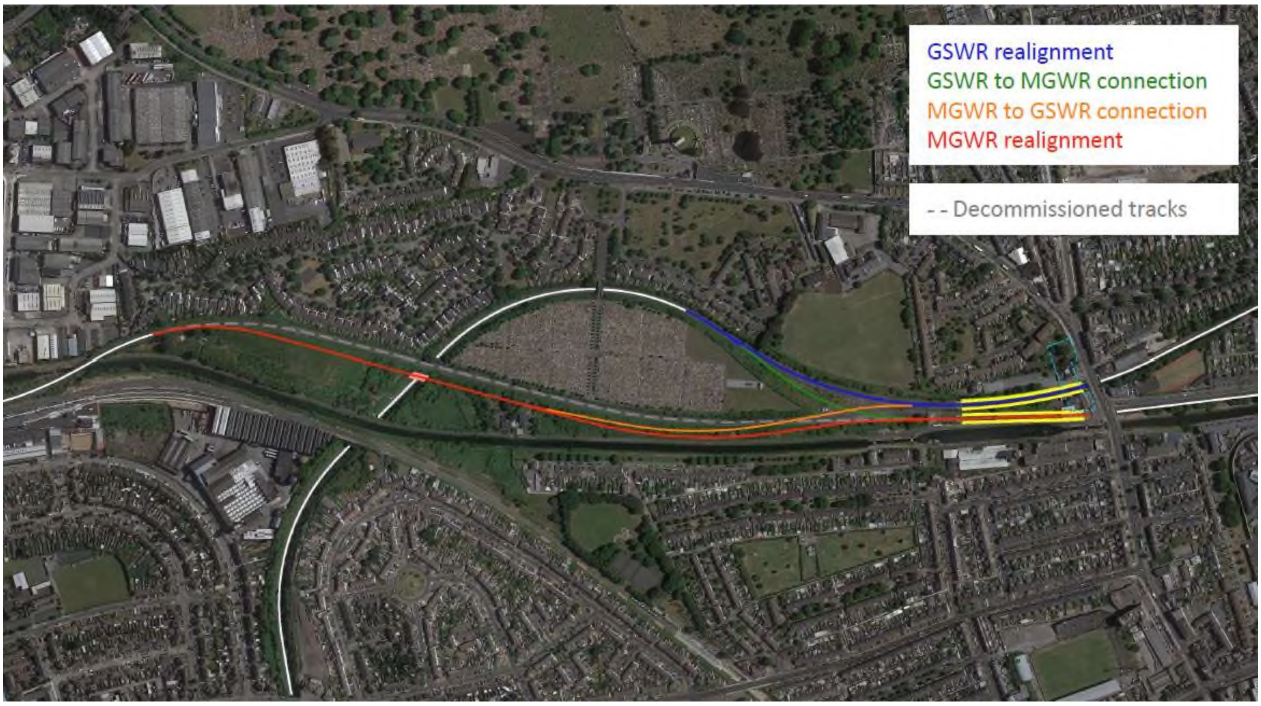


Figure 13 Lines 2 and 3 in the Glasnevin Jct. area (Jacobs and IDOM Metrolink study)

Details of the double crossover “X” section provide for 4 pairs of switches and a diamond crossing between connecting spurs, as shown on the figure:

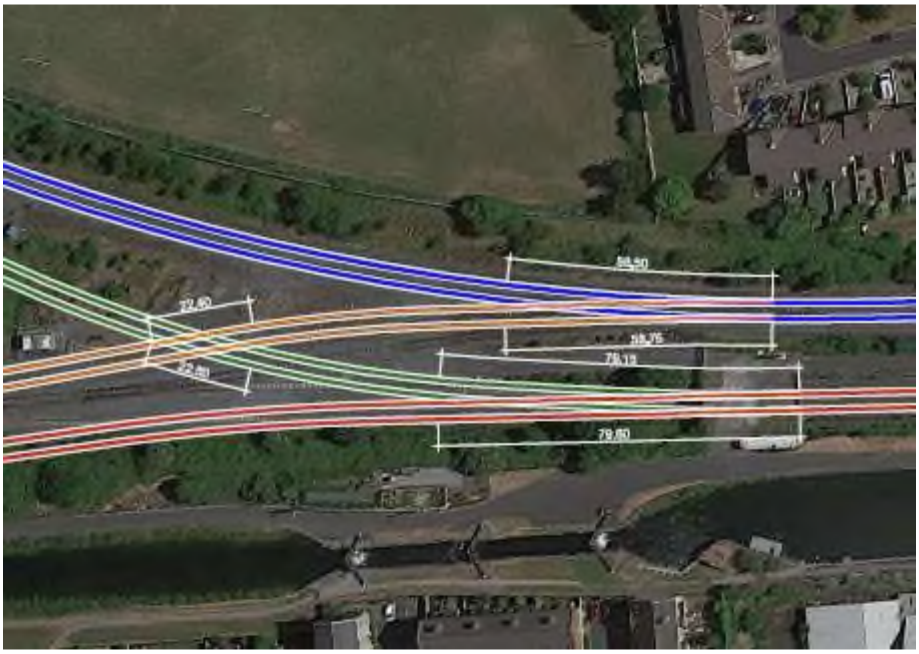


Figure 14 Details of Glasnevin Jct. (Jacobs and IDOM Metrolink study)

3.5.3 Line 3 Newcomen Jct. – Maynooth

Section of line 3 between Docklands Station and Newcomen Jct. is covered in chapters: 3.4.3 (line) and 3.4.4 (Newcomen Jct.).

3.5.3.1 Newcomen Jct. – Glasnevin Jct. and Drumcondra South

It is envisaged that a new station (Drumcondra South) is built on the Newcomen Jct. – Glasnevin Jct. section in the proximity of the viaduct of Drumcondra Rd. Lower. This new station will serve as one interchange point between rail and bus transport, together with existing Drumcondra Station on line 2 (distance of approx.. 150 m). The new station will allow for operational flexibility as regards providing service to a densely populated area of Drumcondra. It will allow acting as an alternative to Drumcondra for trains that are routed through line 3 to Docklands. Drumcondra is one of the most used stations on connections between Connolly and Maynooth (average daily alighting in 2018, reaching on the level of 1590). For those reasons, its location was given a favourable opinion of IE Operations.

The exact location of the station is to be confirmed by the technical study.

Glasnevin Jct. solutions are described in chapter 3.5.2.

3.5.3.2 Glasnevin Jct. – Maynooth

New station of Pelletstown is envisaged as functional for the purpose of the study. This section will also have level crossings removed.

Maynooth station is envisaged as the place where two turn-back sidings are located on both sides of the line, immediately after platforms and double crossover.

3.5.3.3 Maynooth – Kilcock – Enfield

Section of line 3 west of Maynooth is given a high-level overview in two aspects:

- functioning access to the Maynooth depot;
- traffic conditions and capacity of the Maynooth – Enfield section as affecting traffic at Maynooth.

Depot access and its options are subject to a separate report.

Maynooth – Kilcock – Enfield section is a problematic line for expected traffic (2 tphpd). General speed restriction on Maynooth – Mullingar section is 70 mph (DMU) / 75 mph (ICR), according to WTT 2018. Maynooth – Enfield section measures approximately 18 km, while Enfield – Killucan section – over 24 km. Travel time (WTT 2018) on each of them is 14 min. 30 s. Those parameters would not allow for regular traffic of 2 tphpd.

It might be considered (out of the scope of the study) to remodel Kilcock into a station with a passing loop and/or turn-back siding. Such a solution would also facilitate manoeuvres at the depot entrance, assuming other entrance on the Kilcock side.

3.5.4 Line 4 Clonsilla – M3 Parkway

At this stage, no assumptions were made for this section.

Future development and reconstruction of this line to Navan are not modelled in this report. Dead-end tracks at M3 Parkway are considered as potential stabling sidings.

3.6 Other lines and stations

Lines, stations and junctions not covered by the design process within the scope of the study are implemented in the modelling with several assumptions, based on other available studies, consultations with IE and assessment of needs and possibilities.

Those lines are not redesigned. In some places, additional functionalities (like sidings) are added. In a limited number of locations, alignment of main lines is altered if that seems necessary. The overall and very high-level assessment was made as regards locations in terms of land availability.

Lines in the DART Expansion area are generally, for future projections, considered to be electrified. A notable exception applies to line 5 between Inchicore and Hazelhatch and Heuston station platforms serving long-distance traffic.

It is considered that all lines are equipped with modern signalling systems that allow for generally 3-minute headway and that headways above 3-minutes do not constitute a constrain for operations. However, there is no detailed study on block sections, line and station signalling carried out for lines that are not covered by the detailed study (City Centre and Maynooth lines).

This chapter summarizes the main proposed adjustments of infrastructure on lines not covered directly by the study.

3.6.1 Line 1 (East Wall Junction – Malahide – Drogheda)

There are several adjustments of infrastructure envisaged on line 1 (Northern). Since the line serves both local and long-distance services a station with available passing sidings in both directions in necessary on approach to Dublin. For that reason, construction of the planned initially Clongriffin station with two passing loops and modernised Malahide station that would enable zoning of traffic.

Summary of proposed changes:

3.6.1.1 Fairview depot platforms

Staff-only platforms at Fairview depot are considered unused. An alternative location for a change of drivers is provided at Clontarf Road Station (distance - 190 m). Pedestrian overbridge may be considered at the southern end of platforms to facilitate safe access. Existence of the pedestrian overbridge has no impact on train operations.

It is considered that train pass at speed former staff-only platforms.

3.6.1.2 Howth Junction

Because of the constraints in the area, the general shape of the junction is considered unchanged.

3.6.1.3 Clongriffin

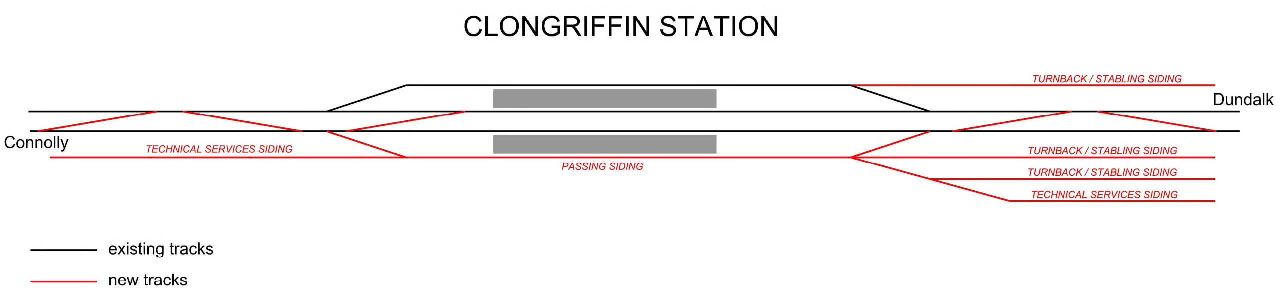


Figure 15 Clongriffin station potential enhancement

Clongriffin station potential enhancement provides for passing sidings on both sides of the station. Since the station is one of not many that are located in not a very densely urbanized area and has a potential of the future junction with lines serving the northern part of Dublin; both passing sidings are prolonged to serve as turn-back/stabling tracks. Additionally, service sidings are proposed.

3.6.1.4 Malahide

The station is Malahide has an important role as a turn-back location for trains coming from Dublin. For that reason, turn-back track north of the existing platforms is necessary. In line with previous proposals, the best location for it is supposed to be in between main lines, north of the existing station, as indicated on the scheme.

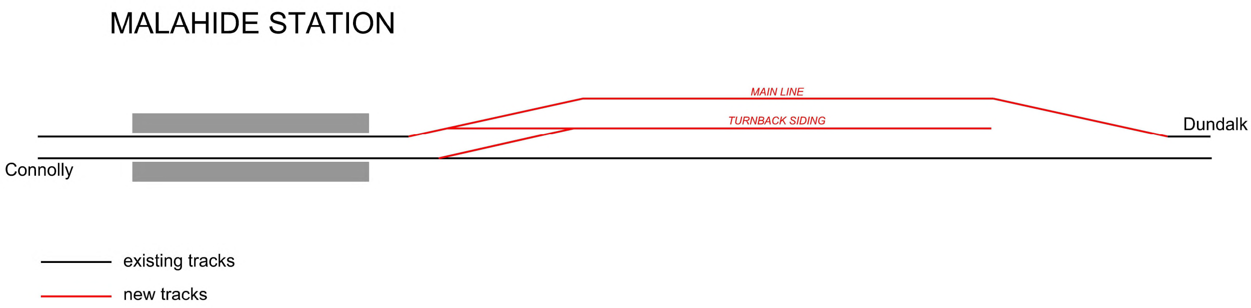


Figure 16 Malahide station potential enhancement

The new track would allow for a possible quick vacating of main lines in the platform area by terminating trains.

At the same time, siding south of the Malahide platforms is retained as stabling or technical location.

3.6.1.5 Skerries

Station of Skerries is potentially equipped with two crossovers that may allow the use of the siding also by northbound trains.

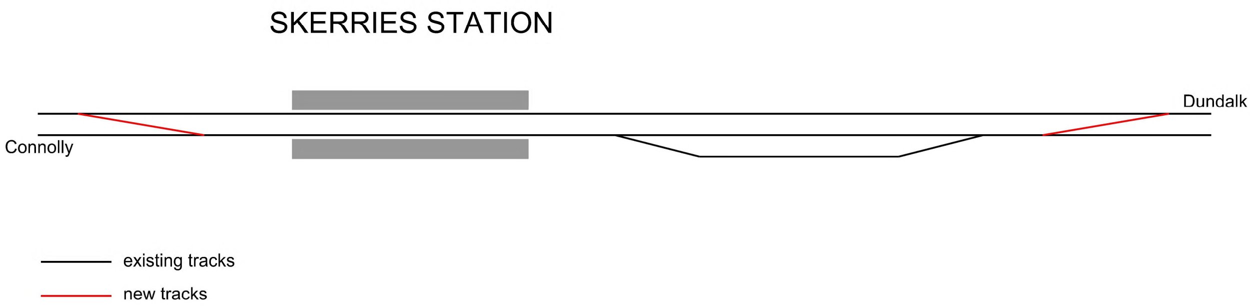


Figure 17 Skerries station potential enhancement

3.6.1.6 Balbriggan

Since Balbriggan is a sizeable town between Malahide and Drogheda, it may be considered to be a potential location for terminating some of the services from Dublin, especially in case limited capacity of Drogheda station restricts the number of trains that can be serviced there.

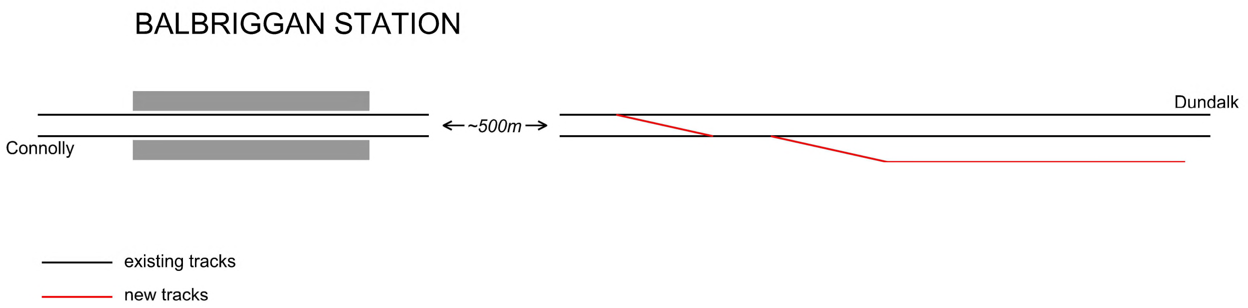


Figure 18 Balbriggan station turn-back track

For that reason, it is proposed that a turn-back track is located in the proximity of Balbriggan station. Locating it right in the station is constrained by the bridge (just south or platforms) and waterfront location of the whole infrastructure.

3.6.1.7 Drogheda

Drogheda is a potential terminating station for electric DART services from Dublin. The station also serves through connections toward Dundalk and Belfast; at certain times passing is being done at platform tracks because of a single-track section through the Boyne Viaduct, immediately north of the station. There is one terminus track for terminating trains in such case, and that would be the capacity concern for the future level of services.

Since the station is located on the sharp curve and in demanding terrain, additionally it serves as a junction with the freight-only (now) line to Navan, there are several potential ways to enhance it to provide more terminus tracks. Those solutions may include the transformation of some of the depot tracks into platform tracks, construction of the new track and platform west of existing station building, in the location currently used as a car park or transformation of the first part of one of the Navan line tracks (used as a parking place for freight locomotives) into a platform for terminating services from Dublin. Detailed proposals in these aspects are beyond the scope of this study.

3.6.2 Line 1a (Howth Junction – Howth)

No changes are proposed in alignment or stations on this line.

3.6.3 Line 2 (Glasnevin – Islandbridge Junction)

There are two new stations (Cabra and Heuston West) envisaged on this section. Approach to Islandbridge Jct. is taking under consideration solutions proposed in the report "DART Expansion Project – Four Tracking from West of Hazelhatch to Phoenix Park Tunnel" (Ove Arup & Partners, 2018).

3.6.4 Line 5 (fast; Heuston – Park West – Hazelhatch – Kildare) and line 6 (slow; Heuston – Park West – Hazelhatch)

General alignment for both lines between Heuston, Islandbridge and Hazelhatch is based on solutions proposed in the report "DART Expansion Project – Four Tracking from West of Hazelhatch to Phoenix Park Tunnel" (Ove Arup & Partners, 2018) and associated drawings, which basically envisages change of the current mode of operation from (north to south) fast-slow-slow-fast to slow-slow-fast-fast tracking. At the same time, several unsolved issues were observed in the referred material. High-level proposals of adjustments are enumerated below. For operational reasons, as it was indicated that Inchicore Depot might also play a role in servicing EMUs, adequate solutions as regards crossovers and electrification are provided.

3.6.4.1 Heuston station and sidings

The general layout of the Heuston station provides for future electrification of platform tracks 7 and 8; with remaining tracks remaining non-electrified. It is assumed that 4 sidings located north of track 8 are also electrified. It needs to be noted that access to those sidings is difficult and manoeuvres from platform tracks or other locations of the station to those tracks or vice versa require a turn-back at mainline tracks.

3.6.4.2 Islandbridge Junction

The junction is realigned in accordance with the report "DART Expansion Project – Four Tracking from West of Hazelhatch to Phoenix Park Tunnel" (Ove Arup & Partners, 2018) and associated drawings.

2.6.1.1. Inchicore works area

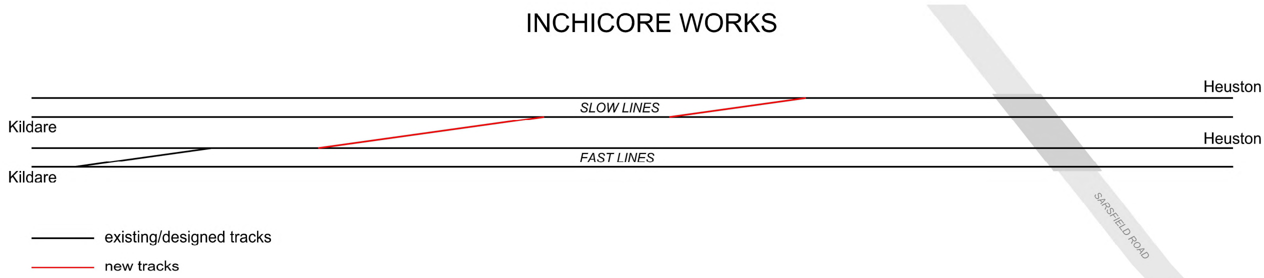


Figure 19 Inchicore Works area – new crossovers

In comparison with the design of four trackings, the section just west of Inchicore is provided with a set of new crossovers (electrified), allowing access to Inchicore from slow tracks.

3.6.4.3 Kylemore Road station

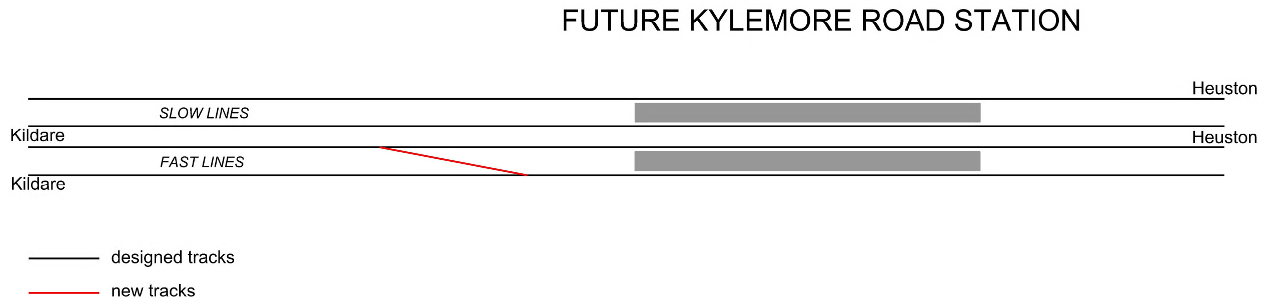


Figure 20 Kylemore Road Station – new crossovers

New crossover is proposed between fast tracks just west of the newly designed Kylemore Road Station to provide access to Inchicore from the fast track towards Heuston.

3.6.4.4 Park West station area

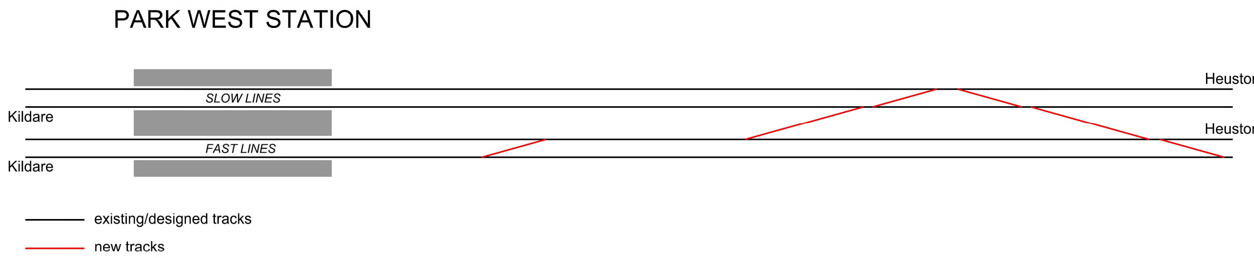


Figure 21 Park West Station – new crossovers

A new set of crossovers connecting all tracks is envisaged just east of the Park West station and allows for possible route change for trains of different categories.

3.6.4.5 Kishogue

It is envisaged that Kishogue station will work as a passenger station for DART services.

3.6.4.6 Adamstown

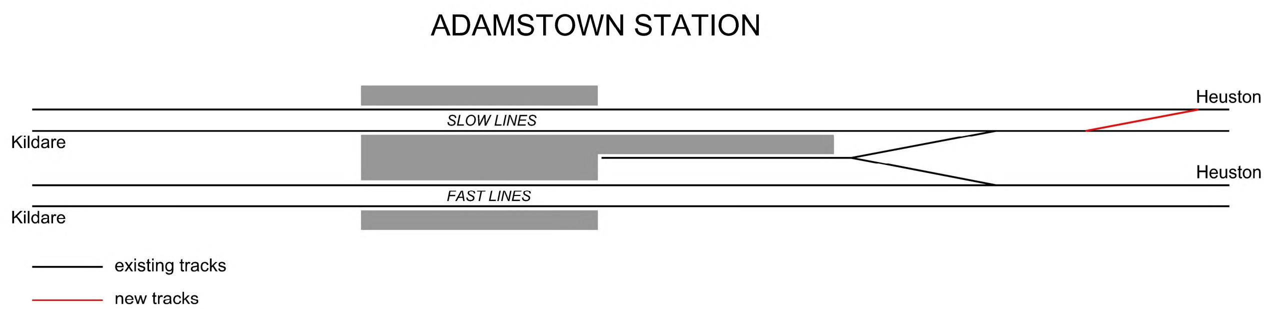


Figure 22 Adamstown Station – new crossovers

Access to the turn-back siding has to be provided primarily from "slow" tracks. Design of four trackings seems to be missing that in case of Adamstown and Hazelhatch stations. Proposed solution (new crossovers) is less practical than the existing one (with a turn-back track in between "slow" tracks). Still, without significant remodelling of the station infrastructure, it might be the only possibility.

3.6.4.7 Hazelhatch

Hazelhatch is going to play the role of the interchange hub on the approach to Dublin, and all categories of passenger services are expected to stop there. Because of the altered track designation to "slow-slow-fast-fast" (north to south), there are several adjustments necessary.

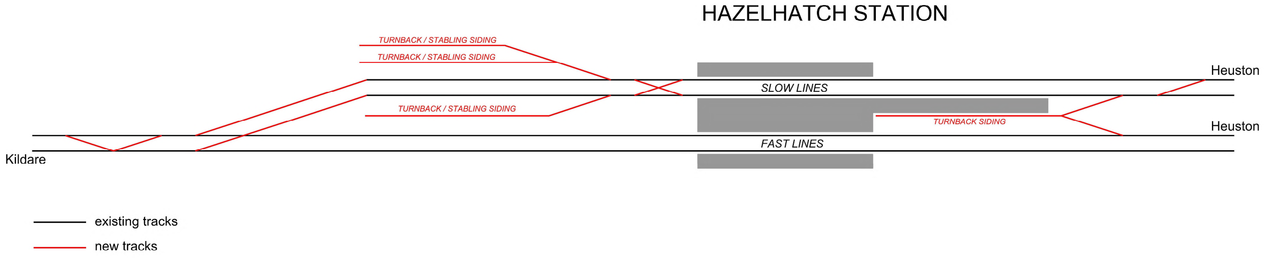


Figure 23 Hazelhatch station – new proposals

First adjustment: Access to the turn-back siding has to be provided primarily from "slow" tracks. Design of four trackings seems to be missing that in case of Adamstown and Hazelhatch stations. Proposed solution (new crossovers) is less practical than the existing one (with a turn-back track in between "slow" tracks). Still, without significant remodelling of the station infrastructure, it might be the only possibility.

Second adjustment: the western throat of the station should be remodelled to accommodate traffic without single-track sections.

Third adjustment: turn backtracks/stabling sidings (electrified) might be added next to slow tracks; access to it via a new crossover located just west of platforms.

3.6.5 Line 7 (Pearse – Greystones)

The southern coastal line gives limited chances of construction of additional sidings or stabling tracks. Main proposed changes refer to Dun Laoghaire station, where enhanced facilities for turn-backs are provided.

3.6.5.1 Pearse and Grand Canal Dock

Pearse and Grand Canal Dock stations remain substantially unchanged, offering limited turn-back or stabling facilities.

2.6.1.2. Dun Laoghaire

The station of Dun Laoghaire offers limited opportunities for turn-backs. It is proposed to be enhanced through adding of another turn-back track and remodelling of the station throat through adding crossovers.

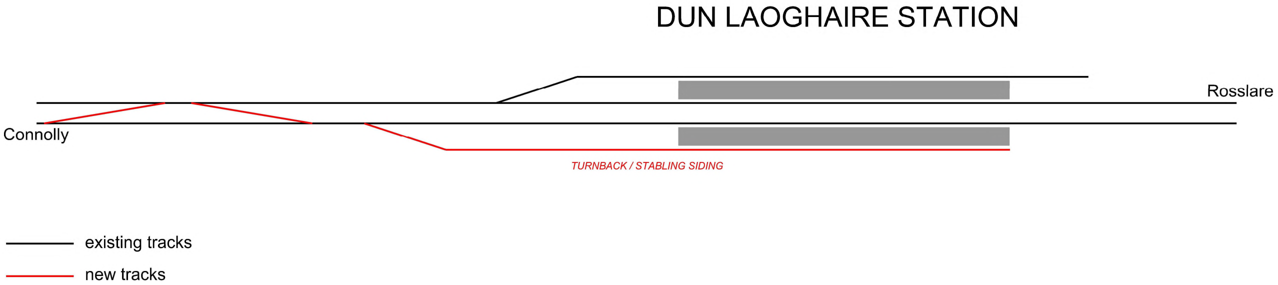


Figure 24 Dun Laoghaire – new turn-back siding

3.6.5.2 Bray

Bray station and sidings remain substantially unchanged.

3.6.5.3 Bray – Greystones section

The single track section between Bray and Greystones (the only longer single track in DART Expansion area) is a constraint to capacity. The section, due to its alignment on cliffs, is also a serious engineering challenge. There were several ideas related to the capacity increase of the section. They included the construction of long passing loops (as extensions of station tracks in Bray and Greystones).

Capacity issues on the section do not have a direct impact on the city centre solutions. Since potential new alignment and improvements on this section require a comprehensive, separate study, it will not be taken under consideration at this stage and for purposes of modelling.

3.6.5.4 Greystones

In analysed scenarios Greystones station remains substantially unchanged.

4. Analysed options – operations

4.1 Initial assumptions

Operational scenarios developed at the preliminary stage are aimed at presenting the necessary data for the choice of the operational and infrastructure scenarios which will be developed at the later stage. For that reason, do not yet reflect all particularities.

Since the city centre area and particularly Connolly station is the main challenge of the operational modelling in the whole Greater Dublin Area, analysed options are focused on train movements at Connolly station and adjacent lines and junctions. Docklands station is considered a relief and second choice, where the balance of trains that cannot be accommodated at Connolly, is directed.

For those reasons, known capacity constraints on other lines are not considered to be hindering analysed operational options. Similarly, details as regards stations of origin and destination of particular services outside of the city centre area have secondary meaning. For instance, at this stage it is crucial that the train passes through the Connolly station coming from line no. 1 (North) and going to line no. 7 (Southern), while the fact of whether it comes from Malahide or Drogheda or goes to Bray or Dun Laoghaire is less important. However, operational assessment of needs as regards turn-back tracks was made and proposed scenarios reflect possibilities in that aspect.

Analysed scenarios are to reflect the proposed initially options, contained in the Design Review Report:

Option 1 - Mixed traffic - continuing and terminating services at Connolly from all feeding lines from the north or west; associated with limited infrastructure change ("do minimum option");

Option 2 - Separated traffic –to achieve the maximal potential of each line number of conflicting ("mixing") train paths is reduced. In this scenario generally trains to come from the North terminate at Connolly while trains from the west (Maynooth and Hazelhatch) continue south. The option is also associated with limited infrastructure change;

Option 3 - North-to-South continuation – in this scenario generally trains from the north continue south; while trains from westerly directions terminate at Connolly. To avoid clashes, the northern throat of the station is remodelled.

4.2 The capacity of lines and stations.

Analysed scenarios assume that line capacity on all network sections allows for conducting the traffic with theoretical headways of not less than 3 minutes (except for some sections, line single-track line Bray – Greystones). It will be done through appropriate adjustment of infrastructure and signalling. Detailed solutions are beyond the scope of this report.

The capacity of stations and especially the possibility of turning back there is taken under consideration and assumed in relation to stations outside the direct study area (city centre and Maynooth lines).

4.3 Preparation of train services specifications

Preparation of modelling train services specifications (TSS) in the preparatory stage has three stages:

1) Initial TSS, based on design review report concept and previously prepared TSS, submitted by the IE;
2) Adjusted TSS, with amendments arising from first checks and aimed at elimination of most visible conflicts;
3) Modelling TSS – scenarios with further amendments identified in the modelling process, aimed at allowing the trains to be moving in the model.

4.3.1.1 Initial TSS stage

Basic service levels on particular sections of lines were determined on the basis of Revised TSS Option 1 – Balanced City Centre Distribution (Systra & Jacobs, DART Expansion Programme Option Assessment –

Addendum Report; August 2018). In some cases, adjustments were made. Since the TSS Option 1 – Balanced City Centre Distribution does not contain detailed data on transfers of trains through Connolly station, certain assumptions of balanced distribution between three feeding directions (Northern line, Hazelhatch, Maynooth) was made. As regards Howth trains, as they were not mentioned in the TSS Option 1 – Balanced City Centre Distribution; the number of 6 shuttle services (Howth – Howth Junction) was assumed, in accordance with TSS Bundle 6 – Enhanced PPT, as contained in Systra & Jacobs DART Expansion Programme Option Assessment, October 2018; Appendix E. There were minor adjustments made on other lines to accommodate the cyclic schedule.

The main change in comparison to Systra & Jacobs TSS Option 1 is related to the elimination of services on line 3a (Connolly – Newcomen Jct.), so planned initially services were rerouted either through line 2 (Glasnevin – Drumcondra – Connolly section) or through line 3 to Docklands Station. As a result of opinion exchange with IÉ, direct services between the city centre area and Howth or M3 Parkway are maintained.

Following the Design Review Report, three basic traffic scenarios (TSS), named IDOM A, IDOM B and IDOM C are developed.

TSS IDOM A – provides for termination of services from line no. 1 (north) at Connolly and continuation of services from the west (Maynooth, Hazelhatch) to the south.

TSS IDOM B – provides for termination of most of the services from the west and selected services from the north at Connolly and continuation of most of the services from the north and some services from the west to the south.

TSS IDOM C – provides for termination of mixed traffic with possibly similar general services to Systra & Jacobs TSS Option 1 (Balanced City Centre Distribution).

Comparison of initial TSS in terms of the number of trains per hour per direction (tphpd) may be found in the table:

Table 4 Comparison of initial TSS

INITIAL TRAIN SERVICE SPECIFICATION COMPARISON						
Line no.	section		TSS Systra & Jacobs Bundle 6 Option 1 Balanced City Centre Distribution	IDOM A	IDOM B	IDOM C
	Connolly	East Wall Jct.	11	15	15	15
	East Wall Jct	Howth Jct.	13	15	15	15
	Howth Jct.	Clongriffin	13	11	11	11
1	Clongriffin	Malahide	10	11	11	11
	Malahide	Balbriggan	7	7	7	7
	Balbriggan	Drogheda	7	7	7	7
	Drogheda	Dundalk (Belfast)	3	3	3	3
1a	Howth Jct.	Howth	6	4	4	4
	Connolly	North Strand Jct.	5	16	12	12
2	North Strand Jct.	Glasnevin Jct.	10	16	12	12
	Glasnevin Jct.	Islandbridge Jct.	10	8	8	8
	Docklands	Newcomen Jct.	5	8	12	12
3	Newcomen Jct.	Glasnevin Jct.	15	8	12	12
	Glasnevin Jct.	Clonsilla	15	16	16	16

INITIAL TRAIN SERVICE SPECIFICATION COMPARISON						
Line no.	section		TSS Systra & Jacobs Bundle 6 Option 1 Balanced City Centre Distribution	IDOM A	IDOM B	IDOM C
	Clonsilla	Maynooth	15	12	12	12
	Maynooth	Longford (Sligo)	2	2	2	2
3a	Connolly	Newcomen Jct.	10	0	0	0
4	Clonsilla	M3 Parkway	5	4	4	4
5 (fast)	Heuston	Islandbridge Jct .	12	12	12	12
	Islandbridge Jct.	Park West	12	12	12	12
	Park West	Hazelhatch	12	12	12	12
	Hazelhatch	Kildare	12	12	12	12
6 (slow)	Heuston	Islandbridge Jct .	4	4	4	4
	Islandbridge Jct.	Park West	14	12	12	12
	Park West	Adamstown	14	12	12	12
	Adamstown	Hazelhatch	14	12	12	12
7	Connolly	Pearse	18	17	17	17
	Pearse	Grand Canal Dock	18	17	17	17
	Grand Canal Dock	Dun Laoghaire	13	13	13	13
	Dun Laoghaire	Bray	9	9	9	9
	Bray	Greystones	2	3	3	3
	Greystones	Wicklow (Rosslare)	1	1	1	1
9	East Wall Jct	Docklands	2	0	0	0
9a	North Strand Jct.	Docklands	5	0	0	0

4.3.2 Initial basic traffic scenarios (TSS)

Three developed initial TSS offer a similar level of service on crucial sections, but different interchanges.

TSS IDOM A in its initial version provides for separation of traffic. In general, trains from the north terminate at Connolly station and trains from the west either go to the south or are routed to Docklands station. That is the case also of long-distance services to/from Sligo. Glasnevin becomes an important passenger interchange. Services are not strictly separated at Glasnevin: equal shares of 8 tphpd are routed via line 2, line 3 and between line 3 (Clonsilla direction) and line 2 (North Strand Jct. direction). There are no scheduled passenger services between line 3 (Docklands direction) and line 2 (Islandbridge Jct. direction).

Details may be found in the table:

Table 5 IDOM Initially proposed TSS (for modelling) - option A (West goes South, North terminates)

train number	section		301-302	101-102	501-502	511-512	521-522	503-504	513-514	305-306	507-508	509-510	553-554	363-364	157-158	557-558	563-564	total:
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	M3 Parkway	Maynooth	Connolly	Dun Laoghaire	GCD	Docklands	Docklands	Heuston	Heuston	Maynooth	
train destination			Connolly	Connolly	Connolly	Connolly	Connolly	Greystones	Bray	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands	
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU	
Line no.								via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra						
1	Connolly	East Wall Jct.	2	1	4	4	4											15
	East Wall Jct	Howth Jct.	2	1	4	4	4											15
	Howth Jct.	Clongriffin	2	1	4	4												11
	Clongriffin	Malahide	2	1	4	4												11
	Malahide	Balbriggan	2	1	4													7
	Balbriggan	Drogheda	2	1	4													7
	Drogheda	Dundalk (Belfast)	2	1														3
1a	Howth Jct.	Howth					4											4
2	Connolly	North Strand Jct.						2	6		4	4						16
	North Strand Jct.	Glasnevin Jct.						2	6		4	4						16
	Glasnevin Jct.	Islandbridge Jct.									4	4						8
3	Docklands	Newcomen Jct.											2	2			4	8
	Newcomen Jct.	Glasnevin Jct.											2	2			4	8
	Glasnevin Jct.	Clonsilla						2	6				2	2			4	16
	Clonsilla	Maynooth							6					2			4	12
	Maynooth	Longford (Sligo)												2				2
3a	Connolly	Newcomen Jct.																0
4	Clonsilla	M3 Parkway						2					2					4
5 (fast)	Heuston	Islandbridge Jct .													12			12
	Islandbridge Jct.	Park West													12			12
	Park West	Hazelhatch													12			12
	Hazelhatch	Kildare													12			12
6 (slow)	Heuston	Islandbridge Jct .														4		4
	Islandbridge Jct.	Park West									4	4				4		12
	Park West	Adamstown									4	4				4		12
	Adamstown	Hazelhatch									4	4				4		12
7	Connolly	Pearse						2	6	1	4	4						17
	Pearse	Grand Canal Dock						2	6	1	4	4						17
	Grand Canal Dock	Dun Laoghaire						2	6	1	4							13
	Dun Laoghaire	Bray						2	6	1								9
	Bray	Greystones						2		1								3
	Greystones	Wicklow (Rosslare)								1								1
9	East Wall Jct	Docklands																0

train number	section		301-302	101-102	501-502	511-512	521-522	503-504	513-514	305-306	507-508	509-510	553-554	363-364	157-158	557-558	563-564	total:
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	M3 Parkway	Maynooth	Connolly	Dun Laoghaire	GCD	Docklands	Docklands	Heuston	Heuston	Maynooth	
train destination			Connolly	Connolly	Connolly	Connolly	Connolly	Greystones	Bray	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands	
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU	
Line no.								via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra						
9a	North Strand Jct.	Docklands																0
		STOPS	Dundalk-Malahide: all; Malahide - Connolly: nonstop	Drogheda	all	all	all	all	all	Tara, Pearse, GCD, Dun Laoghaire, Bray	all	all	all	Drumcondra South, Glasnevin, Broombridge	Hazelhatch	all	all	

TSS IDOM B in its initial version envisages continuation of the service pattern with trains from the north serving southern coastal line and trains from the west mostly terminating at Connolly. Since some trains from the north (Enterprise trains to/from Belfast and DMU services to/from Dundalk) terminate at Connolly, some services from line 2 (Hazelhatch) are routed south to Grand Canal Dock (4 tphpd). Glasnevin continues to serve as an important passenger interchange and a crucial junction: trains from both western directions serve both eastern directions (Connolly and Docklands), so there are 4 tphpd between Docklands and Hazelhatch and 8 tphpd from Clonsilla direction towards Connolly via line 2 (North Strand Jct.). Routing of 4 tphpd in the course of line 2 and 8 tphpd in the course of line 3 means a substantial number of conflicting moves at that junction, however, gives a variety of passenger offers.

Details may be found in the table:

Table 6IDOM Initially proposed TSS (for modelling) - option B (North goes South, West terminates at Connolly or Docklands)

train number	section		301-302	101-102	531-532	541-542	561-562	533-534	543-544	305-306	537-538	539-540	553-554	363-364	157-158	557-558	563-564		
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	Connolly	Connolly	Connolly	GCD	Docklands	Docklands	Docklands	Heuston	Heuston	Maynooth		
train destination			Connolly	Connolly	Bray	Dun Laoghaire	Bray/Greystones	M3 Parkway	Maynooth	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands		
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU		
Line no.								via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra						total option B:	Difference to TSS IDOM A
	Connolly	East Wall Jct.	2	1	4	4	4											15	0
	East Wall Jct	Howth Jct.	2	1	4	4	4											15	0
	Howth Jct.	Clongriffin	2	1	4	4												11	0
1	Clongriffin	Malahide	2	1	4	4												11	0
	Malahide	Balbriggan	2	1	4													7	0
	Balbriggan	Drogheda	2	1	4													7	0
	Drogheda	Dundalk (Belfast)	2	1														3	0
1a	Howth Jct.	Howth					4											4	0
	Connolly	North Strand Jct.						2	6		4							12	-4
2	North Strand Jct.	Glasnevin Jct.						2	6		4							12	-4
	Glasnevin Jct.	Islandbridge Jct.									4	4						8	0
	Docklands	Newcomen Jct.										4	2	2			4	12	4
	Newcomen Jct.	Glasnevin Jct.										4	2	2			4	12	4
3	Glasnevin Jct.	Clonsilla						2	6				2	2			4	16	0
	Clonsilla	Maynooth							6					2			4	12	0
	Maynooth	Longford (Sligo)												2				2	0
3a	Connolly	Newcomen Jct.																0	0
4	Clonsilla	M3 Parkway						2					2					4	0
	Heuston	Islandbridge Jct .													12			12	0
5 (fast)	Islandbridge Jct.	Park West													12			12	0
	Park West	Hazelhatch													12			12	0
	Hazelhatch	Kildare													12			12	0
	Heuston	Islandbridge Jct .														4		4	0
6 (slow)	Islandbridge Jct.	Park West									4	4				4		12	0
	Park West	Adamstown									4	4				4		12	0
	Adamstown	Hazelhatch									4	4				4		12	0
	Connolly	Pearse			4	4	4			1	4							17	0
	Pearse	Grand Canal Dock			4	4	4			1	4							17	0
7	Grand Canal Dock	Dun Laoghaire			4	4	4			1								13	0
	Dun Laoghaire	Bray			4		4			1								9	0
	Bray	Greystones					2			1								3	0
	Greystones	Wicklow (Rosslare)								1								1	0
9	East Wall Jct	Docklands																0	0

train number	section		301-302	101-102	531-532	541-542	561-562	533-534	543-544	305-306	537-538	539-540	553-554	363-364	157-158	557-558	563-564		
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	Connolly	Connolly	Connolly	GCD	Docklands	Docklands	Docklands	Heuston	Heuston	Maynooth		
train destination			Connolly	Connolly	Bray	Dun Laoghaire	Bray/Greystones	M3 Parkway	Maynooth	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands		
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU		
Line no.								via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra						total option B:	Difference to TSS IDOM A
9a	North Strand Jct.	Docklands																0	0
		STOPS	Dundalk-Malahide: all; Malahide - Connolly: nonstop	Drogheda	all	all	all	all	all	Tara, Pearse, GCD, Dun Laoghaire, Bray	all	all	all	Drumcondra South, Glasnevin, Broombridge	Hazelhatch	all	all		

TSS IDOM C is similar to option B, however there is more mixing of traffic at Connolly. Several DART services from the north (Malahide) terminate at Connolly, while some of services from Maynooth continue south. Role of Glasnevin junction is the same as in option IDOM B.

Details may be found in the table:

Table 7 IDOM Option C - mixed traffic (some trains from the West and North terminate, some go through Connolly to the South)

train number	section		301-302	101-102	531-532	541-542	561-562	533-534	543-544	305-306	507-508	539-540	553-554	363-364	157-158	557-558	563-564			
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	Connolly	Connolly/GCD	Connolly	Dun Laoghaire	Docklands	Docklands	Docklands	Heuston	Heuston	Maynooth			
train destination			Connolly	Connolly	Bray	Connolly	Bray/Greystones	M3 Parkway	Maynooth	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands			
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU			
Line no.								via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra						total option C:	Difference to option A	Difference to option B
1	Connolly	East Wall Jct.	2	1	4	4	4											15	0	0
	East Wall Jct	Howth Jct.	2	1	4	4	4											15	0	0
	Howth Jct.	Clongriffin	2	1	4	4												11	0	0
	Clongriffin	Malahide	2	1	4	4												11	0	0
	Malahide	Balbriggan	2	1	4													7	0	0
	Balbriggan	Drogheda	2	1	4													7	0	0
	Drogheda	Dundalk (Belfast)	2	1														3	0	0
1a	Howth Jct.	Howth					4											4	0	0
2	Connolly	North Strand Jct.						2	6		4							12	-4	0
	North Strand Jct.	Glasnevin Jct.						2	6		4							12	-4	0
	Glasnevin Jct.	Islandbridge Jct.									4	4						8	0	0
3	Docklands	Newcomen Jct.										4	2	2			4	12	4	0
	Newcomen Jct.	Glasnevin Jct.										4	2	2			4	12	4	0
	Glasnevin Jct.	Clonsilla						2	6				2	2			4	16	0	0
	Clonsilla	Maynooth							6					2			4	12	0	0
	Maynooth	Longford (Sligo)												2				2	0	0
3a	Connolly	Newcomen Jct.																0	0	0
4	Clonsilla	M3 Parkway						2					2					4	0	0
5 (fast)	Heuston	Islandbridge Jct .													12			12	0	0
	Islandbridge Jct.	Park West													12			12	0	0
	Park West	Hazelhatch													12			12	0	0
	Hazelhatch	Kildare													12			12	0	0
6 (slow)	Heuston	Islandbridge Jct .														4		4	0	0
	Islandbridge Jct.	Park West									4	4				4		12	0	0
	Park West	Adamstown									4	4				4		12	0	0
	Adamstown	Hazelhatch									4	4				4		12	0	0
7	Connolly	Pearse			4		4		4	1	4							17	0	0
	Pearse	Grand Canal Dock			4		4		4	1	4							17	0	0
	Grand Canal Dock	Dun Laoghaire			4		4			1	4							13	0	0
	Dun Laoghaire	Bray			4		4			1								9	0	0
	Bray	Greystones					2			1								3	0	0

train number	section		301-302	101-102	531-532	541-542	561-562	533-534	543-544	305-306	507-508	539-540	553-554	363-364	157-158	557-558	563-564			
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	Connolly	Connolly/GCD	Connolly	Dun Laoghaire	Docklands	Docklands	Docklands	Heuston	Heuston	Maynooth			
train destination			Connolly	Connolly	Bray	Connolly	Bray/Greystones	M3 Parkway	Maynooth	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands			
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU			
Line no.								via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra						total option C:	Difference to option A	Difference to option B
	Greystones	Wicklow (Rosslare)								1								1	0	0
9	East Wall Jct	Docklands																0	0	0
9a	North Strand Jct.	Docklands										4						4	4	4
		STOPS	Dundalk-Malahide: all; Malahide - Connolly: nonstop	Drogheda	all	all	all	all	all	Tara, Pearse, GCD, Dun Laoghaire, Bray	all	all	all	Drumcondra South, Glasnevin, Broombridge	Hazelhatch	all	all			

4.4 Adjustment of TSS

4.4.1 Initial assessment of train paths conflicts

Different infrastructure options were checked initially for the occurrence of conflicts. Following situations were considered conflicts (conflicting train paths) for this comparison:

- crossing paths of two trains through a flat crossing;
- crossing paths through a typical segment of tracks;
- bi-directional traffic on a single-track line segment

The entry of trains from two directions onto the same line is not considered a conflict for this comparison since those trains have to depart in a headway sequence.

For conflict analyses in the city centre following stations and junctions were taken under consideration:

- Connolly station (for "do minimum" and different investment options);
- Newcomen Junction (for selected options);
- Glasnevin Junction (for investment option as designed by Metrolink).

Potential conflicts at North Strand Junction were added to calculation at a later stage only for options providing for passenger traffic on line 9a (Docklands – North Strand Jct.).

Conflicts at access to terminus tracks at Connolly (platforms 1 – 4) were not noted, as platform allocation is not done at this level.

The specific situation is related to trains potentially terminating at Connolly, arriving from line no. 7 (Connolly – Rosslare services). Because of their minimal number (1 tphpd in some of the options) and potential conflicts strongly associated with the track they are received at and with potential manoeuvres, for those initial comparisons those trains are not counted in conflict matrix.

Conflicts in this sense are not identical with train path conflicts identified in the process of RailSys modelling.

Following tables illustrate the conflict matrix for "do minimum" and different investment options. In each table "1" means the existence of a conflict, while "0" – the opposite.

Current infrastructure ("do minimum" / "do nothing" options for Connolly, Metrolink option for Glasnevin):

Table 8 Conflicts - "do minimum."

	CONNOLLY ENTRIES AND DEPARTURES		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
	From:	To:														
C1	Line 1 (North)	Line 7 (Pearse)	0	0	0	1	0	0	0	0	0	0	1	1	0	0
C2	Line 1 (North)	terminates		0	0	0	0	0	0	0	0	0	0	0	0	0
C3	Line 2 (North Strand)	Line 7 (Pearse)			0	0	0	0	1	0	0	0	0	1	0	0
C4	Line 2 (North Strand)	terminates				0	0	0	0	0	0	0	0	0	0	0
C5	Line 3 (Newcomen Jct.)	Line 7 (Pearse)					0	0	1	1	1	0	0	0	1	0
C6	Line 3 (Newcomen Jct.)	terminates						0	1	1	1	0	0	0	1	0
C7	Line 7 (Pearse)	Line 1 (North)							0	0	0	0	0	1	1	1
C8	Line 7 (Pearse)	Line 2 (North Strand)								0	0	0	0	0	1	1
C9	Line 7 (Pearse)	Line 3 (Newcomen Jct.)									0	0	0	0	0	1
C10	Line 7 (Pearse)	terminates										0	0	0	0	0
C11	starts	Line 1 (North)											0	0	0	0
C12	starts	Line 2 (North Strand)												0	0	0
C13	starts	Line 3 (Newcomen Jct.)													0	0
C14	starts	Line 7 (Pearse)														0

	GLASNEVIN ENTRIES AND DEPARTURES		C15	C16	C17	C18	C19	C20	C21	C22
	From:	To:								
C15	Line 2 (North Strand)	Line 2 (Islandbridge)	0	0	0	0	0	1	1	0
C16	Line 2 (North Strand)	Line 3 (Clonsilla)		0	1	0	0	1	0	1
C17	Line 3 (Newcomen Jct.)	Line 2 (Islandbridge)			0	0	0	0	1	1
C18	Line 3 (Newcomen Jct.)	Line 3 (Clonsilla)				0	0	0	0	0
C19	Line 2 (Islandbridge)	Line 2 (North Strand)					0	0	0	0
C20	Line 2 (Islandbridge)	Line 3 (Newcomen Jct.)						0	1	0
C21	Line 3 (Clonsilla)	Line 2 (North Strand)							0	0
C22	Line 3 (Clonsilla)	Line 3 (Newcomen Jct.)								0

	NEWCOMEN JCT. ENTRIES AND DEPARTURES		C23	C24	C25	C26
	From:	To:				
C23	Line 3 (Docklands)	Line 3 (Glasnevin)	0	0	0	1
C24	Line 3a (Connolly)	Line 3 (Glasnevin)		0	0	1
C25	Line 3 (Glasnevin)	Line 3 (Docklands)			0	0
C26	Line 3 (Glasnevin)	Line 3a (Connolly)				0

There are 19 conflicts at Connolly, 8 conflicts at Glasnevin and 2 conflicts at Newcomen.

For infrastructure option IDOM1 (1 track overbridge on line 2, Connolly – North Strand section) the conflict matrix looks as follows:

Table 9 Conflicts - option IDOM 1

	CONNOLLY ENTRIES AND DEPARTURES		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
	From:	To:														
C1	Line 1 (North)	Line 7 (Pearse)	0	0	0	0	0	0	0	0	0	0	1	1	0	0
C2	Line 1 (North)	terminates		0	0	0	0	0	0	0	0	0	0	0	0	0
C3	Line 2 (North Strand)	Line 7 (Pearse)			0	0	0	0	0	0	0	0	0	1	0	0
C4	Line 2 (North Strand)	terminates				0	0	0	0	0	0	0	0	0	0	0
C5	Line 3 (Newcomen Jct.)	Line 7 (Pearse)					0	0	1	1	1	0	0	0	1	0
C6	Line 3 (Newcomen Jct.)	terminates						0	1	1	1	0	0	0	1	0
C7	Line 7 (Pearse)	Line 1 (North)							0	0	0	0	0	1	1	1
C8	Line 7 (Pearse)	Line 2 (North Strand)								0	0	0	0	0	1	1
C9	Line 7 (Pearse)	Line 3 (Newcomen Jct.)									0	0	0	0	0	1
C10	Line 7 (Pearse)	terminates										0	0	0	0	0
C11	starts	Line 1 (North)											0	0	0	0
C12	starts	Line 2 (North Strand)												0	0	0
C13	starts	Line 3 (Newcomen Jct.)													0	0
C14	starts	Line 7 (Pearse)														0

	GLASNEVIN ENTRIES AND DEPARTURES		C15	C16	C17	C18	C19	C20	C21	C22
	From:	To:								
C15	Line 2 (North Strand)	Line 2 (Islandbridge)	0	0	0	0	0	1	1	0
C16	Line 2 (North Strand)	Line 3 (Clonsilla)		0	1	0	0	1	0	1
C17	Line 3 (Newcomen Jct.)	Line 2 (Islandbridge)			0	0	0	0	1	1
C18	Line 3 (Newcomen Jct.)	Line 3 (Clonsilla)				0	0	0	0	0
C19	Line 2 (Islandbridge)	Line 2 (North Strand)					0	0	0	0
C20	Line 2 (Islandbridge)	Line 3 (Newcomen Jct.)						0	1	0
C21	Line 3 (Clonsilla)	Line 2 (North Strand)							0	0
C22	Line 3 (Clonsilla)	Line 3 (Newcomen Jct.)								0

	NEWCOMEN JCT. ENTRIES AND DEPARTURES		C23	C24	C25	C26
	From:	To:				
C23	Line 3 (Docklands)	Line 3 (Glasnevin)	0	0	0	1
C24	Line 3a (Connolly)	Line 3 (Glasnevin)		0	0	1
C25	Line 3 (Glasnevin)	Line 3 (Docklands)			0	0
C26	Line 3 (Glasnevin)	Line 3a (Connolly)				0

There are 17 conflicts at Connolly, 8 at Glasnevin and 2 at Newcomen.

For infrastructure option IDOM1 (2-track overbridge on line 2, Connolly – North Strand section) there is a following conflict matrix:

Table 10 Conflicts - option IDOM 2

	CONNOLLY ENTRIES AND DEPARTURES		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
	From:	To:														
C1	Line 1 (North)	Line 7 (Pearse)	0	0	0	0	0	0	0	1	0	0	1	0	0	0
C2	Line 1 (North)	terminates		0	0	0	0	0	0	0	0	0	0	0	0	0
C3	Line 2 (North Strand)	Line 7 (Pearse)			0	0	0	0	0	0	0	0	0	1	0	0
C4	Line 2 (North Strand)	terminates				0	0	0	0	0	0	0	0	0	0	0
C5	Line 3 (Newcomen Jct.)	Line 7 (Pearse)					0	0	1	1	1	0	0	0	1	0
C6	Line 3 (Newcomen Jct.)	terminates						0	1	1	1	0	0	0	1	0
C7	Line 7 (Pearse)	Line 1 (North)							0	0	0	0	0	0	1	1
C8	Line 7 (Pearse)	Line 2 (North Strand)								0	0	0	0	0	1	1
C9	Line 7 (Pearse)	Line 3 (Newcomen Jct.)									0	0	0	0	0	1
C10	Line 7 (Pearse)	terminates										0	0	0	0	0
C11	starts	Line 1 (North)											0	0	0	0
C12	starts	Line 2 (North Strand)												0	0	0
C13	starts	Line 3 (Newcomen Jct.)													0	0
C14	starts	Line 7 (Pearse)														0

	GLASNEVIN ENTRIES AND DEPARTURES		C15	C16	C17	C18	C19	C20	C21	C22
	From:	To:								
C15	Line 2 (North Strand)	Line 2 (Islandbridge)	0	0	0	0	0	1	1	0
C16	Line 2 (North Strand)	Line 3 (Clonsilla)		0	1	0	0	1	0	1
C17	Line 3 (Newcomen Jct.)	Line 2 (Islandbridge)			0	0	0	0	1	1
C18	Line 3 (Newcomen Jct.)	Line 3 (Clonsilla)				0	0	0	0	0
C19	Line 2 (Islandbridge)	Line 2 (North Strand)					0	0	0	0
C20	Line 2 (Islandbridge)	Line 3 (Newcomen Jct.)						0	1	0
C21	Line 3 (Clonsilla)	Line 2 (North Strand)							0	0
C22	Line 3 (Clonsilla)	Line 3 (Newcomen Jct.)								0

	NEWCOMEN JCT. ENTRIES AND DEPARTURES		C23	C24	C25	C26
	From:	To:				
C23	Line 3 (Docklands)	Line 3 (Glasnevin)	0	0	0	1
C24	Line 3a (Connolly)	Line 3 (Glasnevin)		0	0	1
C25	Line 3 (Glasnevin)	Line 3 (Docklands)			0	0
C26	Line 3 (Glasnevin)	Line 3a (Connolly)				0

There are 16 conflicts at Connolly, 8 at Glasnevin and 2 at Newcomen.

For infrastructure option IDOM3 (two overbridges: 1-track on line 2 allowing for access from North Strand to platform 5, the other connecting platforms 1-4 with North Strand), conflict matrix looks as follows:

Table 11 Conflicts - option IDOM 3

	CONNOLLY ENTRIES AND DEPARTURES		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
	From:	To:														
C1	Line 1 (North)	Line 7 (Pearse)	0	0	0	0	0	0	0	0	0	0	1	0	0	0
C2	Line 1 (North)	terminates		0	0	0	0	0	0	0	0	0	0	0	0	0
C3	Line 2 (North Strand)	Line 7 (Pearse)			0	0	0	0	0	0	0	0	0	1	0	0
C4	Line 2 (North Strand)	terminates				0	0	0	0	0	0	0	0	0	0	0
C5	Line 3 (Newcomen Jct.)	Line 7 (Pearse)					0	0	1	1	1	0	0	0	1	0
C6	Line 3 (Newcomen Jct.)	terminates						0	1	1	1	0	0	0	1	0
C7	Line 7 (Pearse)	Line 1 (North)							0	0	0	0	0	0	1	1
C8	Line 7 (Pearse)	Line 2 (North Strand)								0	0	0	0	0	1	1
C9	Line 7 (Pearse)	Line 3 (Newcomen Jct.)									0	0	0	0	0	1
C10	Line 7 (Pearse)	terminates										0	0	0	0	0
C11	starts	Line 1 (North)											0	0	0	0
C12	starts	Line 2 (North Strand)												0	0	0
C13	starts	Line 3 (Newcomen Jct.)													0	0
C14	starts	Line 7 (Pearse)														0

	GLASNEVIN ENTRIES AND DEPARTURES		C15	C16	C17	C18	C19	C20	C21	C22
	From:	To:								
C15	Line 2 (North Strand)	Line 2 (Islandbridge)	0	0	0	0	0	1	1	0
C16	Line 2 (North Strand)	Line 3 (Clonsilla)		0	1	0	0	1	0	1
C17	Line 3 (Newcomen Jct.)	Line 2 (Islandbridge)			0	0	0	0	1	1
C18	Line 3 (Newcomen Jct.)	Line 3 (Clonsilla)				0	0	0	0	0
C19	Line 2 (Islandbridge)	Line 2 (North Strand)					0	0	0	0
C20	Line 2 (Islandbridge)	Line 3 (Newcomen Jct.)						0	1	0
C21	Line 3 (Clonsilla)	Line 2 (North Strand)							0	0
C22	Line 3 (Clonsilla)	Line 3 (Newcomen Jct.)								0

	NEWCOMEN JCT. ENTRIES AND DEPARTURES		C23	C24	C25	C26
	From:	To:				
C23	Line 3 (Docklands)	Line 3 (Glasnevin)	0	0	0	1
C24	Line 3a (Connolly)	Line 3 (Glasnevin)		0	0	1
C25	Line 3 (Glasnevin)	Line 3 (Docklands)			0	0
C26	Line 3 (Glasnevin)	Line 3a (Connolly)				0

There are 15 conflicts at Connolly, 8 at Glasnevin and 2 at Newcomen.

Although a number of conflicts at the central station (Connolly) seem to be very similar, it needs to be noted that not all conflicts are similarly burdensome and their weight can be assessed only concerning the number of trains that are affected.

For comparative purposes also previously proposed solutions were checked as regards number of conflicts. For those reasons, options 8B and 8D from Jacobs Connolly Station Enhancement Options Study, March 2019, were examined.

For option Jacobs option 8B number of conflicts at Connolly was slightly lower (13), but some of them were transferred to Newcomen (4 conflicts). The details are illustrated in the table:

Table 12 Conflicts - option 8B Jacobs

	CONNOLLY ENTRIES AND DEPARTURES		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
	From:	To:														
C1	Line 1 (North)	Line 7 (Pearse)	0	0	0	1	0	0	0	0	0	0	1	1	0	0
C2	Line 1 (North)	terminates		0	0	0	0	0	0	0	0	0	0	0	0	0
C3	Line 2 (North Strand)	Line 7 (Pearse)			0	0	0	0	1	0	0	0	0	1	0	0
C4	Line 2 (North Strand)	terminates				0	0	0	1	0	0	0	0	1	0	0
C5	Line 3 (Newcomen Jct.)	Line 7 (Pearse)					0	0	0	0	1	0	0	0	0	0
C6	Line 3 (Newcomen Jct.)	terminates						0	0	0	0	0	0	0	1	0
C7	Line 7 (Pearse)	Line 1 (North)							0	0	0	0	0	1	0	1
C8	Line 7 (Pearse)	Line 2 (North Strand)								0	0	0	0	0	0	1
C9	Line 7 (Pearse)	Line 3 (Newcomen Jct.)									0	0	0	0	0	1
C10	Line 7 (Pearse)	terminates										0	0	0	0	0
C11	starts	Line 1 (North)											0	0	0	0
C12	starts	Line 2 (North Strand)												0	0	0
C13	starts	Line 3 (Newcomen Jct.)													0	0
C14	starts	Line 7 (Pearse)														0

	GLASNEVIN ENTRIES AND DEPARTURES		C15	C16	C17	C18	C19	C20	C21	C22
	From:	To:								
C15	Line 2 (North Strand)	Line 2 (Islandbridge)	0	0	0	0	0	1	1	0
C16	Line 2 (North Strand)	Line 3 (Clonsilla)		0	1	0	0	1	0	1
C17	Line 3 (Newcomen Jct.)	Line 2 (Islandbridge)			0	0	0	0	1	1
C18	Line 3 (Newcomen Jct.)	Line 3 (Clonsilla)				0	0	0	0	0
C19	Line 2 (Islandbridge)	Line 2 (North Strand)					0	0	0	0
C20	Line 2 (Islandbridge)	Line 3 (Newcomen Jct.)						0	1	0
C21	Line 3 (Clonsilla)	Line 2 (North Strand)							0	0
C22	Line 3 (Clonsilla)	Line 3 (Newcomen Jct.)								0

	NEWCOMEN JCT. ENTRIES AND DEPARTURES		C23	C24	C25	C26
	From:	To:				
C23	Line 3 (Docklands)	Line 3 (Glasnevin)	0	1	0	1
C24	Line 3a (Connolly)	Line 3 (Glasnevin)		0	1	1
C25	Line 3 (Glasnevin)	Line 3 (Docklands)			0	0
C26	Line 3 (Glasnevin)	Line 3a (Connolly)				0

Option 8D from Jacobs study results are shown in the following table. There are fewer conflicts overall (14 at Connolly and 2 at Newcomen), but the capacity of lines is limited.

Table 13 Conflicts - option 8D Jacobs

	CONNOLLY ENTRIES AND DEPARTURES		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
	From:	To:														
C1	Line 1 (North)	Line 7 (Pearse)	0	0	0	1	0	0	0	0	0	0	1	1	0	0
C2	Line 1 (North)	terminates		0	0	0	0	0	0	0	0	0	0	0	0	0
C3	Line 2 (North Strand)	Line 7 (Pearse)			0	0	0	0	1	0	0	0	0	1	0	0
C4	Line 2 (North Strand)	terminates	-			0	0	0	1	0	0	0	0	1	0	0
C5	Line 3 (Newcomen Jct.)	Line 7 (Pearse)					0	0	0	0	1	0	0	0	1	0
C6	Line 3 (Newcomen Jct.)	terminates						0	0	0	0	0	0	0	1	0
C7	Line 7 (Pearse)	Line 1 (North)							0	0	0	0	0	1	0	1
C8	Line 7 (Pearse)	Line 2 (North Strand)								0	0	0	0	0	0	1
C9	Line 7 (Pearse)	Line 3 (Newcomen Jct.)									0	0	0	0	0	1
C10	Line 7 (Pearse)	terminates										0	0	0	0	0
C11	starts	Line 1 (North)											0	0	0	0
C12	starts	Line 2 (North Strand)												0	0	0
C13	starts	Line 3 (Newcomen Jct.)													0	0
C14	starts	Line 7 (Pearse)														0

	GLASNEVIN ENTRIES AND DEPARTURES		C15	C16	C17	C18	C19	C20	C21	C22
	From:	To:								
C15	Line 2 (North Strand)	Line 2 (Islandbridge)	0	0	0	0	0	1	1	0
C16	Line 2 (North Strand)	Line 3 (Clonsilla)		0	1	0	0	1	0	1
C17	Line 3 (Newcomen Jct.)	Line 2 (Islandbridge)			0	0	0	0	1	1
C18	Line 3 (Newcomen Jct.)	Line 3 (Clonsilla)				0	0	0	0	0
C19	Line 2 (Islandbridge)	Line 2 (North Strand)					0	0	0	0
C20	Line 2 (Islandbridge)	Line 3 (Newcomen Jct.)						0	1	0
C21	Line 3 (Clonsilla)	Line 2 (North Strand)							0	0
C22	Line 3 (Clonsilla)	Line 3 (Newcomen Jct.)								0

	NEWCOMEN JCT. ENTRIES AND DEPARTURES		C23	C24	C25	C26
	From:	To:				
C23	Line 3 (Docklands)	Line 3 (Glasnevin)	0	0	0	1
C24	Line 3a (Connolly)	Line 3 (Glasnevin)		0	0	1
C25	Line 3 (Glasnevin)	Line 3 (Docklands)			0	0
C26	Line 3 (Glasnevin)	Line 3a (Connolly)				0

4.4.2 Comparison of initial TSS

Initially prepared TSS were checked against the conflict tables for different infrastructure options. In the case of each conflict, the number of trains involved was calculated. As a result, the total number of conflicts for different infrastructure options and different traffic scenarios was developed. Not all TSS were checked against all infrastructure options as some solutions (particularly in Jacobs Options 8B and 8D) were inconsistent with the offer on other TSS.

Table 14 Trains affected by conflicts

	TSS:	Systra&Jacobs	IDOM A	IDOM B	IDOM C
OPTION					
CURRENT (with do minimum)	total	160	32	235	231
	Connolly	125	0	139	119
	Glasnevin	0	32	96	96
	Newcomen / North Strand	35			16
IDOM 1	total	149	32	163	171
	Connolly	114	0	67	59
	Glasnevin	0	32	96	96
	Newcomen / North Strand	35			16
IDOM 2	total	160	32	139	151
	Connolly	114	0	43	39
	Glasnevin	0	32	96	96
	Newcomen / North Strand	35			16
IDOM 3	total	149	32	123	139
	Connolly	114	0	27	27
	Glasnevin	0	32	96	96
	Newcomen / North Strand	35			16
Jacobs 8B	total	117			
	Connolly	42			
	Glasnevin	0			
	Newcomen	65			
	North Strand	10			
Jacobs 8D	total	97			
	Connolly	52			
	Glasnevin	0			
	Newcomen	35			
	North Strand	10			

4.4.3 Adjustment of TSS

The high number of conflicts in several options, particularly at Glasnevin, prompts for some adjustment of initially proposed TSS.

This is especially possible with TSS IDOM B and is aimed at elimination of conflicts at Glasnevin. For that reason crossings at Glasnevin are removed through directing all traffic from line 3 (Clonsilla direction) to Docklands station. This affects 2 tphpd between Connolly and M3 Parkway and 6 tphpd between Connolly and Maynooth. At the same time, 4 tphpd between Docklands and Hazelhatch are redirected for Connolly – North Strand Jct. – Glasnevin – Hazelhatch route.

Details are shown in the table:

Table 15 Trains affected by conflicts, adjusted TSS

	TSS:	Systra&Jacobs Balanced City Centre	IDOM A	IDOM B	IDOM B adjusted	IDOM C
OPTION						
CURRENT (do minimum)	total	160	32	235	111	231
	Connolly	125	0	139	111	119
	Glasnevin	0	32	96	0	96
	Newcomen / North Strand	35				16
IDOM 1	total	149	32	163	55	171
	Connolly	114	0	67	55	59
	Glasnevin	0	32	96	0	96
	Newcomen / North Strand	35				16
IDOM 2	total	160	32	139	39	151
	Connolly	114	0	43	39	39
	Glasnevin	0	32	96	0	96
	Newcomen / North Strand	35				16
IDOM 3	total	149	32	123	23	139
	Connolly	114	0	27	23	27
	Glasnevin	0	32	96	0	96
	Newcomen / North Strand	35				16

Adjustment allows to eliminate all conflicts at Glasnevin and in all investment options (IDOM 1 – IDOM 3) it gives substantially better results. It means, however, more substantial dependency on Docklands station and can cause capacity issues there.

Adjustment of that kind has not been taken under consideration for TSS IDOM A, as its primary target was to change the traffic pattern. In case trains from line 3 (Clonsilla direction) were directed to Docklands as in Adjusted TSS IDOM B; trains arriving at Connolly from line 2 (PPT via North Strand Jct.) would have to be supported by 8 tphpd from the north in servicing line 7 to Bray and Greystones. That would reduce the number of possible conflicts at Glasnevin, but cause a certain number of them to appear at Connolly to 15 (infrastructure options IDOM 1 and IDOM 3) or 31 (infrastructure option IDOM 2), so it can be taken under consideration in the future. Still, because of initial TSS conditions at this stage, it will not be modelled.

Adjustment similar to proposed for TSS IDOM B could also be applied to TSS IDOM C with similar results as for TSS IDOM B (elimination of 96 cases of trains affected by conflicts at Glasnevin with a heavier load of trains at Docklands). Since other parameters of TSS IDOM B and IDOM C are similar, no adjustments will be made to investigate the better comparison of those options in further modelling.

Subsequently, base options (TSS) for further modelling are:

- Initial TSS IDOM A
- Adjusted TSS IDOM B
- Initial TSS IDOM C

5. Preselection of modelling options

In a matrix of three proposed TSS and four infrastructure options ("do minimum" and three investment options: IDOM 1, IDOM 2 and IDOM 3) selection process has to be undertaken to determine scenarios that answer IE needs the most. Creation of this shortlist requires taking into consideration several factors that include:

- IE traffic preferences;
- high-level estimation of costs and complexity;
- performance results;
- "value for money" approach.

In terms of IE preferred traffic scenarios TSS IDOM C is most similar to preferred TSS from previously prepared studies (Revised TSS Option 1 – Balanced City Centre Distribution, Systra & Jacobs, DART Expansion Programme Option Assessment – Addendum Report; August 2018). TSS IDOM B (adjusted) does not revolutionize the traffic pattern and from this point of view is closer to IE preferences. TSS IDOM A envisages a significant change in traffic and this sense is considered by IÉ a "reasonable option", although cannot be named preferred.

This aspect leads to the conclusion that each initial or adjusted TSS should be taken under consideration for the shortlist.

IE prefers variants with minimum disturbances for the traffic and possibly moderate budget. From this point of view, the option "do minimum" involves less investment and complexity than other options. Two options with one overbridge (IDOM 1 and IDOM 2) are comparable one to another; while the option IDOM 3 involves significantly more complex construction and higher costs, also because of land occupancy.

Comparison of options is shown in the table:

Table 16 Comparison of options

COSTS & TECHNICAL COMPLEXITY	
Do minimum	significant comparative advantage over other options
IDOM 1	comparable to other options
IDOM 2	comparable to other options
IDOM 3	significant comparative disadvantage over other options

The comparison allows to state that infrastructure option IDOM 3 can be put aside at this stage. Option "do minimum" should naturally be taken under consideration and so it is with one of the less complex investment options (IDOM 1 or IDOM 2), based on performance results.

The table shows performance results for the matrix of options.

Table 17 Variants for preselection - conflicts chart

OPTION		IDOM A	IDOM B adjusted	IDOM C
		number of trains per hour affected by conflicts		
Do minimum	total	32	111	231
	Connolly	0	111	119
	Glasnevin	32	0	96
		comparable	significant disadvantages	significant disadvantages
IDOM 1	total	32	55	171
	Connolly	0	55	59
	Glasnevin	32	0	96
		comparable	some disadvantages	some disadvantages (for Connolly)
IDOM 2	total	32	39	151
	Connolly	0	39	39
	Glasnevin	32	0	96
		comparable	comparable	comparable (for Connolly)
IDOM 3	total	32	23	139
	Connolly	0	23	27
	Glasnevin	32	0	96
		comparable	some advantages	comparable (for Connolly)

In all aspects TSS IDOM C is performing the worst, however main conflict point is at Glasnevin Junction. Since that can be adjusted at the cost of the diversity of connections (similarly like adjustment in case of TSS IDOM B), only the number of trains affected by conflicts at Connolly is taken under consideration. At the same time, for TSS IDOM A overall number of conflict (including Glasnevin) is counted, as that cannot be avoided without significant changes.

Several TSS have performance levels approximately 25-40 trains affected by conflicts and they are considered comparable. Advantage visible in case of TSS IDOM B and infrastructure option IDOM 3 is not significant. As for “do minimum” infrastructure options TSS IDOM A performs best, while two others are significantly worse. For that reason, combination TSS IDOM A – IDOM 1 is chosen to further modelling. For TSS IDOM B option comparable in terms of performance is IDOM 2, and this combination is considered for further modelling. As regards TSS IDOM C – its performance for investment options (IDOM 1 – IDOM 3) is similar, and assessment of IDOM B may give very similar results. On the other hand, as the preferred option in combination with “do minimum” infrastructure option, it can be seen as IE preferred, despite significant disadvantages in initial performance analysis.

In terms of “value for money” TSS IDOM A gets the best performance results at the cheapest infrastructure option (“do minimum”). Infrastructure option IDOM 3, although expensive, may be seen as one giving a very significant improvement of performance for options with mixed traffic. In this way, it offers the highest flexibility of operations for all possible TSS.

In result, shortlist of variants chosen for further analyses is shown in the table:

Table 18 Shortlist of variants (scenarios)

Shortlist of variants	Infrastructure	TSS
Scenario 1	"do minimum"	IDOM C
Scenario 2	"do minimum"	IDOM A
Scenario 3	IDOM 2	IDOM B

6. Modelling results

6.1 Modelling assumptions

It needs to be underlined that results of RailSys modelling do not present a ready timetable. Analyses contained in this chapter are aimed at indicating maximum theoretical capacity. The real capacity of lines and stations is lower and depends on several preferences of the operating carrier and infrastructure manager as regards robustness, timetabling separations, reserves and flexibility.

All simulation and the modelling process were carried out with RailSys 10.3. application.

The main goal of the modelling carried out was to check the technical capability and flexibility of the future timetable construction. In this exercise increasing number of trains for various traffic categories at Maynooth Line and City Centre was considered. The modelling carried out identifies bottlenecks and other possible operational problems at the DART network.

The analysis does not include the influence of suggested timetable at adjacent sections to the corridors listed in chapter 6.1.1.

6.1.1 Infrastructure

Traffic modelling analysis for each option refers to following corridors of railway network:

- Connolly - Drogheda
- Howth Jct - Howth
- Connolly - Islandbridge Jct
- Docklands - Maynooth
- Connolly - Newcomen Jct
- Clonsilla - M3 Parkway
- Heuston - Hazelhatch (Fast & Slow)
- Connolly - Greystones

All used models are based on the existing infrastructure with several exceptions.

At every line, bidirectional 3-aspect signalling system instead of one-directional was introduced.

At Maynooth line, additional signals that divide block sections into shorter section were introduced.

For Docklands Station, the preferred solution is to increase the number of tracks and platforms to 5 and to install crossovers that make it possible to access to each platform from each direction.

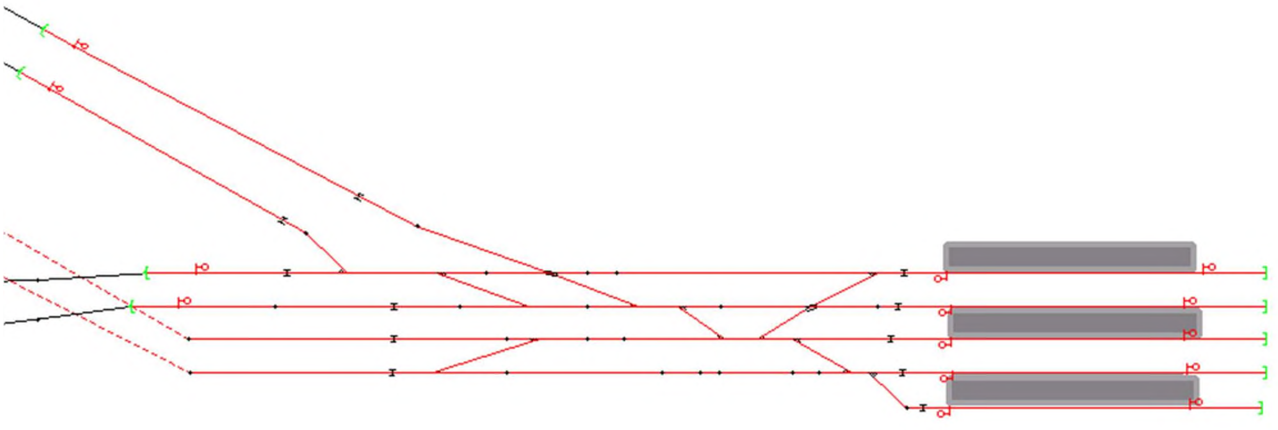


Figure 25 Plan of Docklands station (modelling)

Corridor Heuston – Hazelhatch is based on a 4-track solution presented in *Dart Expansion Project Four Tracking form West of Hazelhatch to Phoenix Park Tunnel*.

Except changes mentioned above, models contain minor improvements like additional sidings, stabling tracks or crossovers enabling better access to the platforms and other tracks, at stations:

- Balbriggan (Northern)
- Skerries (Northern)
- Malahide (Northern)
- Clongriffin (Northern)
- Dun Laoghaire (Southern)
- Inchicore (Kildare)
- Kylemore Rd. (Kildare)
- Adamstown (Kildare)
- Hazelhatch (Kildare)

6.1.2 Rolling stock

For modelling 3 different types of rolling stock for 3 categories of trains were taken under consideration:

- Intercity fast train (DMU/loco)
- Intercity (DMU)
- Commuter/DART (EMU)

Each type of rolling stock has different features, because of the different characters of the traffic demand. Intercity services that involved high-speed traffic and few stops need powerful units with smooth acceleration and aerodynamic structure. For commuter train, high acceleration is more important than high speed due to frequent stops at short distances.

Chosen types of rolling stock and their tractive effort curves are presented at following pictures.

As a potential modern EMU to be modelled the Stadler FLIRT trainset was chosen as one of the most popular suburban EMU trains in the world, with very good tractive parameters and data available for different compositions of trainsets (including 2x4-car set).

Figure 26 Train with Class 201 locomotive

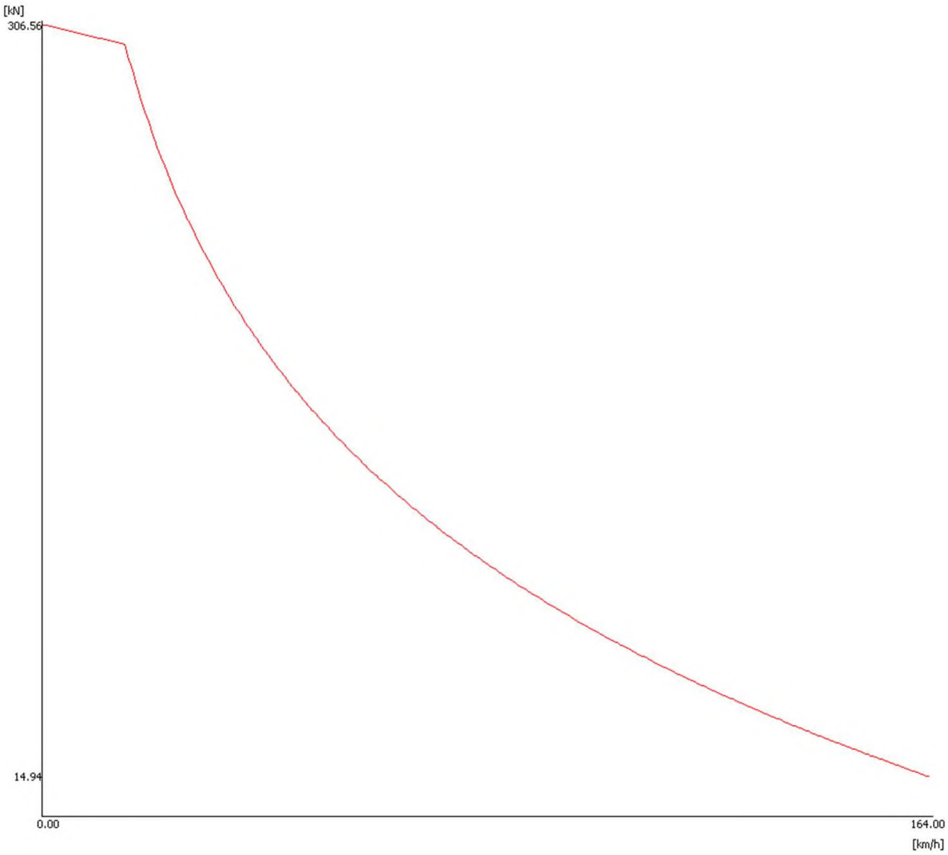


Figure 27 Tractive effort curve of Class 201

Figure 28 Train Class 22000 (DMU – ICR)

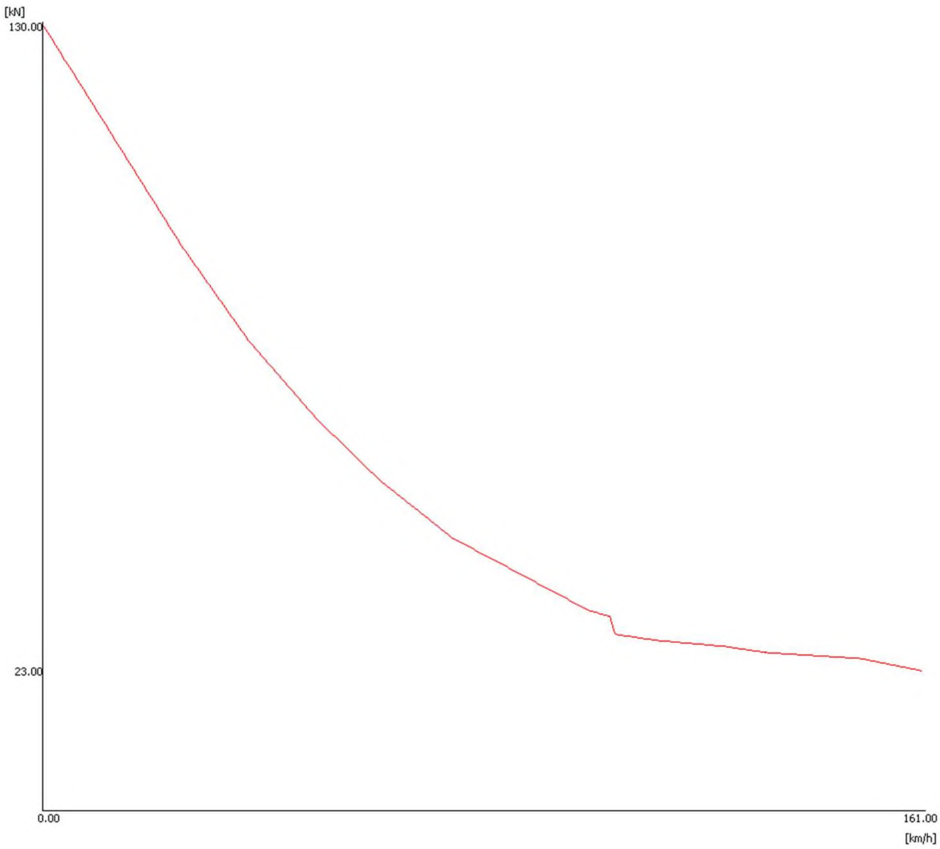


Figure 29 Tractive effort curve of 22000

Figure 30 Stadler FLIRT EMU

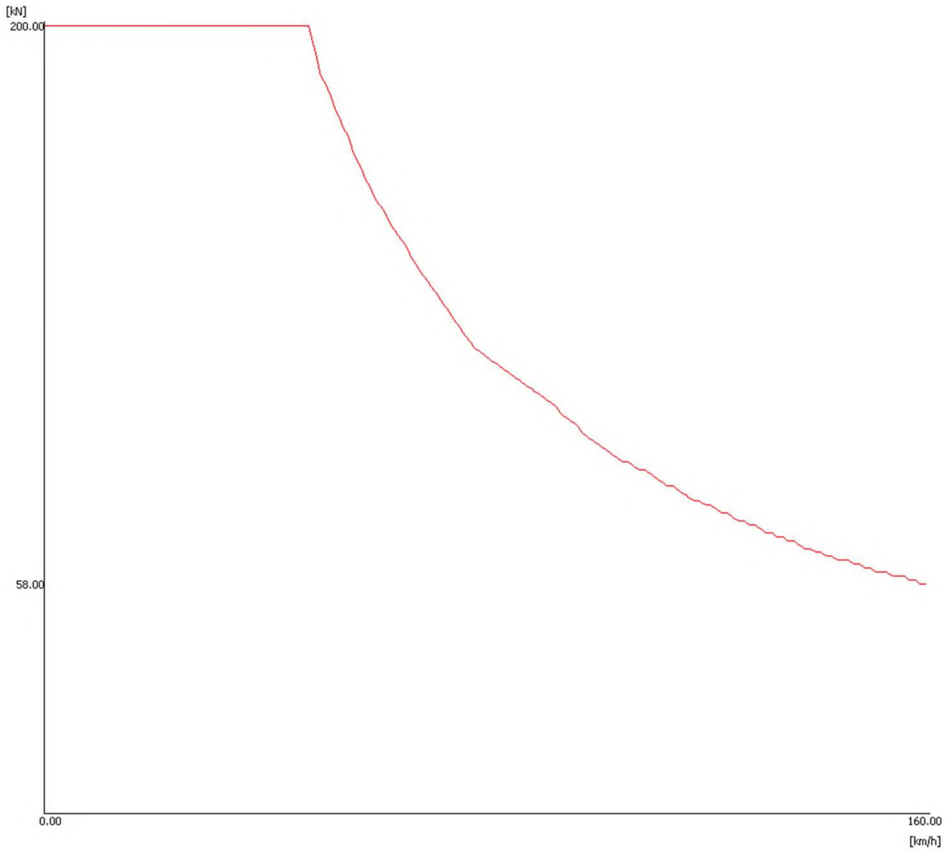


Figure 31 Tractive effort curve of Stadler FLIRT EMU

The summary of the basic parameters is presented in the following table:

Table 19 Rolling stock summary

Rolling stock summary			
Category	Intercity (fast)	Intercity	Commuter/DART
Name	201	22000	Stadler FLIRT
Type	loco	traction unit (DMU)	traction unit (EMU)
traction type	diesel	diesel	electric
no. of units	1	2	2
no. of coaches	8	4	4
trailer (m)	189	0	0
max speed (km/h)	160	160	160
length (m)	207	140	149
weight (t)	352	378	276

6.1.3 Traffic conditions

For traffic modelling, following main assumptions were used:

- timetable is set without conflicts – number of trains for some itineraries might be reduced if it is necessary;
- every train is scheduled with maximum speed for efficient usage of infrastructure and rolling stock;
- reserve time is proportional to running time in every section;
- commuter trains require longer reserves due to more frequent stops;
- fast trains are given priority over commuter trains;
- passenger trains are given priority over freight trains;
- if a fast (intercity) train approaches a commuter train, and there is no possibility for overtaking, additional stops at stations are possible for a long-distance train;
- 30-second dwell time is assumed standard stations for commuter trains;
- 60-second dwell time (at least) for intercity trains and commuter at main stations;
- Minimum required 3,5-min time for separation (in timetabling) of crossing direction at the same track or crossover;
- Minimum required 8-min time for turn back at terminus track (which represents log-off from the control panel, going to cabin at the opposite side and log-in, and possible delay compensation).

In the course of modelling, some of the assumptions had to be modified. In particular, 3,5-minute timetabling separation between conflicting train paths would make it impossible to achieve anything near requested TSS. In some cases, 8-minute turn-back time was also shortened.

6.1.4 Capacity calculation

The capacity of each corridor is limited by the capacity of the section that is the bottleneck.

Maximum capacity is calculated according to UIC code 406 "Capacity".

At single-track block section, minimal headway is determined by the maximal speed-running time at this section increased by interlocking time (setting and release station route).

At double-track section, minimal headway is determined by the period between two trains with maximum speed-running in the same direction without conflict increased by interlocking time.

If the double-track section uses a multi-aspect signalling system, it is assumed that the reference train can pass section ahead without speed reduction.

6.2 Modelling of traffic – scenarios

All of the infrastructure variants and operational variants were designed to meet the balance of forecasted demand, setting flexible timetable and costs of infrastructure improvements.

The priority points of timetable setting for each option are critical (from the operational perspective). In the case of this model, these are hubs -- stations in the city centre area: Connolly and Docklands. Timetables at all lines are adapted to meet conditions at those stations. As the primary goal of this study is to determine options for city-centre stations (particularly – Connolly), timetables and modelling options at other ends of lines or train routes are less detailed and may contain generalisations. As an example, timetable of long-distance services on line 3 may not provide for train passing at Maynooth (before the single track section), as the following section (Maynooth – Mullingar) has no capacity for 2 tphpd anyway and from this point of view cannot be adequately modelled.

Scenarios 1 and 2 refer to “do minimum” infrastructure option at Connolly. Changes are limited to additional crossover - connection between tracks 6 and 7 that allows collision-safe runs between trains arriving and departing from Maynooth Line. From the operational point of view, at Connolly, those trains use platforms 5-7 in scenario 2 and platforms 1-4 in scenario 1.

Scenario 3 contains a grade-separated connection with overbridge for trains arriving and departing from Maynooth Line above Northern Line, which allows for simultaneous service for both lines in each direction (assuming terminating trains from line 2) and better access to each platform.

Following chapters presents the train graphs for each for different periods, track occupancy at Connolly, and TSS.

6.2.1 Scenario 1: “do minimum” infrastructure – mixed traffic at Connolly, services from all directions both terminate or continue to the south

This scenario envisages very limited changes in the infrastructure of the Connolly station. TSS (version IDOM C) provides for the growth of traffic on all lines while continuing general traffic pattern with many services going from several directions to several destinations. This scenario is tested to check the scale of necessary reductions and illustrate significant problems that appear while the number of services grows.

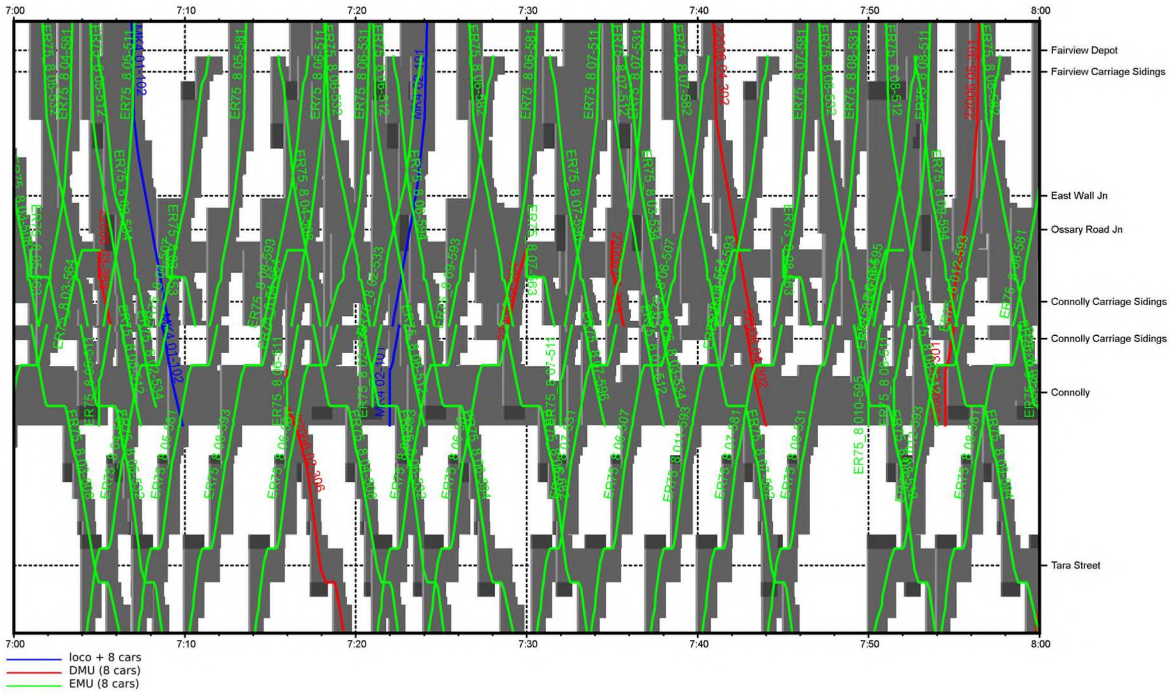


Figure 32 Train diagram - Coastal Line through Connolly - peak hour

Because of the traffic mixing, it is hardly possible to offer a balanced schedule, for instance, on the Connolly – Pearse section. In some cases, conflicts of trains on the Connolly northern throat and coincidence of schedules (and in real life – also delays) of terminating trains from both lines (line 1 and 2) may result in the poor balancing of traffic and relatively long gaps between trains.

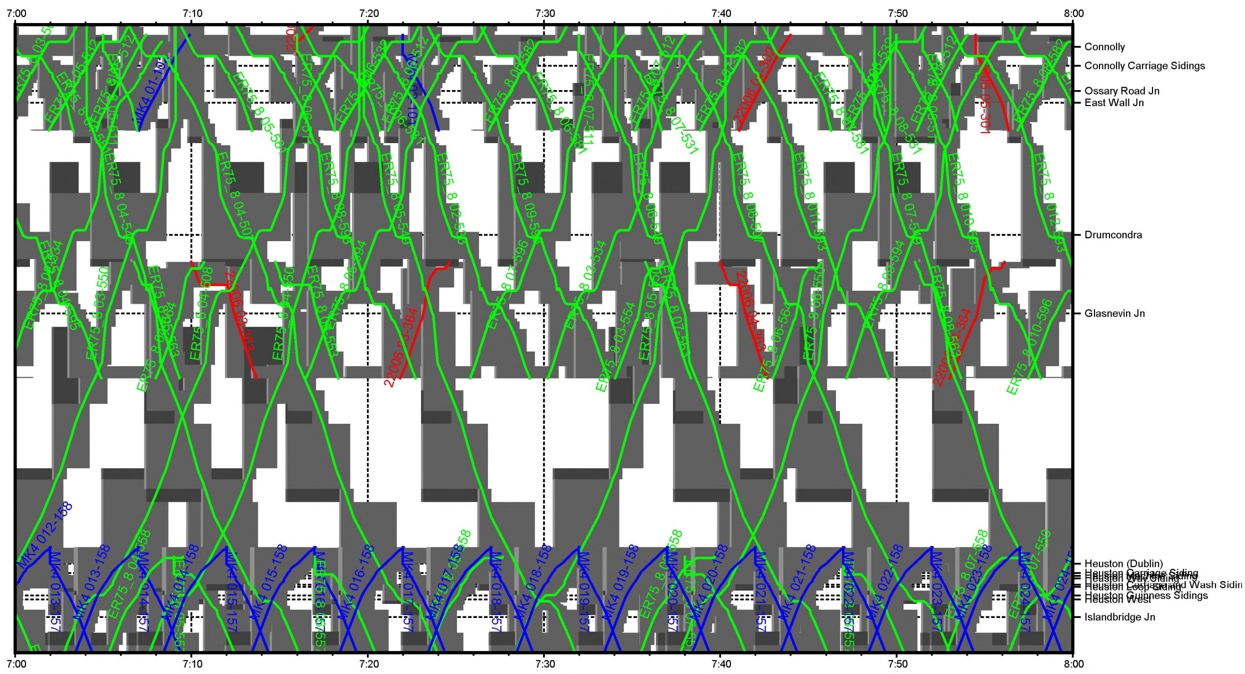


Figure 33 Train diagram Connolly – Glasnevin – Islandbridge Jct. - peak hour

PPT line (line 2) services are also visibly affected by traffic mixing. In several cases a longer gap is caused by parallel occupancy of the segment that is shared with other services, operating at different time intervals. The situation may be visible in both 1-hour scale and 4-hour scale (below).

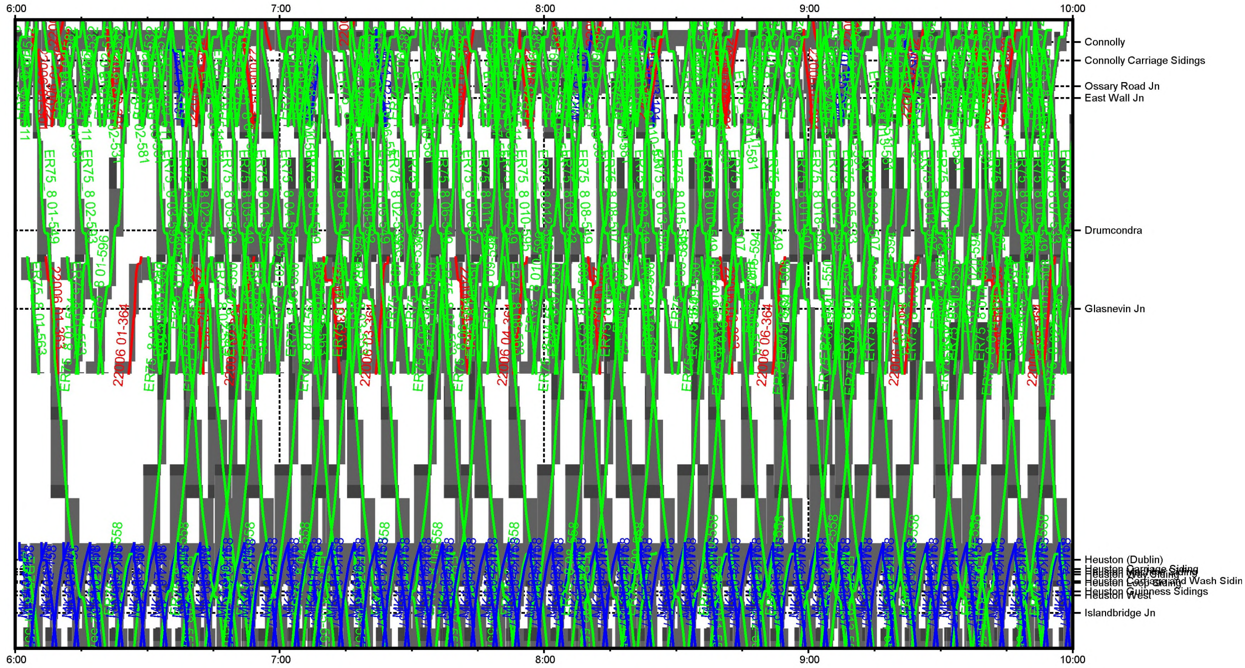


Figure 34 Train diagram Kildare Line - 4 hours

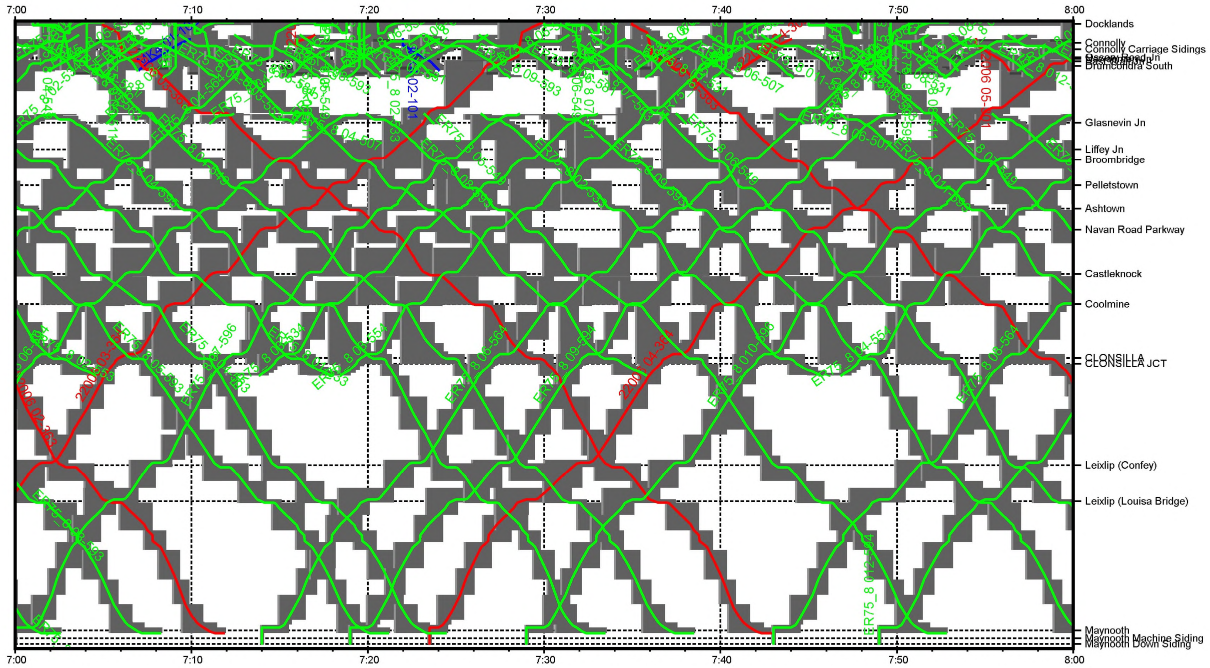


Figure 35 Train diagram - Maynooth Line - peak hour

Train performance on the Maynooth line (line 3, Glasnevin – Maynooth section) shows gaps caused by services coming from or going to M3 Parkway. At the same time, long-distance services on the line with frequent stops decrease capacity. They are not able to run at higher speed (that would require passing loops on every second or third station because of the speed difference between stopping services and intercity trains passing at speed. Slowing those trains down (without coming to a full stop) would mean that keeping low speed (approximately 30-40 km/h) would be necessary in order not to achieve the block section occupied by a slow train ahead. At the same time, low speed and necessary distance to a stopping train ahead would mean even longer occupancy of block sections on the line, thus slowing down the stopping service behind. Better line performance is achieved when a long-distance train comes to a full stop at stations in the same pattern as the stopping service. However, due to different traction characteristics of the EMU (stopping DART service) and DMU (long-distance service), the DMU cannot keep the same acceleration and subsequently slows down the entire sequence of trains.
Currently, there is no passing loop on the entire segment. However, it needs to be noted that passing loops and possibly higher speed may mean that block sections need to be longer, which in case of frequently located stops may cause a capacity reduction.

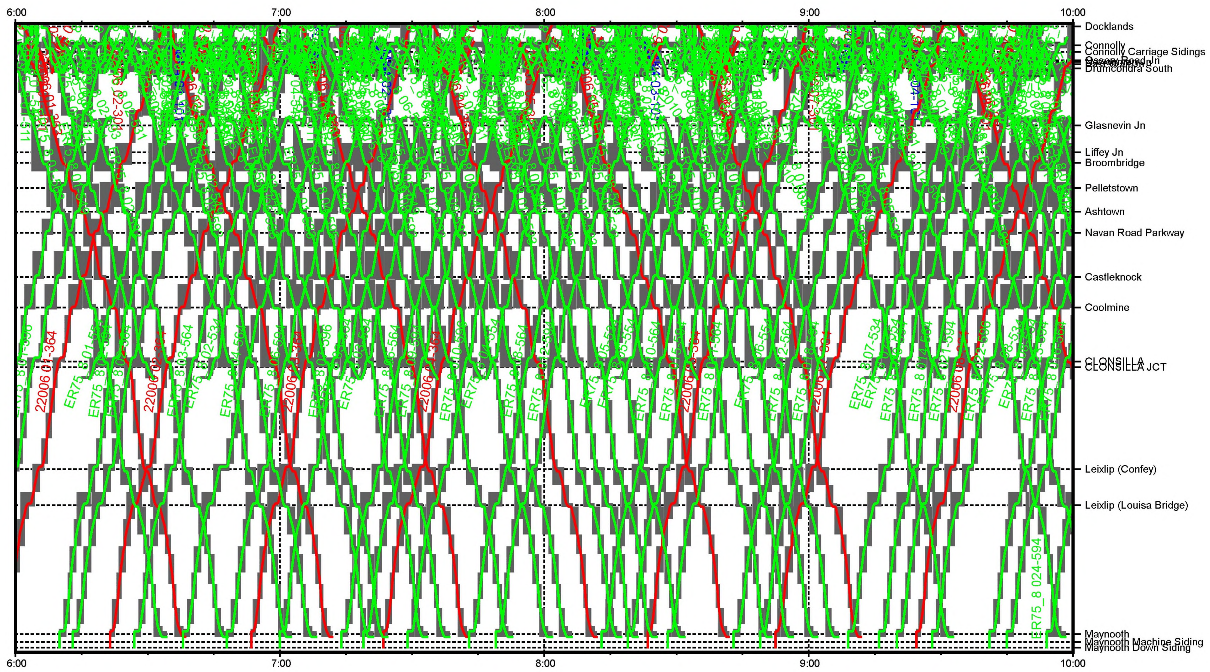


Figure 36 Train diagram - Maynooth Line - 4 hours

Train graph also shows that at least two turn-back tracks at Maynooth station are necessary and that turn-back cannot be done at platforms because of through traffic of long-distance trains. At this graph long-distance trains are not passing at Maynooth station. There are several reasons for that:

- At this stage, schedule construction is optimized for city-centre stations (Connolly and Docklands), since whole line parameters are not yet determined the exact arrival time at Maynooth is not precise;
- Line 3 west of Maynooth will be remodelled, and it will be considered whether some section of it would not be 2-tracked;
- Further segment of line 3 (Maynooth – Mullingar) does not allow for such frequent operations.

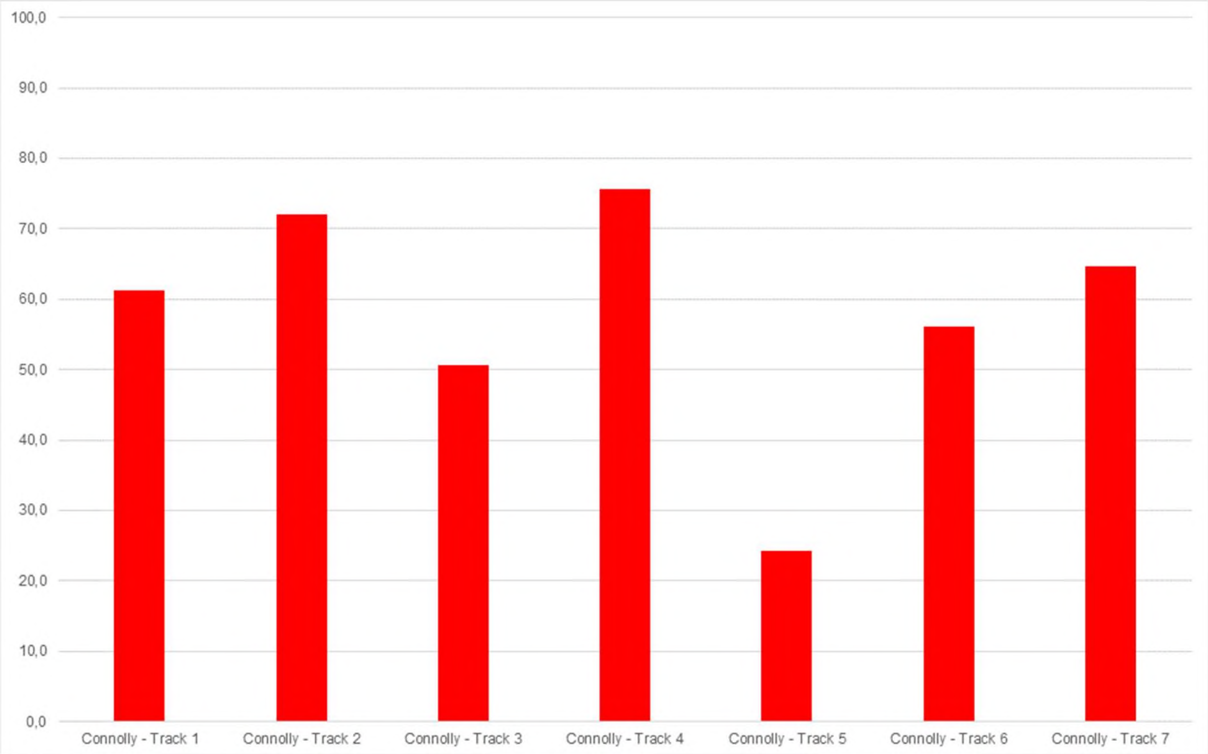


Figure 37 Track occupancy time at Connolly [%] (peak hour)

Track occupancy time graph for Connolly station shows high use of terminus tracks. Low time occupancy of track 5 should be viewed at in pair with occupancy of track 6, as they play the same role for through traffic directed to the south.

Table 20 TSS – Scenario 1

IDOM Option C - mixed traffic (some trains from the West and North terminate, some go through Connolly to the South)																			
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	Connolly	Connolly/GCD	Connolly	Dun Laoghaire	Docklands	Docklands	Docklands	Heuston	Heuston	Maynooth	modelling total amount	planned (original TSS) total amount
train destination			Connolly	Connolly	Bray	Connolly	Bray/Greystones	M3 Parkway	Maynooth	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands		
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU		
Line no.	From	To						via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra							
1	Connolly	East Wall Jct.	2	1	3	4	3											13	15
	East Wall Jct	Howth Jct.	2	1	3	4	3											13	15
	Howth Jct.	Clongriffin	2	1	3	4												10	11
	Clongriffin	Malahide	2	1	3	4												10	11
	Malahide	Balbriggan	2	1	3													6	7
	Balbriggan	Drogheda	2	1	3													6	7
	Drogheda	Dundalk (Belfast)	2	1														3	3
1a	Howth Jct.	Howth					3											3	4
2	Connolly	North Strand Jct.						2	3		3							8	12
	North Strand Jct.	Glasnevin Jct.						2	3		3							8	12
	Glasnevin Jct.	Islandbridge Jct.									3	3						6	8
3	Docklands	Newcomen Jct.										3	2	2			3	10	12
	Newcomen Jct.	Glasnevin Jct.										3	2	2			3	10	12
	Glasnevin Jct.	Clonsilla						2	3				2	2			3	12	16
	Clonsilla	Maynooth							3					2			3	8	12
	Maynooth	Longford (Sligo)												2				2	2
3a	Connolly	Newcomen Jct.																0	0
4	Clonsilla	M3 Parkway						2					2					4	4
5 (fast)	Heuston	Islandbridge Jct .													12			12	12
	Islandbridge Jct.	Park West													12			12	12
	Park West	Hazelhatch													12			12	12
	Hazelhatch	Kildare													12			12	12
6 (slow)	Heuston	Islandbridge Jct .														4		4	4
	Islandbridge Jct.	Park West									3	3				4		10	12
	Park West	Adamstown									3	3				4		10	12
	Adamstown	Hazelhatch									3	3				4		10	12
7	Connolly	Pearse			3		3		1	1	3							11	17
	Pearse	Grand Canal Dock			3		3		1	1	3							11	17
	Grand Canal Dock	Dun Laoghaire			3		3			1	3							10	13
	Dun Laoghaire	Bray			3		3			1								7	9

IDOM Option C - mixed traffic (some trains from the West and North terminate, some go through Connolly to the South)																			
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	Connolly	Connolly/GCD	Connolly	Dun Laoghaire	Docklands	Docklands	Docklands	Heuston	Heuston	Maynooth	modelling total amount	planned (original TSS) total amount
train destination			Connolly	Connolly	Bray	Connolly	Bray/Greystones	M3 Parkway	Maynooth	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands		
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU		
Line no.	From	To						via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra							
	Bray	Greystones					2			1								3	3
	Greystones	Wicklow (Rosslare)								1								1	1
9	East Wall Jct	Docklands																0	0
9a	North Strand Jct.	Docklands										3						3	4
Stops			Dundalk-Malahide: all; Malahide - Connolly: nonstop	Drogheda	all	all	all	all	all	Tara, Pearse, GCD, Dun Laoghaire, Bray	all	all	all	Drumcondra South, Glasnevin, Broombridge	Hazelhatch	all	all		
Reduction					-1		-1		-3		-3	-1					-1		

The row “Reduction” presented above represents the number of trains that has to be removed from TSS, because of insufficient capacity. It should not be viewed at the limitation of services to some of the system’s ends (like Howth or M3 Parkway), as at this stage timetabling is orientated on city centre stations and connections to those destinations are interchangeable with other connections on main lines leading to junctions.

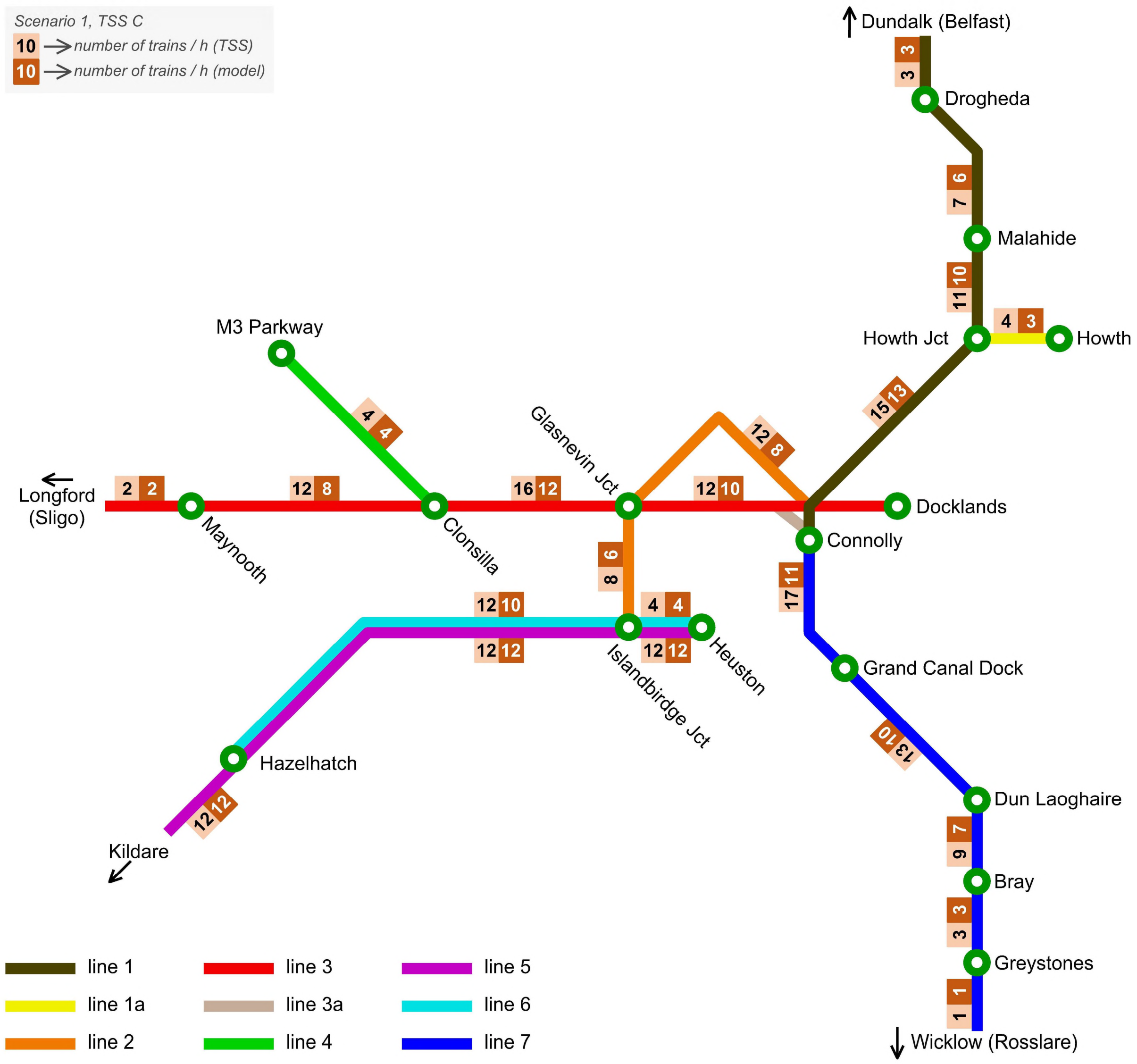


Figure 38 TSS for Scenario 1

It can be seen that the most drastic reduction in the city centre area affects the Loopline bridge – part of line 7 between Connolly and Pearse. It might be contributed to the increased number of conflicts at Connolly, which results in a reduction of numbers of available train paths for through connections between line 1 and line 2 on one side and line 7 on the other.

6.2.2 Scenario 2 – "do minimum" infrastructure – change of traffic pattern at Connolly, northern services terminating

This scenario envisages very limited changes in the infrastructure of the Connolly station. TSS (version IDOM A) provides for maximum separation of services on particular lines. It is assumed that services from line 1 (north) generally terminate at Connolly, services from Hazelhatch (line 6 and 2) generally continue south from Connolly and only services from Maynooth (line 3) or M3 Parkway (line 4) are split at Glasnevin for those that go via line 2 to Glasnevin and further south and those that continue through line 3 to Docklands. Since northern line services are all terminating another important conflict – originating services to the north and through services from the north – is eliminated.

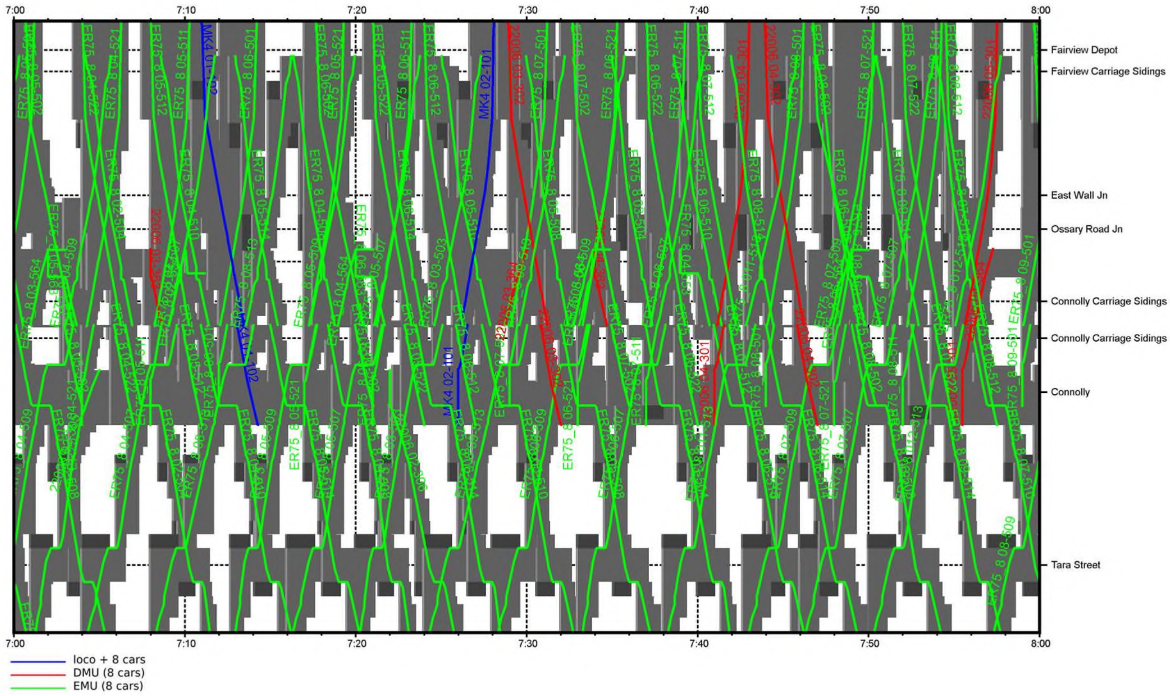


Figure 39 Train diagram Coastal Line through Connolly - peak hour

It may be seen that much better regularity of services is kept on the Loop line (line 7, Connolly – Pearse), while there is no transfer between the northern and southern part of the coastal line.

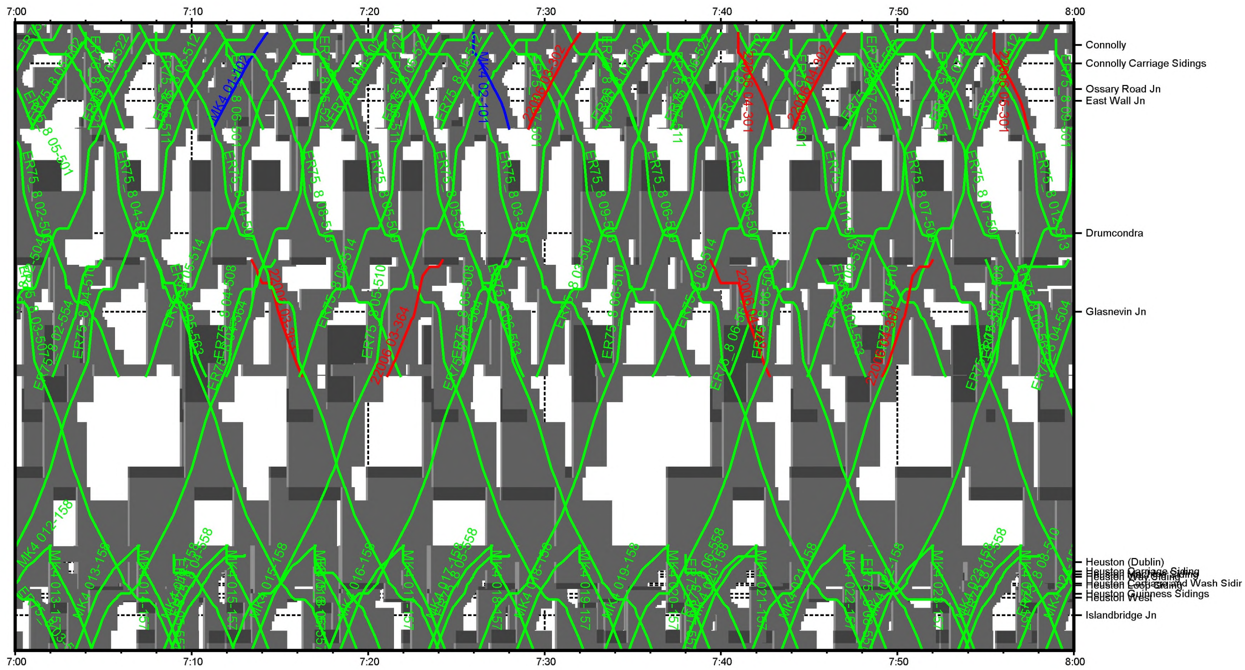


Figure 40 Train diagram line 2 (Connolly – Islandbridge Jct.) - peak hour

This graph shows the impact of splitting PPT and Maynooth line connections at Glasnevin. Train schedule there is dependent to Maynooth line trains going onto line 2 at Glasnevin. Part of line 3 services through Glasnevin Jct. is also shown to indicate potential conflicts – as for some trains crossing between line 2 and 3 conflicts are possible with services continuing on either of those lines.

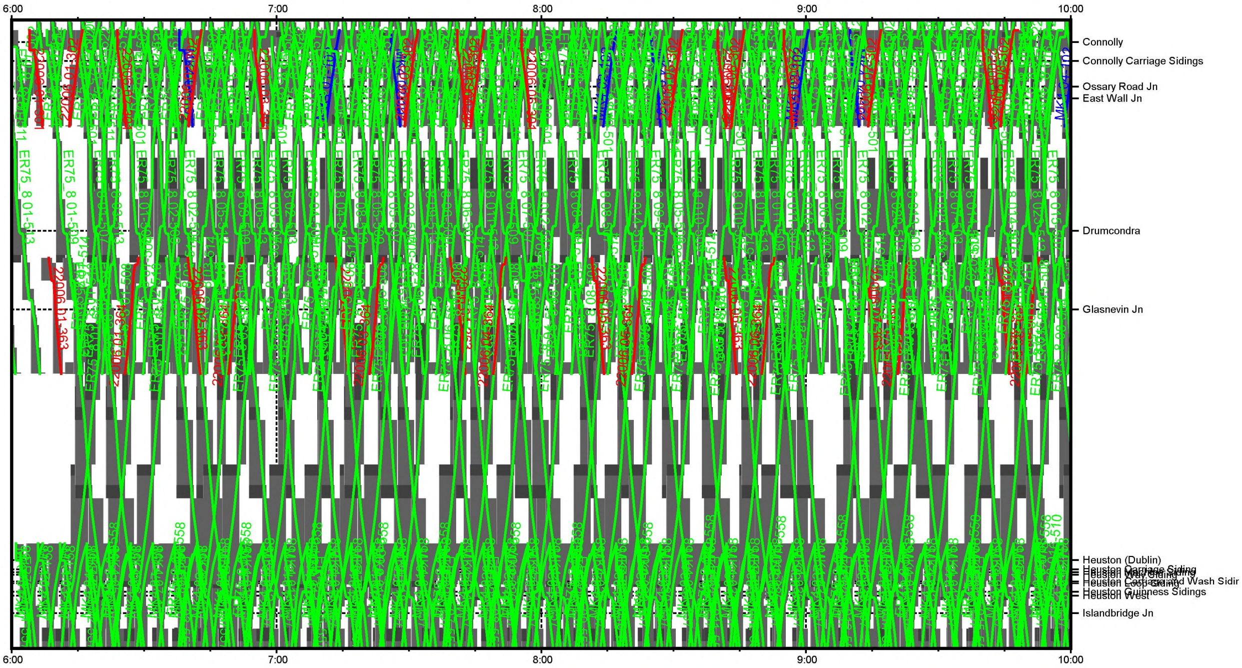


Figure 41 Train diagram - line 2 - 4 hour

Longer perspective schedule can show regularity of connections on line 2.

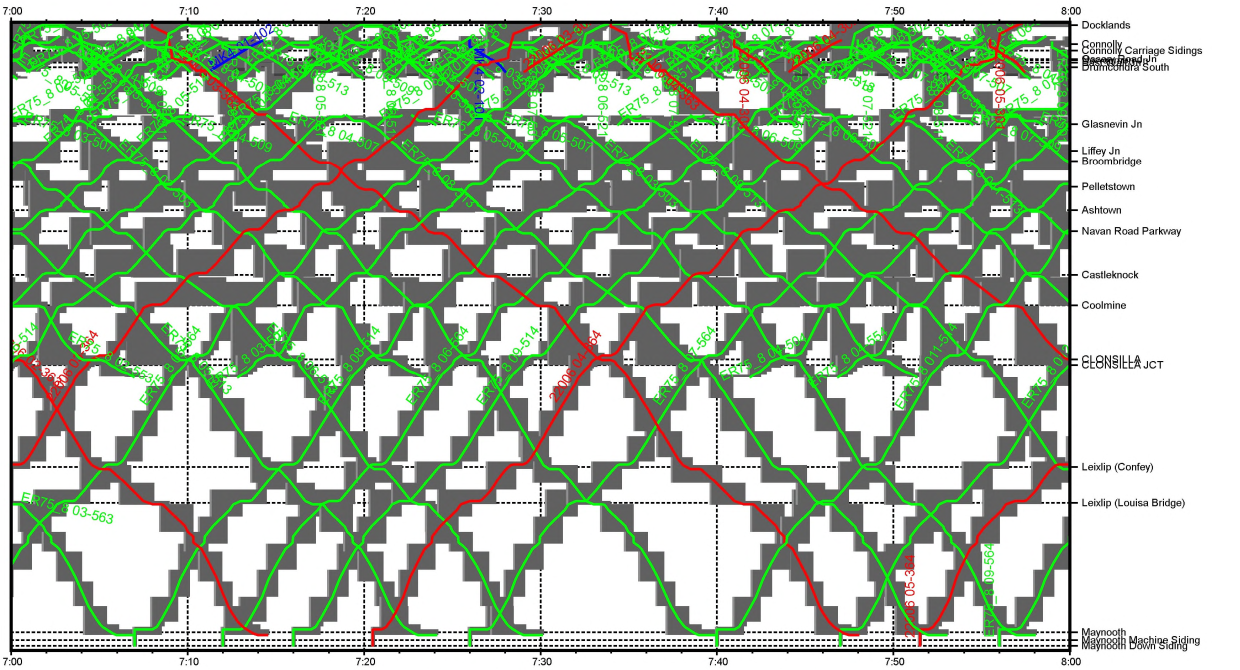


Figure 42 Train diagram Maynooth Line - peak hour

Maynooth line schedule is not substantially different from the one analysed in scenario 1.

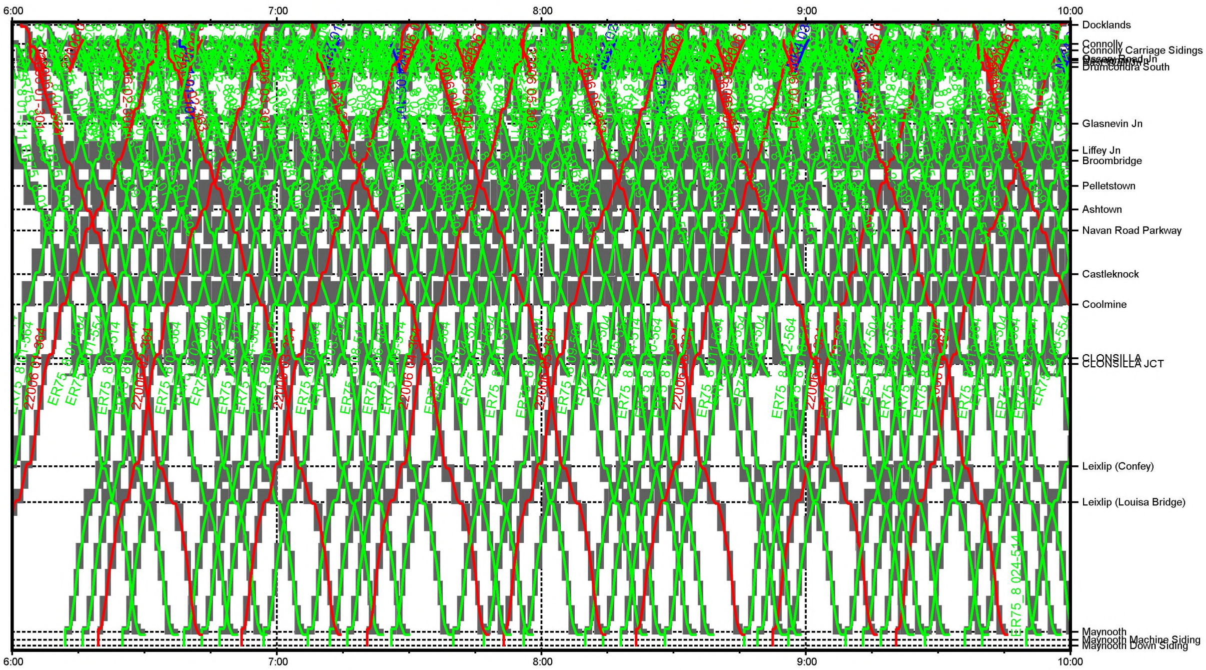


Figure 43 Train diagram Maynooth Line - 4 hour

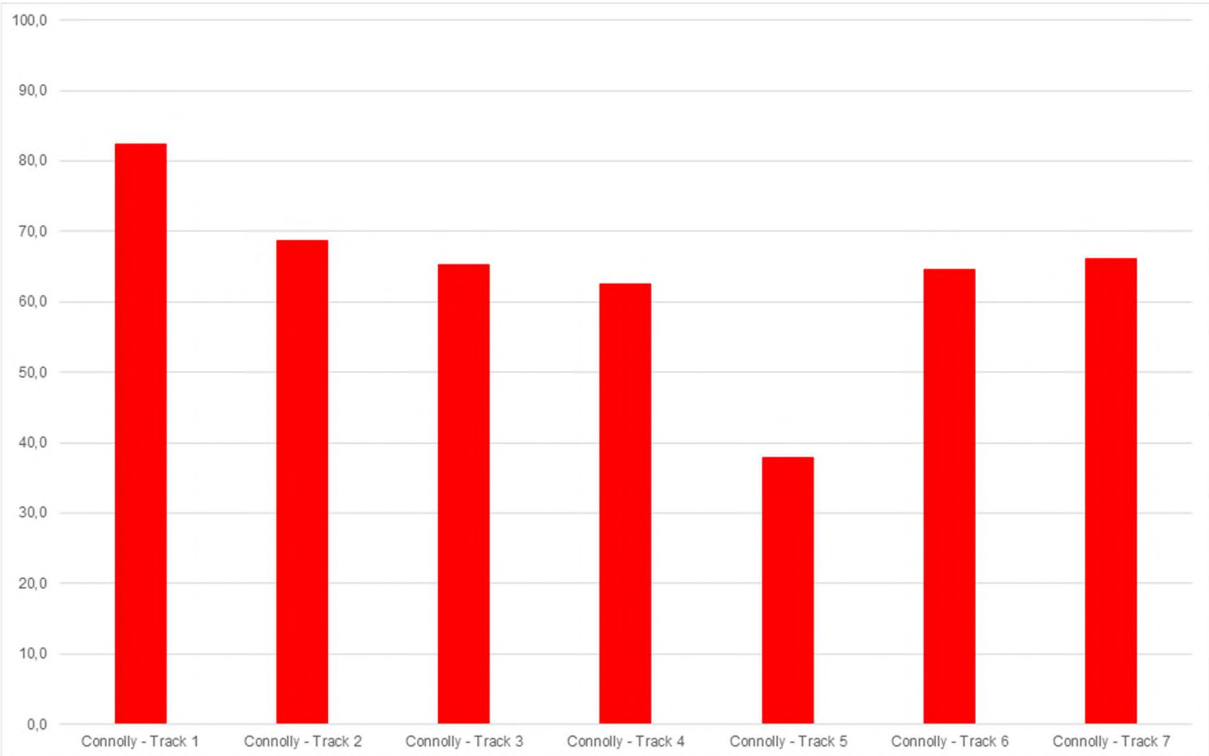


Figure 44 Track occupancy time at Connolly [%]

Connolly station platform track occupancy time shows very high values for terminus tracks, as all northern line services terminate there and in case of some of them (like Enterprise services to Belfast) track occupancy is relatively long. Same as in other scenarios, occupancy of track 5 and 6 should be treated jointly. The sum is higher compared to track occupancy of platform 7 because of terminating train to/from Rosslare (line 7).

Table 21 TSS – Scenario 2

IDOM Initially proposed TSS (for modelling) - option A (West goes South, North terminates)																					
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	M3 Parkway	Maynooth	Connolly	Dun Laoghaire	GCD	Docklands	Docklands	Heuston	Heuston	Maynooth	modelling total amount	planned total amount
train destination			Connolly	Connolly	Connolly	Connolly	Connolly	Greystones	Bray	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands		
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU		
Line no.	From	To						via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra							
	Connolly	East Wall Jct.	2	1	4	4	4											15	15
	East Wall Jct	Howth Jct.	2	1	4	4	4											15	15
	Howth Jct.	Clongriffin	2	1	4	4												11	11
1	Clongriffin	Malahide	2	1	4	4												11	11
	Malahide	Balbriggan	2	1	4													7	7
	Balbriggan	Drogheda	2	1	4													7	7
	Drogheda	Dundalk (Belfast)	2	1														3	3
1a	Howth Jct.	Howth					4											4	4
	Connolly	North Strand Jct.						2	4		4	4						14	16
2	North Strand Jct.	Glasnevin Jct.						2	4		4	4						14	16
	Glasnevin Jct.	Islandbridge Jct.									4	4						8	8
	Docklands	Newcomen Jct.											2	2			3	7	8
	Newcomen Jct.	Glasnevin Jct.											2	2			3	7	8
3	Glasnevin Jct.	Clonsilla						2	4				2	2			3	13	16
	Clonsilla	Maynooth							4					2			3	9	12
	Maynooth	Longford (Sligo)												2				2	2
3a	Connolly	Newcomen Jct.																0	0
4	Clonsilla	M3 Parkway						2					2					4	4
	Heuston	Islandbridge Jct .													12			12	12
5 (fast)	Islandbridge Jct.	Park West													12			12	12
	Park West	Hazelhatch													12			12	12
	Hazelhatch	Kildare													12			12	12
	Heuston	Islandbridge Jct .														4		4	4
6 (slow)	Islandbridge Jct.	Park West									4	4				4		12	12
	Park West	Adamstown									4	4				4		12	12
	Adamstown	Hazelhatch									4	4				4		12	12
	Connolly	Pearse						2	4	1	4	4						15	17
	Pearse	Grand Canal Dock						2	4	1	4	4						15	17
7	Grand Canal Dock	Dun Laoghaire						2	4	1	4							11	13
	Dun Laoghaire	Bray						2	4	1								7	9
	Bray	Greystones						2		1								3	3
	Greystones	Wicklow (Rosslare)								1								1	1
9	East Wall Jct	Docklands																0	0

IDOM Initially proposed TSS (for modelling) - option A (West goes South, North terminates)																		
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	M3 Parkway	Maynooth	Connolly	Dun Laoghaire	GCD	Docklands	Docklands	Heuston	Heuston	Maynooth	modelling total amount	planned total amount
train destination			Connolly	Connolly	Connolly	Connolly	Connolly	Greystones	Bray	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands		
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU		
Line no.	From	To						via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra							
9a	North Strand Jct.	Docklands																0	0
Stops			Dundalk-Malahide: all; Malahide - Connolly: nonstop	Drogheda	all	all	all	all	all	Tara, Pearse, GCD, Dun Laoghaire, Bray	all	all	all	all	Hazelhatch	all	all		

		Reduction							-2								-1		

The row “Reduction” presented above represents the number of trains that has to be removed from TSS, because of insufficient capacity.

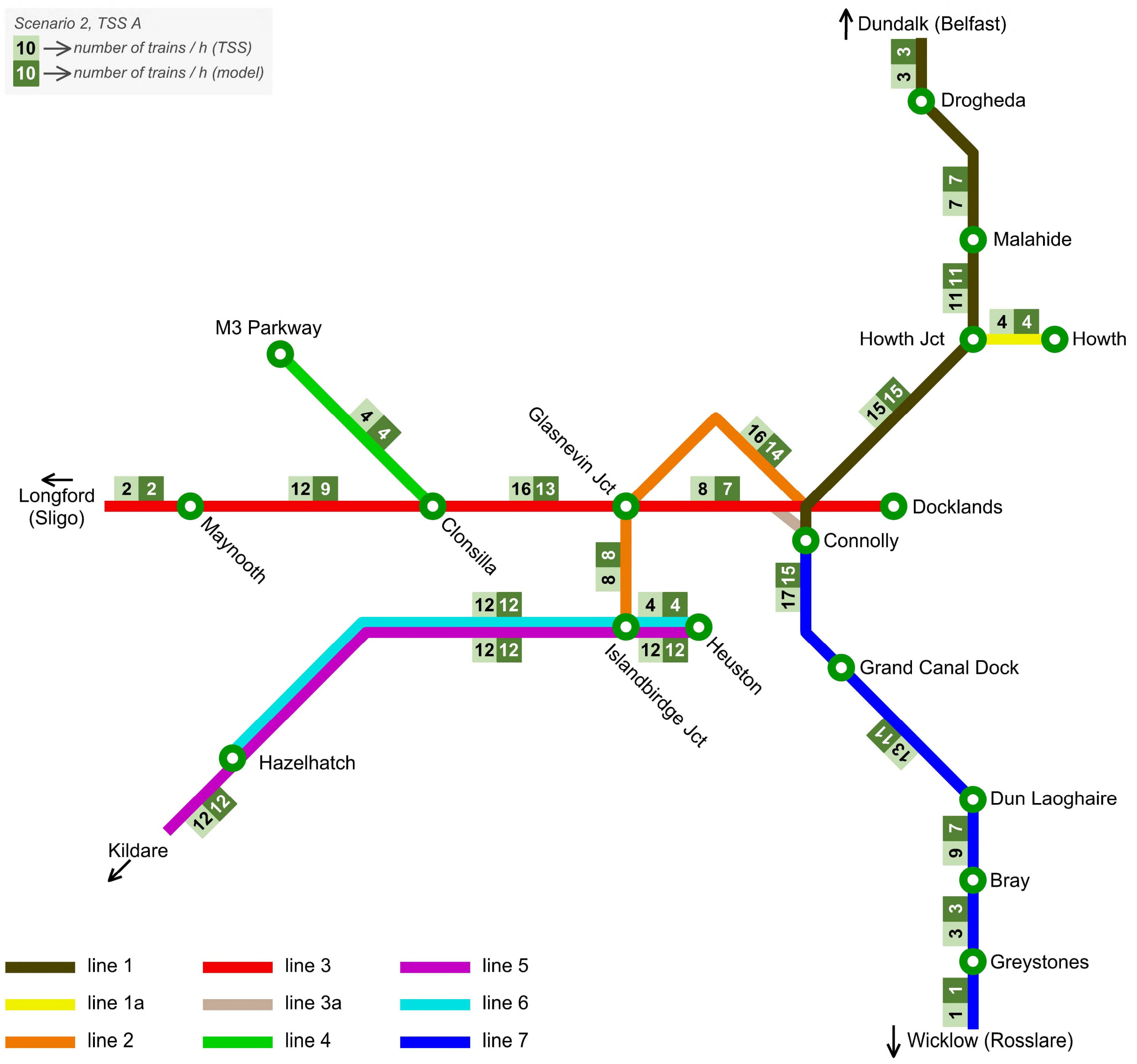


Figure 45 TSS for the DART network in Scenario 2

Scenario 2 offers the lowest reductions compared to the original (adjusted) TSS. The main problem of the network is the Glasnevin Jct. and it required lowering the number of trains going from Maynooth through Glasnevin Jct. (2 to Bray and 1 to Docklands). Service reduction on line 7 on Grand Canal Dock – Bray segment can be substituted by extending some of the services from GCD to Bray.

6.2.3 Scenario 3 – reconstruction of the Connolly northern throat - mixed traffic with Maynooth trains terminating at Connolly

This scenario envisages severe changes in the infrastructure of the Connolly station – new overbridge linking line 2 with terminus tracks.

TSS (version IDOM B) provides for the general pattern of servicing the coastal line (line 1 and 7) by through services and terminating services from the west (lines 2 and 3) at Connolly. However, since some of the services from the north (long-distance) have to terminate at Connolly as well, some services from the west need to replace them t offer an adequate service level on line 7, south of Connolly. In those aspects, the TSS IDOM B comes closer to “mixed service” TSS IDOM C. In the preparatory stage it was adjusted, so conflicts at Glasnevin are eliminated, but that is done at the cost of a higher number of interchanges and reduction of the number of services on Maynooth line due to Docklands station limitations.

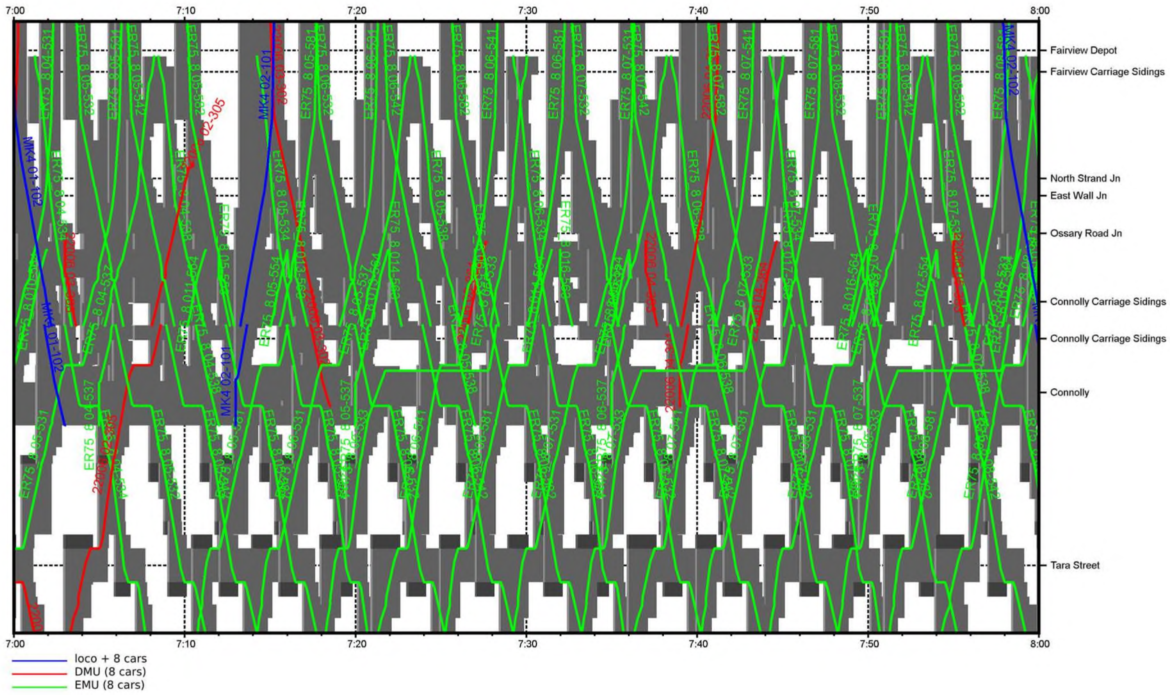


Figure 46 Train diagram - Coastal Line through Connolly - peak hour

North-South traffic through Connolly with the general pattern of servicing the south by trains coming from the north (with support from the west) gives, in general, an adequately frequent timetable.

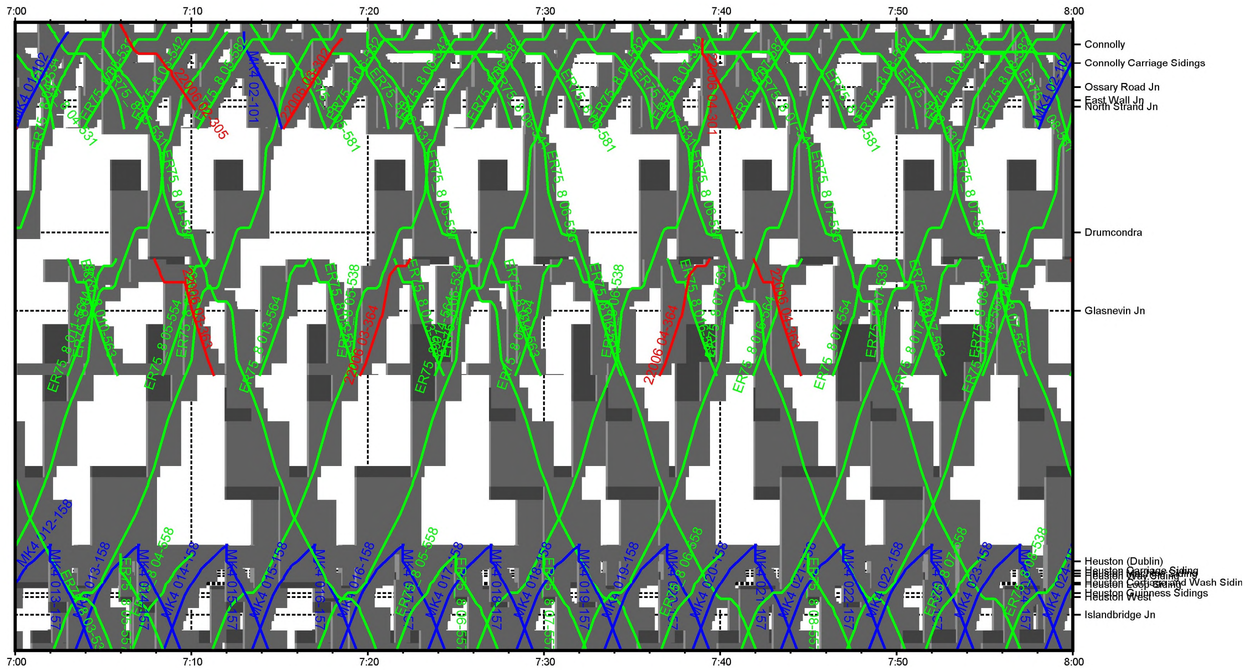


Figure 47 Train diagram – line 2 - peak hour

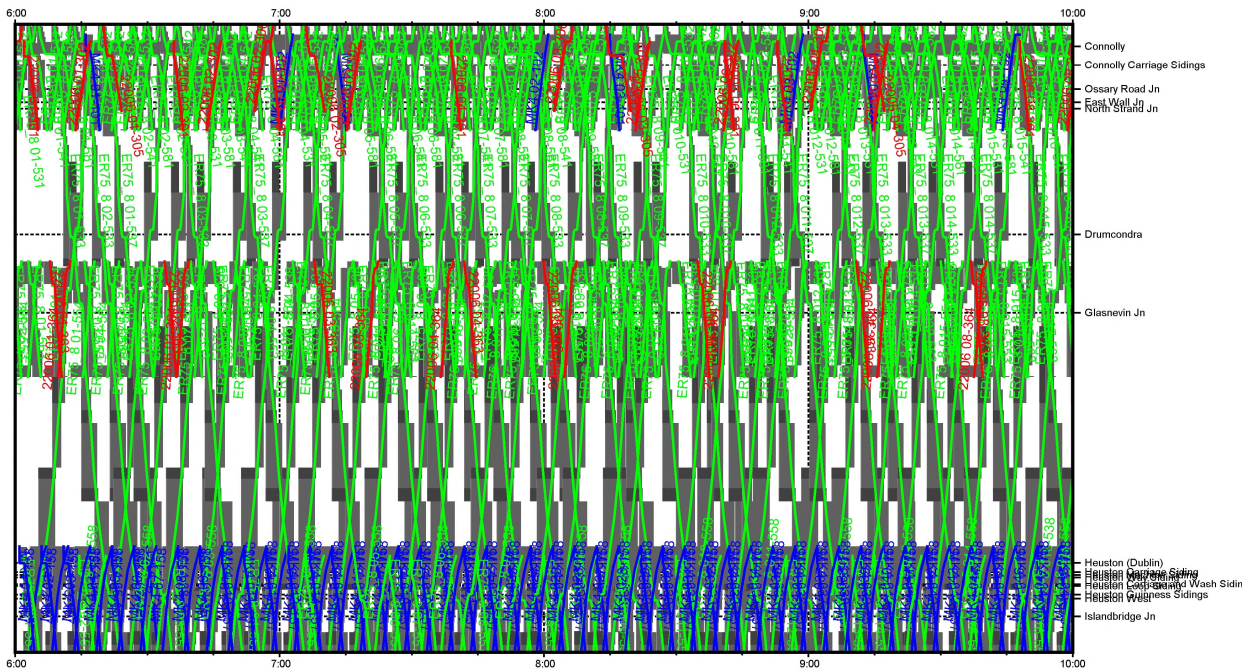


Figure 48 Train diagram - line 2 - 4 hours

Since conflicts at Glasnevin were eliminated in adjusted TSS; services on line 2 are much more regular but, at the same time, less frequent.

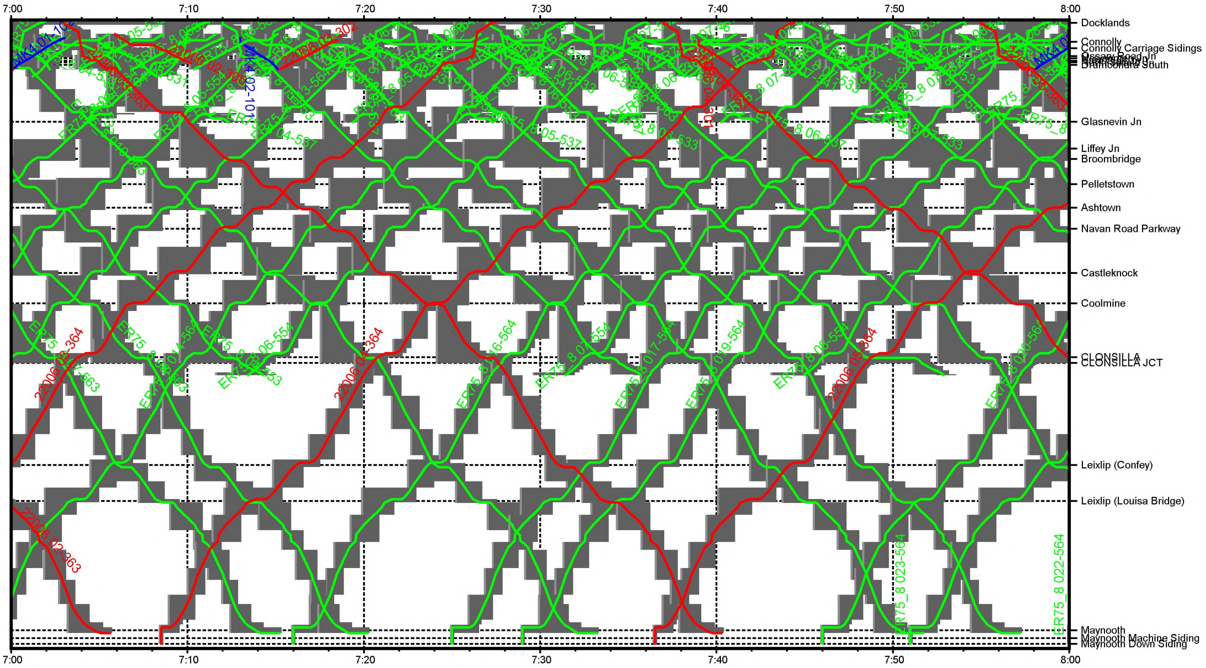


Figure 49 Train diagram - Maynooth Line - peak hour

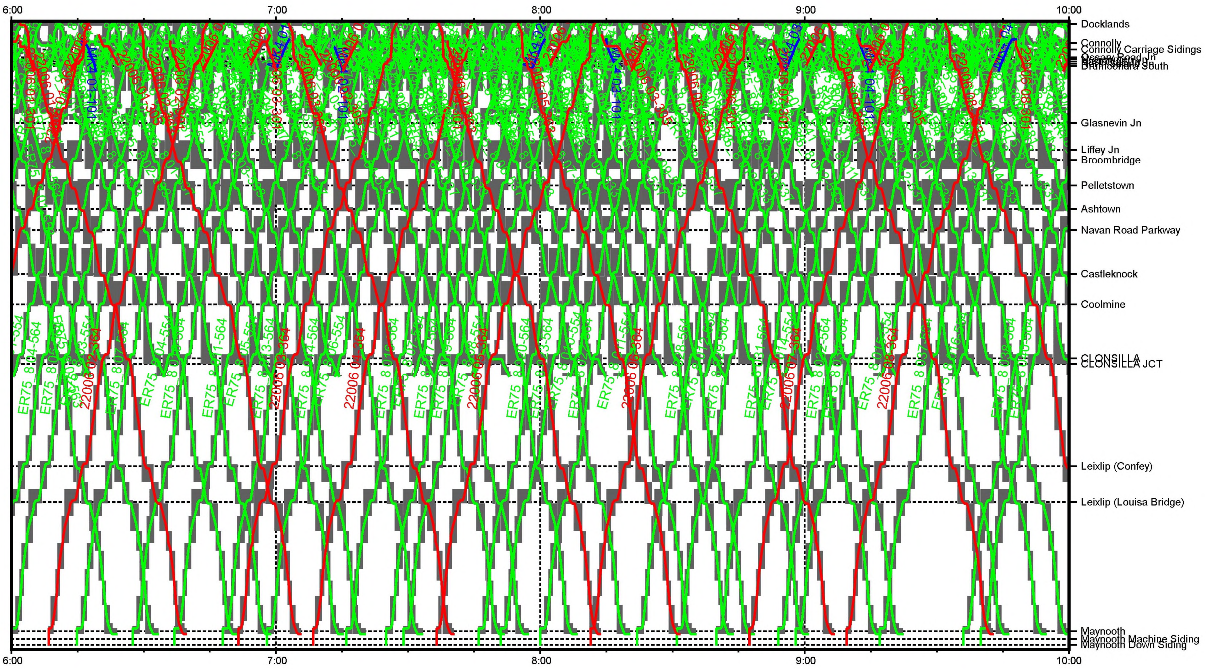


Figure 50 Train diagram - Maynooth Line - 4 hour

Similarly to line 2, line 3 has a better regularity, but worse frequency, which is constrained by the limited capacity of the Docklands station and elimination of additional trains being supplied from line 2 at Glasnevin.

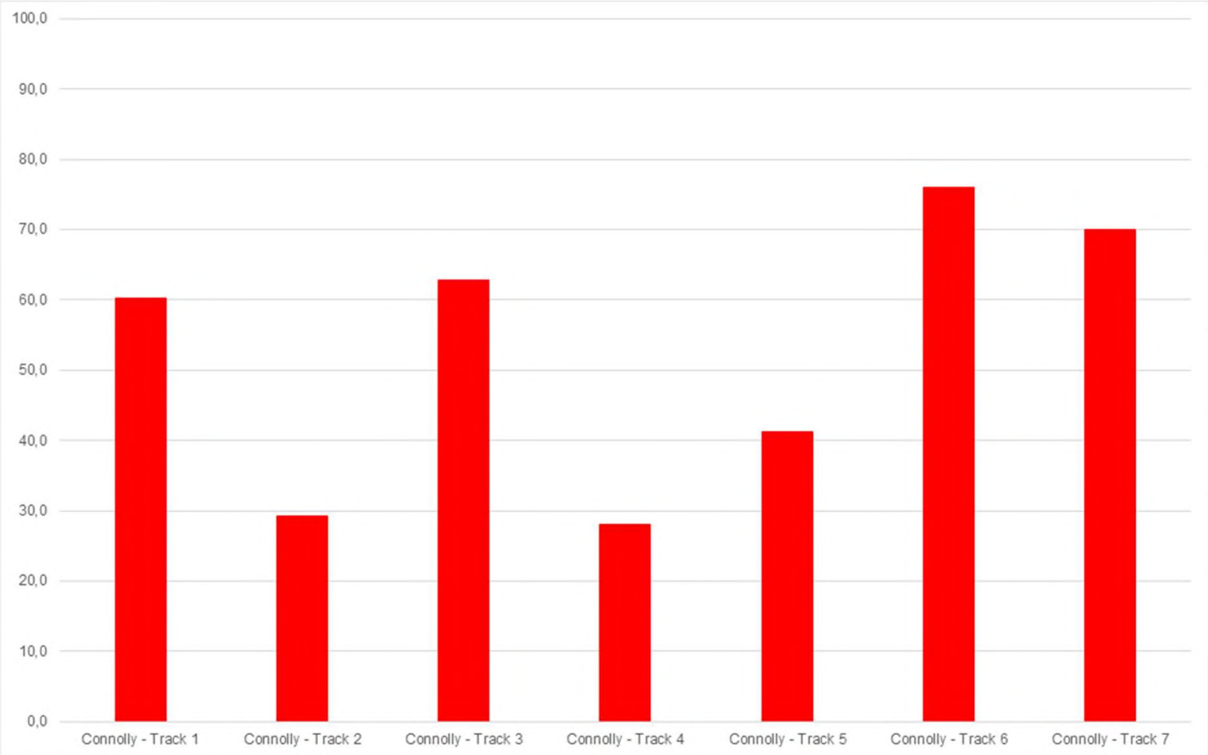


Figure 51 Track occupancy time at Connolly [%] (peak hour)

Connolly station track use is lower compared to other options, as less trains are terminating. Line 1 trains were all, but long-distance sent south, while there is a limited number of trains arriving from line 2 and terminating, as part of them needs to be also sent further south.

Table 22 TSS – Scenario 3

IDOM Initially proposed TSS (for modelling) - option B (North goes South, West terminates at Connolly or Docklands)																			
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	Connolly	Connolly	Connolly	GCD/Connolly	Docklands	Docklands	Docklands	Heuston	Heuston	Maynooth	modelling total amount	TSS planned total amount
train destination			Connolly	Connolly	Bray	Dun Laoghaire	Bray/Greystones	M3 Parkway	Maynooth	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands		
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU		
Line no.	From	To						via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra							
	Connolly	East Wall Jct.	2	1	3	4	3											13	15
	East Wall Jct	Howth Jct.	2	1	3	4	3											13	15
	Howth Jct.	Clongriffin	2	1	3	4												10	11
1	Clongriffin	Malahide	2	1	3	4												10	11
	Malahide	Balbriggan	2	1	3													6	7
	Balbriggan	Drogheda	2	1	3													6	7
	Drogheda	Dundalk (Belfast)	2	1														3	3
1a	Howth Jct.	Howth					3											3	4
	Connolly	North Strand Jct.									4							4	8
2	North Strand Jct.	Glasnevin Jct.									4							4	8
	Glasnevin Jct.	Islandbridge Jct.									4							4	8
	Docklands	Newcomen Jct.											3	2			6	11	16
	Newcomen Jct.	Glasnevin Jct.											3	2			6	11	16
3	Glasnevin Jct.	Clonsilla											3	2			6	11	16
	Clonsilla	Maynooth												2			6	8	12
	Maynooth	Longford (Sligo)												2				2	2
3a	Connolly	Newcomen Jct.																0	0
4	Clonsilla	M3 Parkway											3					3	4
	Heuston	Islandbridge Jct .													12			12	12
5 (fast)	Islandbridge Jct.	Park West													12			12	12
	Park West	Hazelhatch													12			12	12
	Hazelhatch	Kildare													12			12	12
	Heuston	Islandbridge Jct .														4		4	4
6 (slow)	Islandbridge Jct.	Park West									4					4		8	12
	Park West	Adamstown									4					4		8	12
	Adamstown	Hazelhatch									4					4		8	12
	Connolly	Pearse			3	4	3			1	2							13	17
	Pearse	Grand Canal Dock			3	4	3			1	2							13	17
7	Grand Canal Dock	Dun Laoghaire			3	4	3			1								11	13
	Dun Laoghaire	Bray			3		3			1								7	9
	Bray	Greystones					2			1								3	3

IDOM Initially proposed TSS (for modelling) - option B (North goes South, West terminates at Connolly or Docklands)																			
train origin			Dundalk	Belfast	Drogheda	Malahide	Howth	Connolly	Connolly	Connolly	GCD/Connolly	Docklands	Docklands	Docklands	Heuston	Heuston	Maynooth	modelling total amount	TSS planned total amount
train destination			Connolly	Connolly	Bray	Dun Laoghaire	Bray/Greystones	M3 Parkway	Maynooth	Rosslare	Hazelhatch	Hazelhatch	M3 Parkway	Sligo	country	Hazelhatch	Docklands		
type			DMU	loco	EMU	EMU	EMU	EMU	EMU	DMU	EMU	EMU	EMU	DMU	DMU/loco	EMU	EMU		
Line no.	From	To						via Drumcondra	via Drumcondra		via Drumcondra	via Drumcondra							
	Greystones	Wicklow (Rosslare)								1								1	1
9	East Wall Jct	Docklands																0	0
9a	North Strand Jct.	Docklands																0	0
Stops			Dundalk-Malahide: all; Malahide-Connolly: nonstop	Drogheda	all	all	all	all	all	Tara, Pearse, GCD, Dun Laoghaire, Bray	all	all	all	Drumcondra South, Glasnevin, Broombridge	Hazelhatch	all	all		
Reduction					-1		-1				-4 / -2		-1				-4		

The row "Reduction" presented above represents the number of trains that has to be removed from TSS, because of insufficient capacity.

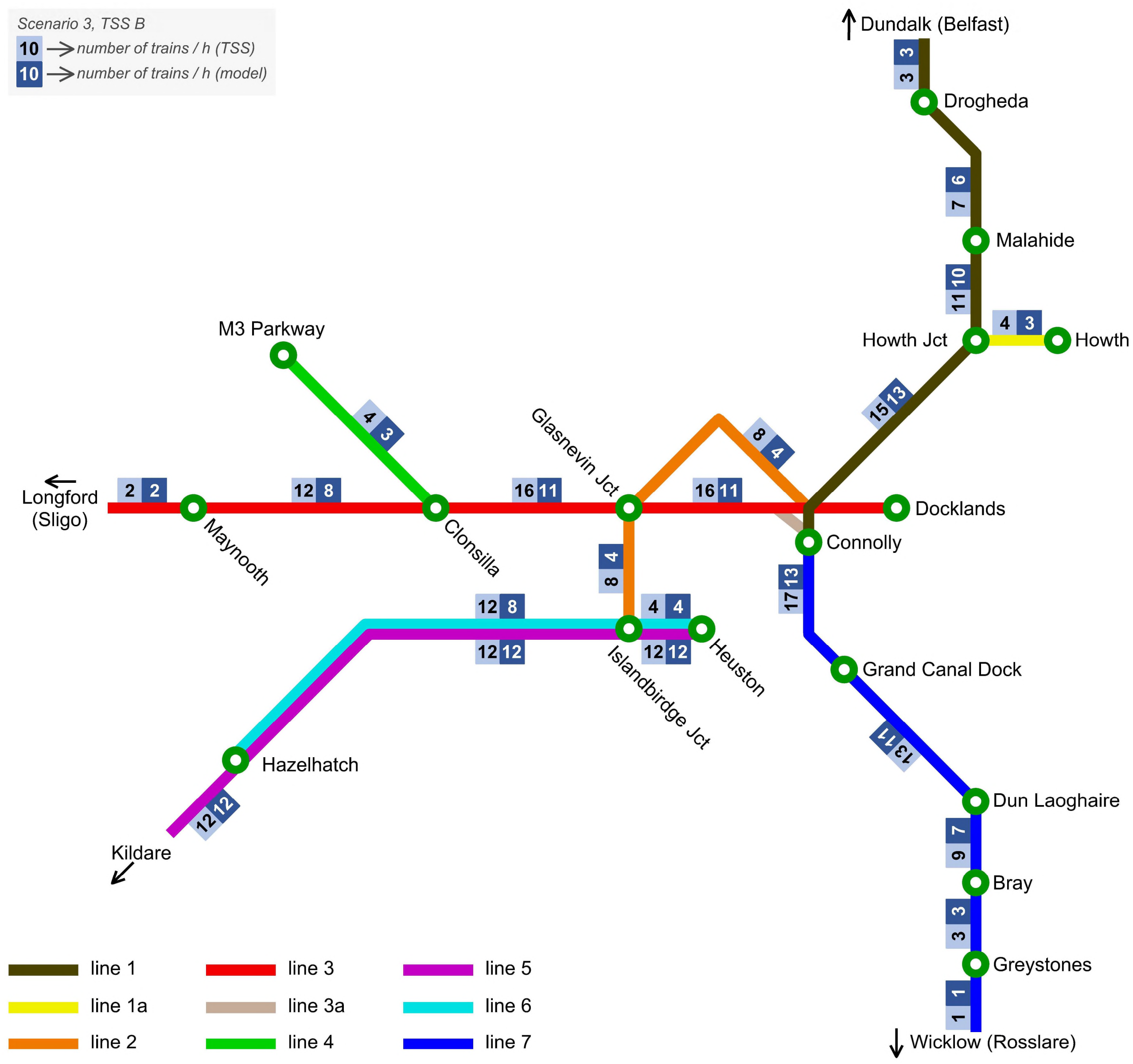


Figure 52 TSS for Scenario 3

Scenario 3 modelling results show substantial reductions in services. Line 3 is to have its services reduced because of the limited capacity of Docklands station. Since no "mixing of traffic" at Glasnevin is envisaged, reduction at Docklands entails a reduction of the number of Maynooth and M3 Parkway services. As Connolly track layout is designed for termination, not continuation of services to the west (line 2) it needs to have the number of services reduced because despite the overbridge there are conflicts between the coastal line services and line 2 services going south.

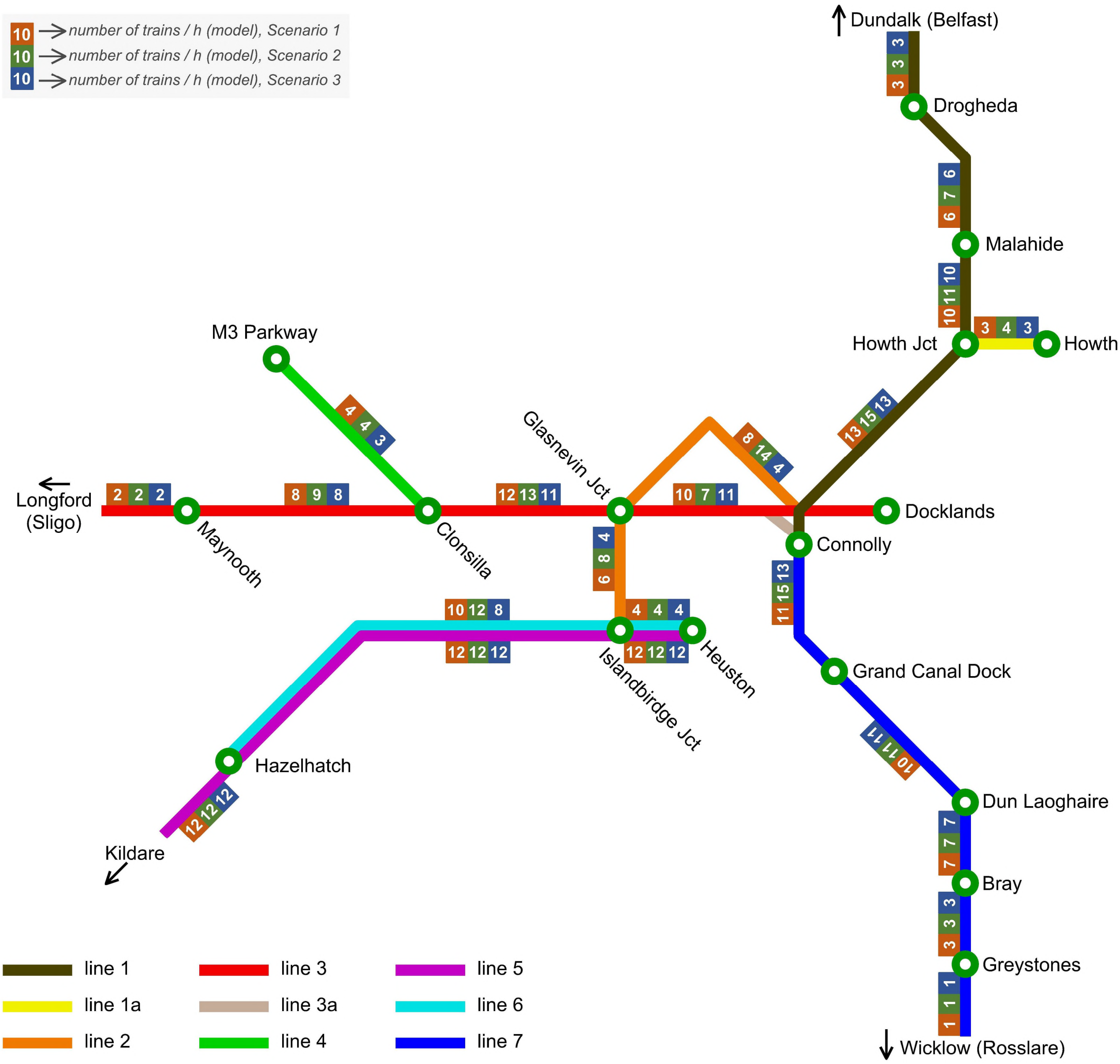
6.3 Modelling conclusions

General conclusions:

1. Increasing number of trains and setting flexible timetable at lines involving Connolly and Docklands requires reconfiguration of the Glasnevin Junction.

2. All timetable/capacity problems solved at Connolly and Docklands or through the division between them might be transferred to Glasnevin Junction and North Strand Junction (if line 9a is used – scenario 1, TSS IDOM C). Taking regard to their limited capacity scale of transferring the problems should be limited.
3. There is a tendency that more terminating trains from line 1 (north) compared to trains continuing south from line 1 means less traffic conflicts.
4. Stopping services on the Maynooth line do not exceed the speed of 90 km/h. Introduction higher speeds for long-distance services will lower the overall capacity of the line because of signalling/block sections division and practical low chance to utilise the higher speed by some trains.
5. Usage of two alternative routes from Docklands to Glasnevin (line 3 or line 9a and 2) in case trains are to be directed onto one line west of Glasnevin is not justified – because of different journey times trains are likely to block one another at Glasnevin; additional location of potential conflicts is added at North Strand Jct.
6. Capacity at Docklands is limited not by number of platforms, but by track layout and its capacity – especially by same grade crossovers and switches on station throats.
7. The more traffic is mixed, the lower the general capacity of the system is – because trains from different lines bring disturbances and limitations onto other services. As regards timetabling, different frequencies on different lines cause negative elimination of trains on junctions (combined frequency may be worse than the frequency of the less frequent of two combined services).
8. Special attention was paid to long-distance trains (DMUs) on Docklands - Sligo route, that run on the same route with slower EMU trains. To increase the line capacity, additional stops were added for the long-distance service.
9. Robustness of the timetable is highest when services on several lines are possibly not interconnected operationally.
10. Comparison of traffic and infrastructure scenarios shows the best modelling results for scenario 2. There is the lowest scale of necessary reductions compared to the original TSS (each TSS provided

for same number of trains on each section) – see figure:



11. Figure 53 Comparison of RailSys modelling Scenarios 1, 2, 3

Scenario 1:

1. Connolly station was characterized by the occurrence of many train path conflicts, which mainly involved trains starting and terminating at this station.
2. The total number of trains operating at peak hours at Connolly station was lower than in scenario 2.
3. The DMU trains on the Connolly - Rosslare service have been moved to the free track 5 at Connolly station (southbound traffic operated via track 6). Those trains caused many conflicts, however, after moving to track 5, the station capacity improved significantly.
4. The most problematic section was the section from Connolly to Glasnevin and the adjacent lines.
5. Critical problem of the railway junction is generated by many conflicting train paths with limited track layout:
    a. Train paths conflicts are generated on the northern throat of Connolly, at Glasnevin and North Strand Jct.

b. The main capacity limitation is at Glasnevin - trains running from Islandbridge Jct. conflicting with trains running from Clonsilla (line 3), passing through Glasnevin and further line 2.

Scenario 2:

1. In this scenario, the total number of trains running in peak hours at this station was the highest out of all modelled scenarios.
2. Connolly station northern throat conflicts were eliminated.
3. Many conflicts have also been reported on the Glasnevin – Clonsilla section – it was necessary to reduce the number of trains compared to the initial TSS.
4. Docklands station causes capacity issues even when equipped with 5 platform tracks – same grade crossovers at the station throat do not allow for very frequent traffic. This will be further investigated when detailed design might be prepared.
5. The main problem occurs in both directions with trains changing lines (from North Strand – line 2 – towards Clonsilla – line 3).
6. The DMU trains on the Connolly - Rosslare service have been moved to the free track 5 at Connolly station (southbound traffic operated via track 6). Those trains caused many conflicts; however, after moving to track 5, the station capacity improved significantly.

Scenario 3:

1. Docklands station causes capacity issues even when equipped with 5 platform tracks – same grade crossovers at the station throat do not allow for very frequent traffic. This will be further investigated when detailed design might be prepared.
2. It does not seem possible to build a "pure" scenario where trains from north run south and trains from the west terminate – because the demand and capacity south of Connolly are higher than on the northern line, services coming from the north need to be supported by trains arriving from line 2. At the same time, some of the services from the north need to terminate, and in result, the traffic scenario is more or less "mixed".
3. Crossing train paths at various routes at Connolly and the adjacent station. Crossing train paths at Connolly north throat are less problematic than in 'do minimum' infrastructure Scenarios 1 and 2. Still, those train path conflicts also occur - especially between trains running towards line 2 from line 7 with services running from line 1 onto line 7.
4. In this scenario, DMU operated long-distance services from the Connolly - Rosslare route are sent to the Fairview Depot for turn back, as it caused fewer conflicts compared to turn back on track 5 or 6 of the Connolly station.

7. Multi-criteria analysis

7.1 Selection of criteria

The criteria list was elaborated following the previously prepared and shared with IÉ for the level crossing assessment. There are 6 main parameters (groups of criteria):

- Economy
- Integration
- Environment
- Accessibility and Social inclusion
- Safety
- Physical Activity

The operation plan consists of many characteristics of the railway infrastructure in different scenarios with the assumed operational skims design for each infrastructure scenario. The multi-criteria analysis main goal is to compare those characteristics for each scenario. The list of characteristics was elaborated to present as many possible characteristics as possible and to keep those characteristics independent to each other.

The comparison was made between considering the following evaluation scale:

Table 23. Evaluation scale

Significant comparative advantage over other scenarios
Some comparative advantage over other scenarios
Comparable to other scenarios
Some comparative disadvantage over other scenarios
Significant comparative disadvantage over other scenarios

7.2 Assessment of options

The table at the following pages includes all the parameters with their criteria for all scenarios.

DART Maynooth & City Centre Enhancements. MCA Criteria and parameters							
Operational scenario Assessment							
	Parameter		Criteria	Sub-Criteria (Quantitative Qualitative)	Scenario 1	Scenario 2	Scenario 3
1	Economy	1.1	CAPEX - Railway infrastructure	Estimated cost of all railway infrastructure (excluding utilities reconstruction and construction or reconstruction of big engineering objects like: bridges, canals, viaducts etc.)	**Some comparative advantage over other scenarios** The infrastructure scenario "do minimum" has lower capital expenditures on the tracks and track devices. The improvements and modernization of the line has still significant costs	**Some comparative advantage over other scenarios** The infrastructure scenario "do minimum" has lower capital expenditures on the tracks and track devices. The improvements and modernization of the line has still significant costs	**Some comparative disadvantage over other scenarios** The track layout in the scenario with overbridge is slightly more expensive in case of tracks and track turnovers. The major increase of capital costs is related to the overbridge reconstruction
		1.2	Viaducts, Bridges	Estimated cost	**Some comparative advantage over other scenarios** The infrastructure scenario "do minimum" has lower capital expenditures on the tracks and track devices. The improvements and modernization of the line has still significant costs	**Some comparative advantage over other scenarios** The infrastructure scenario "do minimum" has lower capital expenditures on the tracks and track devices. The improvements and modernization of the line has still significant costs	**Significant comparative disadvantage over other scenarios** The scenario includes the reconstruction of 500-meter overbridge at the northern throat of Connolly and adjustment of the horizontal geometry of the line
		1.3	Utilities conflicts	Estimated cost	**Some comparative advantage over other scenarios** Utilities conflict cost for infrastructure "do minimum" scenario are similar in Scenario 1 and Scenario 2, it is not clear how many utilities will be affected in Scenario 3 at this phase, but there is a significant risk that utilities conflict cost will be higher in scenario 3	**Some comparative advantage over other scenarios** Utilities conflict cost for infrastructure "do minimum" scenario are similar in Scenario 1 and Scenario 2, it is not clear how many utilities will be affected in Scenario 3 at this phase, but there is a significant risk that utilities conflict cost will be higher in scenario 3	**Some comparative disadvantage over other scenarios** Utilities conflict cost for infrastructure "do minimum" scenario are similar in Scenario 1 and Scenario 2, it is not clear how many utilities will be affected in Scenario 3 at this phase, but there is a significant risk that utilities conflict cost will be higher in scenario 3
2	Integration	2.1	number of train paths conflicts	Number of train paths potential conflicts at Connolly Station and in its proximity (adjacent junctions). Conflicting paths are counted as ones that involve trains from two directions or crossing paths (not following same tracks to the switch)	**Significant comparative disadvantage over other scenarios** In Scenario 1 the number of train path conflicts is significantly higher than in other Scenarios. With such a number of Train Path conflicts it is impossible to implement the assumed TSS	**Significant comparative advantage over other scenarios** Number of train path conflicts is lowest in the second scenario	**Some comparative advantage over other scenarios** The Scenario with overbridge has significantly less train path conflicts than Scenario 1. Still some train path conflicts limits the capacity of the railway junction
		2.2	capacity of Connolly Station	Total number of trains served in peak hour (with assumed operational skim)	**Some comparative disadvantage over other scenarios** Capacity estimated at 22 trains	**Significant comparative advantage over other scenarios** Capacity estimated at 30 trains	**Some comparative advantage over other scenarios** Capacity estimated at 22 trains
		2.3	reserves at Connolly station	Used operational reserves on terminating tracks at Connolly (platforms 1-4)	**Comparable to other scenarios** The operational reserves is estimated at 2 trains	**Comparable to other scenarios** The operational reserves is estimated at 1 train	**Some comparative advantage over other scenarios** The operational reserves is estimated at 5 trains
		2.4	capacity of Maynooth line	Total number of trains served in peak hour (with assumed operational skim); counted on Glasnevin - Clonsilla section	**Comparable to other scenarios** Scenario 1 places in between other scenarios as regards offer on this segment	**Some comparative advantage over other scenarios** Separation of traffic at Connolly gives opportunity to run the highest number of trains at the Maynooth line	**Some comparative disadvantage over other scenarios** Separation of traffic at Glasnevin with limited capacity of Docklands enables for lowest number of connections

DART Maynooth & City Centre Enhancements. MCA Criteria and parameters							
Operational scenario Assessment							
	Parameter		**Criteria**	**Sub-Criteria (Quantitative Qualitative)**	**Scenario 1**	**Scenario 2**	**Scenario 3**
		2.5	Resistance for delays; time table robustness	Resistance for delays is the element of well design railway system. In case of the timetable with small reserves and many train paths conflicts, delay of the single train can cause serious disturbances in the network	**Significant comparative disadvantage over other scenarios** The timetable robustness depends on time reserves for each train and on the train dependencies. In Scenario 1 the reserves are limited to minimum and the number of train path conflicts is significant	**Significant comparative advantage over other scenarios** In scenario 2 the robustness of the timetable and train operation is higher compared to scenario 1 and 3.	**Some comparative advantage over other scenarios** In scenario 3 the robustness of the timetable and train operation is moderate, although better compared to scenario 1.
		2.6	Adaptability in the future	Reflecting adaptability potential for future needs	**Some comparative advantage over other scenarios** The development of DART Underground will reduce de demand for capacity at the north throat of Connolly thus it will solve the current problems	**Some comparative advantage over other scenarios** The development of DART Underground will reduce de demand for capacity at the north throat of Connolly thus it will solve the current problems	**Some comparative disadvantage over other scenarios** After DART underground construction the demand for the train capacity of the northern throat will be reduced so the reconstruction that increase the capacity in Scenario 3 will not be necessary
3	**Environment**	3.1	Land occupation	Square meters of additional land used for new railway infrastructure	**Some comparative advantage over other scenarios** It is assumed that all infrastructure upgrades will happen within the existing railway land plots	**Some comparative advantage over other scenarios** It is assumed that all infrastructure upgrades will happen within the existing railway land plots	**Some comparative disadvantage over other scenarios** During the reconstruction of the overbridge additional land will be necessary to access the adjacent land plots. This temporary land occupation will have significant social impact as some lease contracts will have to be ended and some buildings removed
		3.2	Urban landscape	Impact on the urban landscape	**Some comparative advantage over other scenarios** In Scenario 1 and in Scenario 2 will not impact the urban landscape	**Some comparative advantage over other scenarios** In Scenario 1 and in Scenario 2 will not impact the urban landscape	**Some comparative disadvantage over other scenarios** Reconstruction of the existing overbridge with the change of the vertical profile will have negative impact on the urban landscape
		3.3	Land expropriations	Number of plots/buildings to be expropriated	**Significant comparative advantage over other scenarios** No building expropriation is planned for this Scenario	**Significant comparative advantage over other scenarios** No building expropriation is planned for this Scenario	**Significant comparative disadvantage over other scenarios** Although the planned overbridge is planned within the land plots that belong to the IÉ, for the construction period, it will be necessary to get an access to the land plots adjacent to the upgraded overbridge
		3.4	Similarity in offered services to current schedule (as of 2020)	Number of services that follow same general patterns as in current (2020) timetable, counted with assessment of their importance in traffic.	**Some comparative advantage over other scenarios** Generally yes, although some trains will be redirected to Docklands station	**Some comparative disadvantage over other scenarios** Some trains will end with the same origins and destination, but certain percentage of train will have different destination station (Docklands for the Maynoonth line and Connolly for the line from Malahide)	**Some comparative advantage over other scenarios** Generally yes, although some trains will be redirected to Docklands station
4	**Accessibility & Social inclusion**	4.1	Flexibility of creation different passenger patterns	Possibility of adjustment or change of the operational skim	**Some comparative disadvantage over other scenarios** The in-grade solution at the north throat enables significant change of the operational scheme	**Some comparative disadvantage over other scenarios** The in-grade solution at the north throat enables significant change of the operational scheme	**Some comparative advantage over other scenarios** The additional grade separated connection enables higher flexibility of the operational scheme

DART Maynooth & City Centre Enhancements. MCA Criteria and parameters							
Operational scenario Assessment							
	Parameter		**Criteria**	**Sub-Criteria (Quantitative Qualitative)**	**Scenario 1**	**Scenario 2**	**Scenario 3**
		4.2	Passenger comfort	Offering frequent and cyclic schedule	**Some comparative disadvantage over other scenarios**	**Some comparative advantage over other scenarios**	**Comparable to other scenarios**
					Cyclic of the schedule is similar in all 3 scenarios. The offered frequency is lowest in Scenario 1	Cyclic of the schedule is similar in all 3 scenarios. The offered frequency of the departure is the highest	Cyclic of the schedule is similar in all 3 scenarios.
		4.3	Number of peak-hour 1-change services to crucial locations in the city	Convenience of changes to crucial locations of the city (interchange into other means of transport)	**Comparable to other scenarios**	**Some comparative advantage over other scenarios**	**Some comparative advantage over other scenarios**
					The number of connecting trains in Scenario 1 is slightly lower	Due to the highest number of connections the Scenario 2 is better for the interchange into other means of transport	The number of connecting trains in Scenario 2 and Scenario 3 is comparable
5	**Safety**	5.1	General safety	General safety of train operation	**Comparable to other scenarios**	**Comparable to other scenarios**	**Comparable to other scenarios**
					In all Scenarios all safety standard is fulfilled.	In all Scenarios all safety standard is fulfilled.	In all Scenarios all safety standard is fulfilled.
6	**Physical Activity**	6.1	Disturbance during the implementation phase	Limitation of traffic during the reconstruction, the disturbance can vary by capacity limitations, limitation of available train paths and duration of works	**Some comparative advantage over other scenarios**	**Some comparative advantage over other scenarios**	**Significant comparative disadvantage over other scenarios**
					The minor track works in Scenario 1 and Scenario 2 will affect the traffic insignificantly	The minor track works in Scenario 1 and Scenario 2 will affect the traffic insignificantly	In Scenario 3 the traffic disturbances will occur on Maynooth line and Malahide line during the reconstruction of the overbridge and track infrastructure at the north throat of Connolly Station
		6.2	Possibility of accommodating the future DART-Underground into the scheme	Adaptability of the schedule (TSS) to the new development	**Some comparative disadvantage over other scenarios**	**Some comparative advantage over other scenarios**	**Some comparative disadvantage over other scenarios**
					The operation plan will have to be remodelled in the Scenario 1 and Scenario 3	Main west-south train movements is uninterrupted in Scenario 2	The operation plan will have to be remodelled in the Scenario 1 and Scenario 3
		6.3	Avoiding potential future collisions	Number of conflicts of the infrastructure (Docklands area)	**Comparable to other scenarios**	**Comparable to other scenarios**	**Comparable to other scenarios**
					In all Scenarios the number of conflicts is comparable	In all Scenarios the number of conflicts is comparable	In all Scenarios the number of conflicts is comparable

7.3 Comparison of options

To receive the comparison of the scenarios Consultant has given numeric values for each level of the scale presented in the table below. The highest note "Significant comparative advantage over other Scenarios" received 5 points, while the lowest note was given 1, was given to "Significant comparative disadvantage over other scenarios". In the way the total received score was estimated and the average note for each scenario. Those results are presented in the table below.

Table 24. Summary of the MCA

	Scenario 1	Scenario 2	Scenario 3
Scored points	**61**	**74**	**55**
Average note	**3,05**	**3,7**	**2,75**

Scenario 1 and Scenario 2 with the in-grade crossing at the north throat of Connolly Station has significantly better results in the parameters:

- Economy
- Environment
- Physical Activity

In the case of the parameter Integration, Scenario 2 and Scenario 3 have significantly higher evaluation than Scenario 1.

As for the Accessibility & Social inclusion, Scenario 2 has slightly better evaluation than Scenario 1 and Scenario 3.

All scenarios have the same evaluation for Safety.

Table at the next page shows the evaluation for each parameter.

Table 25. Scenarios evaluation aggregated for the parameters

Parameter	Scenario 1	Scenario 2	Scenario 3
Economy	**Some comparative advantage over other scenarios**	**Some comparative advantage over other scenarios**	**Significant comparative disadvantage over other scenarios**
Integration	**Some comparative disadvantage over other scenarios**	**Significant comparative advantage over other scenarios**	**Some comparative advantage over other scenarios**
Environment	**Significant comparative advantage over other scenarios**	**Some comparative advantage over other scenarios**	**Some comparative disadvantage over other scenarios**
Accessibility & Social inclusion	**Some comparative disadvantage over other scenarios**	**Some comparative advantage over other scenarios**	**Some comparative advantage over other scenarios**
Safety	**Comparable to other scenarios**	**Comparable to other scenarios**	**Comparable to other scenarios**
Physical Activity	**Comparable to other scenarios**	**Some comparative advantage over other scenarios**	**Some comparative disadvantage over other scenarios**

When dividing the evaluation into 3 main aspects: operational capacity, social and environmental impact and CAPEX, the results are the following:

Table 26. Simplified evaluation of analysed scenarios

Parameter	Scenario 1	Scenario 2	Scenario 3
Operational Capacity	Significantly lower than in Scenario 2 and Scenario 3	Significantly higher than in Scenario 1 and comparable with scenario 3	Significantly higher than in Scenario 1 and comparable with scenario 2
Social & environmental impact	Very low	Low	Significant
CAPEX	Low	Low	Significant

8. Conclusions and recommendations

A main and crucial aspect of this study is that it has a preliminary character. Its purpose is not to present a detailed future TSS and timetable as well as an answer to all questions related to the future shape of infrastructure, but to direct a decision process as regards the choice of the target shape of train services and adequately modelled infrastructure to meet that target TSS.

It needs to be underlined that it comes out of the study that there is a little chance to accommodate the desired level of services on the current or minimally upgraded infrastructure. It might be very challenging if any of the lines are taken separately; it is almost sure not to succeed if the whole system is viewed at and limitations of particular lines or junctions sum up.

Several infrastructural options described in this document are not entirely universal. They are to match a particular service pattern and may not be entirely adequate for a different train service specification. Attempt to create a possibly fully universal infrastructure would entail a range of works substantially exceeding Option 3 from this document. In a feasible form, likely, it would still not give a full guarantee of avoidance of all conflicts.

8.1 Summary of findings

The main conclusions are the following:

- It is impossible to significantly increase the capacity of the system without TSS adjustment or significant infrastructure upgrade.
- Change of TSS has a slightly higher increase in the capacity than the infrastructure improvements.

8.1.1 Operations – Train services specification

1. Frequent services on same-grade junctions are generally not feasible (with timetabling separation assumption of 3,5 minutes) if the number of tphpd on any of lines with conflicting train paths in any direction exceeds 8.
2. TSS IDOM A (separated traffic, west goes south, north terminates at Connolly) gives best results as regards the achievable number of trains on each section (frequency of services) and the robustness of timetable. It also gives the highest chances to achieve similar results in timetabling. It may be achieved with a “do minimum” option as regards infrastructure.
3. TSS IDOM B (mostly separated traffic, most of the northern line services continue south, supported by some of the services from the west, most of the services from the west terminate at Connolly or Docklands) and TSS IDOM C (mixed traffic, some services from the north and the west terminate, some go south) in case of analysed infrastructure options show very high numbers of train path conflicts that will mean substantial reductions of service levels on all lines compared to expectations.
4. Northern line, as itself, has the low number of trains to secure services on line 7 south of Connolly. That means the necessity to use some of the trains from the west (line 2) to continue south.
5. Use of line 3a (Newcomen spur) may cause several traffic disturbances at Connolly and Newcomen Jct.
6. In all analysed options and later scenarios, Glasnevin Jct. in its shape as per Metrolink project becomes a place of major operational constraints.
7. Long-distance services cause severe disturbances on suburban lines with no traffic separation. Frequent and frequently stopping DART services will have to face cuts if long-distance services operate on the same lines:
    a. in case it is assumed that conditions for passing should be provided and much higher speed is expected for long-distance services it might be necessary to provide a passing loop on every second or third station. At the same time, the frequency of DART services in between fast services may be hindered by the line blockade, designed for higher speeds then achievable for stopping services;
    b. in case fast trains are to fit into the train graph of stopping services – they will create gaps in the cyclic schedule of stopping services unless they stop at all stations; if they just reduce speed following the stopping service at the front of them they will be lagging at block sections, slowing down the stopping service behind them;

c. if it is decided that they stop at all stations in the DART Expansion area; their performance (acceleration, weight, traction characteristics) causes overall lower speed compared to DART EMUs, and in this way, DART train sequence cannot be kept. It results in a lower number of tphpd on lines where long-distance services are present.

8. Docklands station has a limited capacity due to the same grade station throat.

8.1.2 Infrastructure

1. Option “do minimum” is a viable one for Connolly in case the operational scenario (TSS) is aimed at separation of traffic flows from the North (that has to terminate there) and continuing traffic from the west to the south, as it is generally outlined in TSS IDOM A. It is not a solution for mixed traffic at Connolly.
2. “Medium” infrastructure option (Option 2, scenario 3) does not meet all expectations because of a lack of clear operational distinction between western and northern services at Connolly when it comes to termination or continuation. Option 3 (2 overbridges) looks more promising. Still, to avoid all conflicts, it would have to be supported by line 1 (northern) remodelling with possibly one more overbridge, eliminating conflicts between starting and southbound services at line 1.
3. Glasnevin Jct. becomes a crucial location for operations. Its future shape as per Metrolink design does not enable unproblematic operations at high frequencies because of double one grade crossover and number of conflicts between services.
4. Line blockade on line 3 (and possibly also on line 1 and 7 in the future) should be optimised for speeds of stopping services.
5. Line 3a and its usability is questionable and Newcomen Jct. causes several engineering concerns.
6. Line 3 west of Maynooth is not prepared for the service level expected in TSS (not enough capacity).
7. Drumcondra South station on line 3 should work as an alternative to highly used Drumcondra station on line 2 and provide more operational flexibility as regards services to Maynooth or M3 Parkway.
8. At least two turn-back tracks are necessary at Maynooth.

8.2 Recommendations

1. It is recommended to adapt scenario 2 as the only option enabling achievement of relatively high service frequencies and robustness of timetable with the scale of works.
2. A separate study should be carried out on enhancement of railway performance in the Glasnevin Jct. direct proximity. The study should potentially foresee a potential change of driving directions, construction of a new spur or spurs and other measures that can help eliminate some of the conflicts.
3. Docklands station should have access from line 3 (major, with all measures aimed at enhancing the capacity of the station throat) and a secondary one from North Strand Junction (line 9a). Access from line 1 (North) is of lesser importance and can have the service character.
4. Line 3a (Newcomen spur) should be dismantled, while the terrain should be preserved and possibly stabling tracks with access to Connolly station should be located after necessary changes in geometry.
5. Line 3 should be equipped with an additional station (Drumcondra South) that should work as an alternative to highly used Drumcondra station on line 2 and provide more operational flexibility as regards services to Maynooth or M3 Parkway.
6. A separate study should be carried out on enhancement of the capacity of line 3 west of Maynooth. It should take under consideration links with the newly designed Maynooth depot; potential enhancement of the Kilcock station and electrification of the Maynooth – Kilcock section; enhancement of the capacity of the further part of the line.

8.3 Further steps

Once the target scenario is adopted, the following steps will be undertaken:

1. Preparation of a draft adjusted TSS for that scenario.

2. Progress with permanent way and SET design will allow for adjustments to the RailSys infrastructure model for the chosen scenario.
3. Draft timetable proposal will be prepared based on progressing infrastructure design for the city centre and Maynooth lines and verified assessments as regards other lines.
4. Number of trains in operation for each line will be assessed based on the draft timetable.
5. Locations and capacities of stabling (off-peak and overnight) tracks will be determined to ensure unproblematic operations, safe stabling locations and necessary flexibility of services.
6. Assessment of non-passenger operations to/from depots will be prepared.

APPENDIX A. KINEMATIC PARAMETERS AND SPEED OF THE TRACKS

- **Line 3 (Docklands – Newcomen Junction) (Section 1)**

Kinematic parameters and speed of the track No.1 Section 1 are shown in the table below:

Table 27 Existing track No. 1 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.0	0.0					45	40
CLOTH.	0.191					59.16	0	26.47		45	40
ARC	0.251	212	0	125.3	-99.0					45	40
CLOTH.	0.282					53.34	0	26.98		45	40
ARC	0.335	2620	0	10.1	-8.0					45	40
CLOTH.	0.382					45.00	0	25.74		45	40
ARC	0.427	258.35	0	102.8	-81.2					45	40
CLOTH.	0.427					45.00	0	24.64		45	40
ARC	0.472	1883	0	14.1	-11.1					45	40
CLOTH.	0.492					33.80	0	5.22		45	40
LINEAR	0.526	0	0	0.0	0.0					50	40
CLOTH.	0.526					32.20	12.94	21.66		50	40
ARC	0.558	408.844	30	50.2	-21.3					50	40
CLOTH.	0.558					32.00	13.02	21.79		50	40
LINEAR	0.590	0	0	0.0	0.0					45	40
CLOTH.	0.635					20.00	12.50	49.31		45	40
ARC	0.655	451	20	78.9	-66.5					45	40
CLOTH.	0.689					21.26	11.76	42.64		45	40
ARC	0.711	3300	0	6.4	-6.4					40	40

Kinematic parameters and speed of the track No.2 Section 1 are shown in the table below:

Table 28 Existing track No. 2 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.00	0.00					45	40
CLOTH.	0.190					25.0	10.0	52.4		45	40

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
ARC	0.215	213	20	104.74	-78.56					45	40
CLOTH.	0.255					38.8	6.4	20.8		45	40
ARC	0.294	660	0	40.24	-31.80					45	40
CLOTH.	0.309					38.7	0.0	9.9		45	40
ARC	0.348	2729	0	9.73	-7.69					45	40
CLOTH.	0.396					19.6	0.0	51.6		45	40
ARC	0.415	293	0	90.69	-71.66					45	40
CLOTH.	0.443					29.0	0.0	33.1		45	40
ARC	0.471	1896	0	14.01	-11.07					45	40
CLOTH.	0.513					20.0	0.0	8.8		45	40
LINEAR	0.533	0	0	0.00	0.00					50	40
CLOTH.	0.533					29.0	0.0	43.5		50	40
ARC	0.562	361	0	90.90	-58.18					50	40
CLOTH.	0.562					29.0	0.0	43.5		50	40
LINEAR	0.591	0	0	0.00	0.00					50	40
CLOTH.	0.669					20.0	0.0	52.5		50	40
ARC	0.677	434	0	75.55	-48.35					50	40
CLOTH.	0.723					20.0	0.0	52.5		50	40
LINEAR	0.745	0	0	0.00	0.00					50	40

- **Line 3a and Newcomen Junction (Section 2)**

Kinematic parameters and speed of the track No.1 Section 2 are shown in the table below:

Table 29 Existing track No. 1 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	176	0	67.22	-67.22					30	30
						0	0		63.9	30	30
ARC	0.023	3600	0	3.28	-3.28					30	30
						0	0		23.4	30	30
ARC	0.057	443	0	26.65	-26.65					30	30
						0	0		29.6	30	30
ARC	0.136	210	0	56.21	-56.21					30	30
						0	0		11.0	30	30
ARC	0.187	261	0	45.23	-45.23					30	30
						0	0		49.2	30	30

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
ARC	0.257	125	0	94.44	-94.44					30	30
						0	0		42.9	30	30
ARC	0.298	229	0	51.55	-51.55					30	30
						0	0		12.2	30	30
ARC	0.349	300	0	39.35	-39.35					30	30
						0	0		36.3	30	30
ARC	0.369	156	0	75.66	-75.66					30	30
						0	0		11.9	30	30
ARC	0.411	185	0	63.81	-63.81					30	30
CLOTH.	0.000					20.0	0.0	26.6		30	30
LINEAR	0.427	0	0	0.00	0.00					30	30

- **Line 2 (Connolly – Glasnevin section) (Section 3)**

Kinematic parameters and speed of the track No.1 Section 3 are shown in the table below:

Table 30 Existing track No. 1 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	3300	0	9.94	-9.94					50	40
						0	0		23.4	50	40
ARC	0.026	984	0	33.31	-33.31					50	40
CLOTH.	0.064					50.0	0.0	16.7		90	80
LINEAR	0.114	0	0	0.00	0.00					90	80
CLOTH.	0.300					120.0	12.5	29.6		90	80
ARC	0.420	526	60	141.89	-99.52					90	80
CLOTH.	0.493					65.0	0.0	55.9		90	80
ARC	0.536	1878	60	3.43	15.30					90	80
CLOTH.	0.698					50.0	30.0	1.7		90	80
LINEAR	0.748	0	0	0.00	0.00					90	80
CLOTH.	0.748					30.0	25.0	40.6		90	80
ARC	0.778	1350	30	48.70	-32.18					90	80
CLOTH.	0.839					30.0	25.0	40.6		90	80
LINEAR	0.869	0	0	0.00	0.00					90	80
CLOTH.	1.115					47.0	8.3	41.7		70	70
ARC	1.162	532	20	100.72	-100.72					70	70

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
CLOTH.	1.162					47.0	8.3	41.7		70	70
LINEAR	1.209	0	0	0.00	0.00					70	70
CLOTH.	1.209					60.0	7.4	40.9		80	70
ARC	1.269	644	20	110.39	-79.83					80	70
CLOTH.	1.269					60.0	7.4	40.9		80	70
LINEAR	1.329	0	0	0.00	0.00					120	80
						0	0		8.6	120	80
ARC	1.553	22000	0	8.59	-3.82					120	80
						0	0		8.6	120	80
LINEAR	1.575	0	0	0.00	0.00					120	80
CLOTH.	2.060					50.0	44.4	33.4		80	80
ARC	2.105	479	100	75.21	-75.21					80	80
CLOTH.	2.105					45.0	49.4	37.1		80	80
LINEAR	2.150	0	0	0.00	0.00					120	80
						0	0		37.8	120	80
ARC	2.424	5000	0	37.77	-16.79					120	80
						0	0		37.8	120	80
LINEAR	2.448	0	0	0.00	0.00					120	80

Kinematic parameters and speed of the track No.2 Section 1 are shown in the table below:

Table 31 Existing track No. 2 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.00	0.00					50	40
CLOTH.	0.000					16.1	0.0	22.2		50	40
ARC	0.016	1270	0	25.82	-16.52					50	40
CLOTH.	0.032					40.0	0.0	9.0		50	40
LINEAR	0.072	0	0	0.00	0.00					50	40
						0	0		10.6	90	80
ARC	0.133	10000	0	10.62	-8.39					90	80
						0	0		10.6	90	80
LINEAR	0.172	0	0	0.00	0.00					90	80
CLOTH.	0.306					106.3	11.8	34.7		90	80
ARC	0.413	538	50	147.48	-106.03					90	80
CLOTH.	0.480					76.8	0.0	46.2		90	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
ARC	0.557	1910	50	5.62	6.05					90	80
CLOTH.	0.681					75.8	16.5	1.9		90	80
LINEAR	0.757	0	0	0.00	0.00					90	80
CLOTH.	0.757					33.0	22.7	48.2		90	80
ARC	0.790	1134	30	63.68	-44.02					90	80
CLOTH.	0.828					40.6	18.5	39.2		90	80
LINEAR	0.868	0	0	0.00	0.00					90	80
CLOTH.	1.083					62.8	7.1	33.6		80	80
ARC	1.146	730	20	95.01	-95.01					80	80
CLOTH.	1.165					40.0	11.1	52.8		80	80
LINEAR	1.188	0	0	0.00	0.00					80	80
CLOTH.	1.188					40.0	0.0	45.6		80	80
ARC	1.228	1024	0	82.01	-82.01					80	80
CLOTH.	1.249					102.0	0.0	17.9		80	80
LINEAR	1.351	0	0	0.00	0.00					120	80
						0	0		18.9	120	80
ARC	1.805	10000	0	18.89	-8.39					120	80
						0	0		18.9	120	80
LINEAR	1.820	0	0	0.00	0.00					120	80
CLOTH.	2.053					55.0	45.5	40.2		90	80
ARC	2.108	564	100	88.41	-48.87					90	80
CLOTH.	2.108					55.0	45.5	40.2		90	80
LINEAR	2.163	0	0	0.00	0.00					120	80
						0	0		18.9	120	80
ARC	2.218	10000	0	18.89	-8.39					120	80
						0	0		18.9	120	80
LINEAR	2.260	0	0	0.00	0.00					120	80
CLOTH.	2.323					34.0	9.8	41.7		60	60
ARC	2.357	449	20	85.05	-85.05					60	60
CLOTH.	2.357					34.0	9.8	41.7		60	60
LINEAR	2.391	0	0	0.00	0.00					60	60
CLOTH.	2.391					40.0	6.9	32.3		50	50
ARC	2.431	290	20	93.01	-93.01					50	50
CLOTH.	2.431					40.0	6.9	32.3		50	50
LINEAR	2.471	0	0	0.00	0.00					50	50
CLOTH.	2.471					30.0	0.0	21.8		50	50
ARC	2.501	697	0	47.08	-47.08					50	50
						0	0		47.1	50	50
LINEAR	2.519	0	0	0.00	0.00					50	50

- **Line 2 and North Strand Junction (Section 4)**

Kinematic parameters and speed of the track No.1 Section 4 are shown in the table below:

Table 32 Existing track No. 1 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	241	30	106.29	-57.22					50	40
CLOTH.	0.141					50.0	8.3	29.5		50	40
LINEAR	0.191	0	0	0.00	0.00					50	40
CLOTH.	0.191					31.0	20.2	38.1		50	40
ARC	0.222	252	45	85.04	-38.23					50	40
						0	0		46.2	50	40
ARC	0.242	391	45	38.86	-8.67					50	40
CLOTH.	0.321					36.5	0.0	7.6		50	40
ARC	0.357	514	45	18.80	4.17					50	40
						0	0		32.6	50	40
ARC	0.422	340	45	51.44	-16.72					50	40
						0	0		32.5	50	40
ARC	0.453	513	45	18.92	4.09					50	40
						0	0		46.5	50	40
ARC	0.508	297	45	65.41	-25.66					50	40
						0	0		10.1	50	40
ARC	0.536	327	45	55.28	-19.18					50	40
CLOTH.	0.580					47.6	7.0	15.1		60	50
ARC	0.627	613	65	12.03	11.51					60	50
						0	0		44.8	60	50
ARC	0.685	388	65	56.82	-19.60					60	50
						0	0		0.3	60	50
ARC	0.715	389	65	56.54	-19.40					60	50
CLOTH.	0.776					126.0	8.6	7.5		60	50
LINEAR	0.902	0	0	0.00	0.00					100	80
CLOTH.	1.076					20.0	27.8	18.9		100	80
ARC	1.096	3905	20	13.59	-1.50					100	80
CLOTH.	1.096					20.0	27.8	18.9		100	80
LINEAR	1.116	0	0	0.00	0.00					100	80
CLOTH.	1.116					20.0	34.7	27.2		100	80
ARC	1.136	2941	25	19.60	-3.54					100	80
CLOTH.	1.136					20.0	34.7	27.2		100	80
LINEAR	1.156	0	0	0.00	0.00					100	80
CLOTH.	1.156					20.0	27.8	23.9		100	80
ARC	1.176	47431	20	17.23	18.23					100	80
CLOTH.	1.176					20.0	27.8	23.9		100	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
LINEAR	1.196	0	0	0.00	0.00					100	80
CLOTH.	1.196					20.0	0.0	11.6		100	80
ARC	1.216	15648	0	8.38	-5.36					100	80
CLOTH.	1.216					20.0	0.0	11.6		100	80
LINEAR	1.236	0	0	0.00	0.00					100	80
CLOTH.	1.377					44.9	34.7	28.1		70	50
ARC	1.422	444	80	64.75	6.15					70	50
CLOTH.	1.484					60.2	25.9	20.9		70	50
LINEAR	1.544	0	0	0.00	0.00					100	80
CLOTH.	1.580					30.0	23.1	37.6		100	80
ARC	1.610	2000	25	40.58	-16.97					100	80
CLOTH.	1.643					30.0	23.1	37.6		100	80
LINEAR	1.673	0	0	0.00	0.00					100	80
						0	0		13.1	100	80
ARC	1.840	10000	0	13.12	-8.39					100	80
						0	0		13.1	100	80
LINEAR	1.852	0	0	0.00	0.00					100	80
CLOTH.	1.999					40.4	27.5	40.0		80	80
ARC	2.039	684	50	72.73	-72.73					80	80
						0	0		3.5	80	80
ARC	2.113	665	50	76.23	-76.23					80	80
						0	0		11.6	80	80
ARC	2.155	732	50	64.68	-64.68					80	80
CLOTH.	2.268					84.8	13.1	17.0		80	80
LINEAR	2.353	0	0	0.00	0.00					80	80
CLOTH.	2.526					20.5	27.1	13.8		50	40
ARC	2.546	544	40	20.33	1.39					50	40
						0	0		27.7	50	40
ARC	2.666	1004	40	7.35	19.11					50	40
						0	0		7.9	50	40
ARC	2.705	808	40	0.58	14.03					50	40
						0	0		46.2	50	40
ARC	2.817	378	40	46.82	-15.56					50	40
						0.0	27.8		46.8	50	40
LINEAR	2.841	0	0	0.00	0.00					50	40
						0.0	27.8		20.7	50	40
ARC	2.841	540	40	20.67	1.17					50	40
						0	0		3.3	50	40
ARC	2.895	513	40	23.92	-0.91					50	40
CLOTH.	2.924					30.0	18.5	11.1		50	40

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	VMAX Passeng. trains	VMIN Freight trains
			D	I	E	L KP	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
LINEAR	2.954	0	0	0.00	0.00					50	40
CLOTH.	2.954					30.0	0.0	23.0		50	40
ARC	2.984	661	0	49.61	-31.75					50	40

Kinematic parameters and speed of the track No.2 Section 4 are shown in the table below:

Table 33 Existing track No. 2 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	VMAX Passeng. trains	VMIN Freight trains
			D	I	E	L KP	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	240	30	36.95	-19.19					35	30
						0	0		1.5	35	30
ARC	0.050	246	30	35.45	-18.08					35	30
						0	0		0.3	35	30
ARC	0.143	247	30	35.16	-17.87					35	30
						0	0		49.7	35	30
ARC	0.163	1039	30	14.54	18.64					35	30
						0	0		46.8	35	30
ARC	0.216	258	30	32.28	-15.75					35	30
						0	0		20.0	35	30
ARC	0.246	380	30	12.28	-1.06					35	30
CLOTH.	0.287					103.3	2.2	2.7		55	45
ARC	0.390	528	45	30.22	-5.35					55	45
						0	0		17.1	55	45
ARC	0.424	430	45	47.27	-16.77					55	45
						0	0		16.0	55	45
ARC	0.484	367	45	63.23	-27.45					55	45
						0.0	15.3		9.4	55	45
ARC	0.536	334	65	53.79	-14.52					55	45
CLOTH.	0.591					50.0	0.0	18.3		55	45
ARC	0.641	673	65	6.02	25.52					55	45
						0	0		43.8	55	45
ARC	0.691	386	65	37.79	-3.81					55	45
CLOTH.	0.779					130.9	7.6	4.4		55	45
LINEAR	0.910	0	0	0.00	0.00					100	80
CLOTH.	1.070					30.0	18.5	7.0		100	80
ARC	1.100	10523	20	7.54	12.02					100	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
CLOTH.	1.100					30.0	18.5	7.0		100	80
LINEAR	1.130	0	0	0.00	0.00					100	80
CLOTH.	1.130					30.0	23.1	6.3		100	80
ARC	1.160	7201	25	6.79	13.34					100	80
CLOTH.	1.160					30.0	23.1	6.3		100	80
LINEAR	1.190	0	0	0.00	0.00					100	80
CLOTH.	1.386					40.9	38.0	30.2		70	50
ARC	1.426	448	80	63.46	6.81					70	50
CLOTH.	1.497					50.7	30.7	24.4		70	50
LINEAR	1.547	0	0	0.00	0.00					100	80
CLOTH.	1.586					30.0	27.8	32.9		100	80
ARC	1.616	2000	30	35.58	-11.97					100	80
CLOTH.	1.651					30.0	27.8	32.9		100	80
LINEAR	1.681	0	0	0.00	0.00					100	80
						0	0		13.1	100	80
ARC	1.841	10000	0	13.12	-8.39					100	80
						0	0		13.1	100	80
LINEAR	1.857	0	0	0.00	0.00					80	60
CLOTH.	2.003					41.9	37.2	26.5		80	60
ARC	2.045	700	70	49.94	2.54					80	60
CLOTH.	2.260					105.0	14.8	10.6		80	60
LINEAR	2.365	0	0	0.00	0.00					35	30
CLOTH.	2.529					30.0	0.0	9.6		35	30
ARC	2.559	544	0	29.54	-21.70					35	30
						0	0		11.4	35	30
ARC	2.668	888	0	18.10	-13.30					35	30
						0	0		1.9	35	30
ARC	2.721	805	0	19.97	-14.67					35	30
						0	0		26.1	35	30
ARC	2.820	349	0	46.04	-33.82					35	30
						0	0		46.0	35	30
LINEAR	2.840	0	0	0.00	0.00					35	30
						0	0		8.6	35	30
ARC	2.840	1867	0	8.61	-6.32					35	30
						0	0		15.9	35	30
ARC	2.860	657	0	24.47	-17.98					35	30
						0	0		16.0	35	30
ARC	2.914	397	0	40.47	-29.73					35	30
						0	0		43.0	35	30
ARC	2.940	6336	0	2.54	-1.86					35	30

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	VMAX Passeng. trains	VMIN Freight trains
			D	I	E	L KP	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
						0	0		14.4	35	30
ARC	3.007	949	0	16.93	-12.44					35	30
CLOTH.	3.037					30.0	0.0	5.5		35	30
LINEAR	3.067	0	0	0.00	0.00					35	30

- **Line 3 (Docklands – Glasnevin – Maynooth – Kilcock) (Section 5,6,7)**

Kinematic parameters and speed of the track No.1 Section 5 are shown in the table below:

Table 34 Existing track No. 1 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	VMAX Passeng. trains	VMIN Freight trains
			D	I	E	L KP	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.00	0.00					110	80
CLOTH.	0.058					90.0	25.9	53.1		110	80
ARC	0.148	885	70	143.42	-24.85					110	80
CLOTH.	0.267					160.0	14.6	29.9		110	80
LINEAR	0.427	0	0	0.00	0.00					110	80
CLOTH.	0.713					65.0	26.9	19.9		70	70
ARC	0.778	411	90	66.37	-66.37					70	70
						0	0		26.9	70	70
ARC	0.994	351	90	93.29	-93.29					70	70
CLOTH.	1.034					40.0	43.8	45.3		70	70
LINEAR	1.074	0	0	0.00	0.00					70	70
CLOTH.	1.074					40.0	29.2	44.0		70	70
ARC	1.114	427	60	90.59	-90.59					70	70
CLOTH.	1.247					35.0	33.3	50.3		70	70
LINEAR	1.282	0	0	0.00	0.00					120	80
CLOTH.	1.426					50.0	40.0	24.6		120	80
ARC	1.476	1950	60	36.86	16.95					120	80
CLOTH.	1.536					55.0	36.4	22.3		120	80
LINEAR	1.591	0	0	0.00	0.00					120	80
CLOTH.	1.714					40.0	41.7	9.5		120	80
ARC	1.754	3075	50	11.42	22.70					120	80
CLOTH.	1.856					35.0	47.6	10.9		120	80
LINEAR	1.891	0	0	0.00	0.00					120	80
CLOTH.	1.956					105.0	25.4	13.2		120	80
ARC	2.061	1555	80	41.46	26.02					120	80
						0	0		39.5	120	80
ARC	2.172	2305	80	1.94	43.58					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
CLOTH.	2.219					50.0	53.3	1.3		120	80
LINEAR	2.269	0	0	0.00	0.00					120	80
CLOTH.	2.524					160.0	16.7	5.2		120	80
ARC	2.684	1800	80	24.93	33.36					120	80
						0	0		35.0	120	80
ARC	2.822	1350	80	59.91	17.82					120	80
						0	0		39.4	120	80
ARC	2.852	1880	80	20.46	35.35					120	80
CLOTH.	2.952					70.0	38.1	9.7		120	80
LINEAR	3.022	0	0	0.00	0.00					120	80
CLOTH.	3.722					35.0	47.6	56.4		120	80
ARC	3.757	1730	50	59.18	1.48					120	80
						0	0		26.2	120	80
ARC	3.847	1395	50	85.39	-10.17					120	80
CLOTH.	3.886					50.0	33.3	56.9		120	80
LINEAR	3.936	0	0	0.00	0.00					120	80
CLOTH.	4.073					80.0	27.8	50.7		100	80
ARC	4.153	580	80	146.07	-64.68					100	80
CLOTH.	4.212					40.0	0.0	55.0		100	80
ARC	4.252	893	80	66.88	-14.00					100	80
						0	0		16.9	100	80
ARC	4.418	801	80	83.75	-24.80					100	80
						0	0		8.8	100	80
ARC	4.528	760	80	92.58	-30.45					100	80
CLOTH.	4.635					95.0	23.4	27.1		100	80
LINEAR	4.730	0	0	0.00	0.00					120	80
CLOTH.	5.159					100.0	33.3	17.6		120	80
ARC	5.259	1235	100	52.93	32.03					120	80
CLOTH.	5.490					85.0	39.2	20.8		120	80
LINEAR	5.575	0	0	0.00	0.00					120	80
CLOTH.	5.774					60.0	50.9	49.2		120	80
ARC	5.834	807	100	96.66	-4.02					120	80
						0	0		16.9	120	80
ARC	6.104	743	100	113.60	-12.98					120	80
CLOTH.	6.188					130.0	23.5	26.7		120	80
LINEAR	6.318	0	0	0.00	0.00					120	80
CLOTH.	6.864					60.0	45.8	4.9		120	80
ARC	6.924	2350	90	9.63	54.28					120	80
CLOTH.	7.377					90.0	33.3	3.6		120	80
LINEAR	7.467	0	0	0.00	0.00					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
CLOTH.	7.851					75.0	57.8	27.1		120	80
ARC	7.926	989	130	61.04	45.09					120	80
CLOTH.	8.135					39.6	0.0	10.8		120	80
ARC	8.175	1060	130	48.18	50.81					120	80
CLOTH.	8.628					125.0	34.7	12.8		120	80
LINEAR	8.753	0	0	0.00	0.00					120	80
CLOTH.	8.943					100.0	40.0	4.8		120	80
ARC	9.043	1405	120	14.43	60.25					120	80
CLOTH.	9.078					100.0	40.0	4.8		120	80
LINEAR	9.178	0	0	0.00	0.00					120	80
CLOTH.	9.767					130.0	20.5	13.0		120	80
ARC	9.897	1445	80	50.71	21.91					120	80
CLOTH.	9.983					130.0	20.5	13.0		120	80
LINEAR	10.113	0	0	0.00	0.00					120	80
CLOTH.	0.000					20	0			120	80
END	0.000	0	0	0.00	0.00					120	80

Kinematic parameters and speed of the track No.2 Section 5 are shown in the table below:

Table 35 Existing track No. 2 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	697	50	42.28	-42.28					70	70
CLOTH.	0.006					20.2	48.2	40.7		70	70
LINEAR	0.026	0	0	0.00	0.00					120	80
CLOTH.	0.047					75.0	31.1	59.9		120	80
ARC	0.102	923	70	134.68	-20.97					120	80
CLOTH.	0.251					140.0	16.7	32.1		120	80
LINEAR	0.406	0	0	0.00	0.00					120	80
CLOTH.	0.692					54.0	37.0	45.1		80	70
ARC	0.746	421	90	109.59	-62.81					80	70
						0	0		19.6	80	70
ARC	0.963	357	90	90.03	-90.03					70	70
CLOTH.	1.013					40.0	43.8	43.8		70	70
LINEAR	1.053	0	0	0.00	0.00					70	70
CLOTH.	1.053					40.0	29.2	47.4		70	70

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
ARC	1.093	408	60	97.47	-97.47					70	70
CLOTH.	1.221					32.0	36.5	59.2		70	70
LINEAR	1.253	0	0	0.00	0.00					120	80
CLOTH.	1.405					50.0	40.0	34.1		120	80
ARC	1.455	1700	60	51.10	10.62					120	80
CLOTH.	1.499					55.0	36.4	31.0		120	80
LINEAR	1.554	0	0	0.00	0.00					120	80
CLOTH.	1.661					118.3	14.1	5.5		120	80
ARC	1.779	2721	50	19.42	19.15					120	80
CLOTH.	1.810					74.2	22.5	8.7		120	80
LINEAR	1.884	0	0	0.00	0.00					120	80
CLOTH.	1.931					96.8	27.5	12.8		120	80
ARC	2.028	1610	80	37.31	27.86					120	80
CLOTH.	2.156					87.3	30.5	14.2		120	80
LINEAR	2.244	0	0	0.00	0.00					120	80
CLOTH.	2.480					237.2	11.2	5.0		120	80
ARC	2.717	1635	80	35.52	28.66					120	80
CLOTH.	2.879					141.8	18.8	8.3		120	80
LINEAR	3.021	0	0	0.00	0.00					120	80
CLOTH.	3.682					81.9	20.3	29.4		120	80
ARC	3.764	1544	50	72.34	-4.37					120	80
CLOTH.	3.865					50.0	33.3	48.2		120	80
LINEAR	3.915	0	0	0.00	0.00					120	80
CLOTH.	4.038					92.8	24.0	38.1		100	80
ARC	4.131	633	80	127.21	-52.61					100	80
CLOTH.	4.223					35.0	0.0	52.0		100	80
ARC	4.253	926	80	61.64	-10.65					100	80
						0	0		26.0	100	80
ARC	4.393	782	80	87.68	-27.32					100	80
						0	0		9.6	100	80
ARC	4.500	740	80	97.25	-33.44					100	80
CLOTH.	4.588					132.6	16.8	20.4		100	80
LINEAR	4.720	0	0	0.00	0.00					120	80
CLOTH.	5.133					110.8	30.1	17.0		120	80
ARC	5.244	1208	100	56.35	30.51					120	80
CLOTH.	5.449					108.9	30.6	17.2		120	80
LINEAR	5.558	0	0	0.00	0.00					120	80
CLOTH.	5.725					113.3	27.0	26.6		110	80
ARC	5.839	800	100	98.48	-4.98					110	80
						0	0		7.6	110	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
ARC	6.056	770	100	106.11	-9.02					110	80
CLOTH.	6.169					130.0	23.5	24.9		110	80
LINEAR	6.299	0	0	0.00	0.00					120	80
CLOTH.	6.846					60.0	50.0	4.7		120	80
ARC	6.906	2315	90	8.41	53.74					120	80
CLOTH.	7.331					130.0	23.1	2.2		120	80
LINEAR	7.461	0	0	0.00	0.00					120	80
CLOTH.	7.829					84.5	51.3	26.2		120	80
ARC	7.913	962	130	66.33	42.74					120	80
CLOTH.	8.149					40.0	0.0	37.1		120	80
ARC	8.189	1244	130	21.85	62.51					120	80
						0	0		28.0	120	80
ARC	8.220	1050	130	49.86	50.06					120	80
CLOTH.	8.600					129.3	33.5	12.8		120	80
LINEAR	8.730	0	0	0.00	0.00					120	80
CLOTH.	8.915					100.0	40.0	3.1		120	80
ARC	9.015	1460	120	9.37	62.50					120	80
CLOTH.	9.055					100.0	40.0	3.1		120	80
LINEAR	9.155	0	0	0.00	0.00					120	80
CLOTH.	9.748					104.9	25.4	12.9		120	80
ARC	9.853	1567	80	40.53	26.43					120	80
CLOTH.	9.981					45.0	59.3	30.0		120	80
LINEAR	10.091	0	0	0.00	0.00					120	80

Kinematic parameters and speed of the track No.1 Section 6 are shown in the table below:

Table 36 Existing track No. 1 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.00	0.00					120	80
CLOTH.	0.223					50.0	52.5	53.9		105	80
ARC	0.273	793	90	92.35	-15.86					105	80
CLOTH.	0.302					50.0	52.5	53.9		105	80
LINEAR	0.352	0	0	0.00	0.00					105	80
CLOTH.	0.682					105.5	47.4	40.5		120	80
ARC	0.788	679	150	128.17	26.37					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
CLOTH.	0.907					97.4	0.0	14.1		120	80
ARC	1.005	797	150	86.91	44.70					120	80
						0	0		3.2	120	80
ARC	1.216	808	150	83.76	46.11					120	80
CLOTH.	1.592					90.7	36.7	31.8		120	80
ARC	1.682	4010	50	2.90	29.07					120	80
CLOTH.	2.035					119.8	13.9	0.8		120	80
LINEAR	2.155	0	0	0.00	0.00					120	80
CLOTH.	2.876					125.0	24.0	24.5		90	80
ARC	3.001	438	120	122.56	-71.65					90	80
CLOTH.	3.130					49.9	0.0	36.3		90	80
ARC	3.180	625	120	50.07	-14.37					90	80
						0	0		8.2	90	80
ARC	3.470	596	120	58.26	-20.85					90	80
						0	0		8.3	90	80
ARC	3.595	625	120	49.99	-14.31					90	80
CLOTH.	3.670					90.0	33.3	13.9		90	80
LINEAR	3.760	0	0	0.00	0.00					120	80
CLOTH.	3.878					55.0	54.5	15.8		120	80
ARC	3.933	1627	90	26.09	38.41					120	80
CLOTH.	4.374					55.0	54.5	15.8		120	80
LINEAR	4.429	0	0	0.00	0.00					120	80
CLOTH.	4.981					40.0	33.3	13.0		120	80
ARC	5.021	3395	40	15.63	15.27					120	80
CLOTH.	5.195					40.0	33.3	13.0		120	80
LINEAR	5.235	0	0	0.00	0.00					120	80
						0	0		9.4	120	80
ARC	5.378	20000	0	9.44	-4.20					120	80
						0	0		9.4	120	80
LINEAR	5.412	0	0	0.00	0.00					120	80
CLOTH.	5.887					75.0	50.0	39.4		90	80
ARC	5.962	396	150	118.22	-61.93					90	80
						0	0		12.2	90	80
ARC	6.060	415	150	106.05	-52.31					90	80
						0	0		19.4	90	80
ARC	6.349	386	150	125.43	-67.62					90	80
CLOTH.	6.423					90.0	41.7	34.8		90	80
LINEAR	6.513	0	0	0.00	0.00					90	80
CLOTH.	6.616					126.8	15.3	2.0		70	70
ARC	6.743	738	100	12.93	12.93					70	70

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
CLOTH.	6.774					61.1	0.0	22.0		70	70
ARC	6.835	411	100	56.37	-56.37					70	70
						0	0		50.0	70	70
ARC	6.908	604	100	6.41	-6.41					70	70
						0	0		44.5	70	70
ARC	6.978	426	100	50.95	-50.95					70	70
						0	0		20.4	70	70
ARC	7.046	375	100	71.39	-71.39					70	70
						0	0		43.0	70	70
ARC	7.170	501	100	28.41	-67.72					70	80
CLOTH.	7.305					125.1	15.5	4.4		70	80
LINEAR	7.430	0	0	0.00	0.00					95	80
CLOTH.	7.781					135.0	13.7	26.6		95	80
ARC	7.916	575	70	135.87	-75.99					95	80
CLOTH.	8.065					73.0	25.3	49.1		95	80
LINEAR	8.215	0	0	0.00	0.00					120	80
CLOTH.	8.239					73.0	50.2	55.8		120	80
ARC	8.312	813	110	122.20	6.80					120	80
						0	0		35.0	120	80
ARC	8.412	958	110	87.15	22.38					120	80
CLOTH.	8.635					112.6	32.6	25.8		120	80
LINEAR	8.747	0	0	0.00	0.00					120	80
CLOTH.	9.282					65.0	30.8	21.4		120	80
ARC	9.347	1856	60	41.76	14.77					120	80
CLOTH.	9.585					35.0	57.1	39.8		120	80
LINEAR	9.615	0	0	0.00	0.00					120	80
CLOTH.	9.656					30.0	55.6	39.8		120	80
ARC	9.686	2200	50	35.85	11.84					120	80
CLOTH.	9.806					30.0	55.6	39.8		120	80
LINEAR	9.836	0	0	0.00	0.00					120	80
CLOTH.	9.919					40.0	33.3	40.7		120	80
ARC	9.959	2127	40	48.79	0.54					120	80
CLOTH.	9.994					65.0	20.5	25.0		120	80
LINEAR	10.059	0	0	0.00	0.00					120	80
CLOTH.	0.000					20	0	0		120	80
ARC	10.699	30000	0	6.30	-2.80					120	80
						0	0		6.3	120	80
LINEAR	10.740	0	0	0.00	0.00					120	80
						0	0		3.8	120	80
ARC	10.952	50000	0	3.78	-1.68					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
						0	0		3.8	120	80
LINEAR	11.007	0	0	0.00	0.00					120	80
CLOTH.	11.626					92.7	36.0	36.9		120	80
ARC	11.719	932	100	102.65	9.93					120	80
						0	0		39.7	120	80
ARC	11.889	779	100	142.32	-7.70					120	80
CLOTH.	12.006					88.5	37.7	53.6		120	80
END	12.095	0	0	0.00	0.00					120	80

Kinematic parameters and speed of the track No.2 Section 6 are shown in the table below:

Table 37 Existing track No. 2 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.0	0.0					120	80
CLOTH.	0.223					46	57.1	59.0		105	80
ARC	0.269	790	90	93.0	-16.3					105	80
CLOTH.	0.302					46	57.1	59.0		105	80
LINEAR	0.348	0	0	0.0	0.0					105	80
CLOTH.	0.677					112.7	44.4	37.2		120	80
ARC	0.790	685	150	125.7	27.5					120	80
CLOTH.	0.908					138.2	0.0	10.6		120	80
ARC	1.046	815	150	81.7	47.0					120	80
						0.0	0		2.06	120	80
ARC	1.220	808	150	83.8	46.1					120	80
CLOTH.	1.599					76.6	43.5	37.1		120	80
ARC	1.675	3890	50	1.4	28.4					120	80
CLOTH.	2.049					86.7	19.2	0.6		120	80
LINEAR	2.136	0	0	0.0	0.0					120	80
CLOTH.	2.878					131.9	22.8	24.3		90	80
ARC	3.010	428	120	128.2	-76.1					90	80
CLOTH.	3.127					35	0.0	52.5		90	80
ARC	3.162	608	120	54.7	-18.0					90	80
						0	0		2.6	90	80
ARC	3.334	617	120	52.1	-16.0					90	80
						0	0		8.2	90	80
ARC	3.527	589	120	60.2	-22.4					90	80
						0	0		1.0	90	80
ARC	3.598	593	120	59.3	-21.6					90	80
CLOTH.	3.652					111.5	26.9	13.3		90	80
LINEAR	3.764	0	0	0.0	0.0					120	80
CLOTH.	3.879					55	54.5	16.1		120	80
ARC	3.934	1620	90	26.6	38.2					120	80
CLOTH.	4.373					55	54.5	16.1		120	80
LINEAR	4.428	0	0	0.0	0.0					120	80
CLOTH.	4.981					40	33.3	13.5		120	80
ARC	5.021	3360	40	16.2	15.0					120	80
CLOTH.	5.190					40	33.3	13.5		120	80
LINEAR	5.230	0	0	0.0	0.0					120	80
						0	0		6.3	120	80
ARC	5.395	30000	0	6.3	-2.8					120	80
						0	0		6.3	120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
LINEAR	5.429	0	0	0.0	0.0					120	80
CLOTH.	5.888					75.9	49.4	40.8		90	80
ARC	5.964	388	150	123.9	-66.4					90	80
						0	0		21.5	90	80
ARC	6.054	421	150	102.4	-49.4					90	80
						0	0		33.3	90	80
ARC	6.369	372	150	135.6	-75.7					90	80
CLOTH.	6.419					101.1	37.1	33.5		90	70
LINEAR	6.520	0	0	0.0	0.0					90	70
CLOTH.	6.620					123.9	15.7	2.4		70	70
ARC	6.744	757	100	15.1	15.1					70	70
CLOTH.	6.764					83.3	0.0	17.1		70	70
ARC	6.847	406	100	58.3	-58.3					70	70
						0	0		44.8	70	70
ARC	6.903	566	100	13.5	-13.5					70	70
						0	0		38.5	70	70
ARC	6.987	423	100	52.0	-52.0					70	70
						0	0		25.1	70	70
ARC	7.055	363	100	77.1	-77.1					70	70
						0	0		51.1	70	70
ARC	7.172	510	100	26.0	-64.6					70	80
CLOTH.	7.322					95.6	20.3	5.3		70	80
LINEAR	7.417	0	0	0.0	0.0					95	80
CLOTH.	7.771					155.4	11.9	23.7		95	80
ARC	7.926	565	70	139.5	-78.6					95	80
CLOTH.	8.055					162.0	11.4	22.7		95	80
LINEAR	8.217	0	0	0.0	0.0					120	80
CLOTH.	8.237					67.6	54.2	58.0		120	80
ARC	8.305	830	110	117.6	8.8					120	80
						0	0		31.3	120	80
ARC	8.413	962	110	86.3	22.7					120	80
CLOTH.	8.635					109.6	33.5	26.3		120	80
LINEAR	8.745	0	0	0.0	0.0					120	80
CLOTH.	9.272					82.7	24.2	16.7		120	80
ARC	9.355	1860	60	41.5	14.9					120	80
CLOTH.	9.577					45.1	44.3	30.7		120	80
LINEAR	9.622	0	0	0.0	0.0					120	80
CLOTH.	9.642					71.4	23.3	20.3		120	80
ARC	9.713	2021	50	43.5	8.5					120	80
CLOTH.	9.779					76.1	21.9	19.0		120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
LINEAR	9.855	0	0	0.0	0.0					120	80
CLOTH.	9.904					56.5	23.6	25.4		120	80
ARC	9.960	2275	40	43.0	3.1					120	80
CLOTH.	9.989					76.9	17.3	18.6		120	80
LINEAR	10.066	0	0	0.0	0.0					120	80
						0	0		6.3	120	80
ARC	10.688	30000	0	6.3	-2.8					120	80
						0	0		6.3	120	80
LINEAR	10.726	0	0	0.0	0.0					120	80
						0	0		3.8	120	80
ARC	10.931	50000	0	3.8	-1.7					120	80
						0	0		3.8	120	80
LINEAR	10.983	0	0	0.0	0.0					120	80
CLOTH.	11.622					96.3	34.6	34.4		120	80
ARC	11.718	948	100	99.3	11.4					120	80
						0	0		40.0	120	80
ARC	11.883	789	100	139.3	-6.3					120	80
CLOTH.	12.011					84.7	39.4	54.8		120	80
END	12.095	0	0	0.0	0.0					120	80

Kinematic parameters and speed of the track No.1 Section 7 are shown in the table below:

Table 38 Existing track No. 1 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.0	0.0					120	80
CLOTH.	0.217					60	38.9	30.1		120	80
ARC	0.277	1520	70	54.3	14.8					120	80
						0	0		14.7	120	80
ARC	0.317	1724	70	39.6	21.3					120	80
						0	0		0.1	120	80
ARC	0.451	1723	70	39.6	21.3					120	80
						0	0		16.3	120	80
ARC	0.485	1500	70	55.9	14.0					120	80
CLOTH.	0.643					50	46.7	37.3		120	80
LINEAR	0.693	0	0	0.0	0.0					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
CLOTH.	0.693					96.8	28.7	25.8		100	80
ARC	0.790	690	100	90.1	-21.7					100	80
						0	0		29.6	100	80
ARC	0.944	597	100	119.7	-40.6					100	80
						0	0		6.8	100	80
ARC	1.096	616	100	112.9	-36.3					100	80
						0	0		4.1	100	80
ARC	1.169	628	100	108.9	-33.7					100	80
						0	0		37.1	100	80
ARC	1.231	764	100	71.8	-9.9					100	80
CLOTH.	1.261					55	0	49.1		100	80
ARC	1.311	1761	100	25.5	52.3					100	80
CLOTH.	1.343					50	55.6	14.2		100	80
LINEAR	1.383	0	0	0.0	0.0					120	80
CLOTH.	2.363					20	33.3	45.4		120	80
ARC	2.383	4000	20	27.2	-1.0					120	80
CLOTH.	2.472					20	33.3	45.4		120	80
LINEAR	2.492	0	0	0.0	0.0					120	80
CLOTH.	2.514					61.7	37.8	31.9		120	80
ARC	2.575	1463	70	59.1	12.6					120	80
CLOTH.	2.619					52.5	0	50.5		120	80
ARC	2.671	3804	70	20.3	47.9					120	80
CLOTH.	2.723					59.8	39.0	11.3		120	80
LINEAR	2.783	0	0	0.0	0.0					120	80
CLOTH.	2.788					71.1	42.2	30.1		120	80
ARC	2.859	1225	90	64.2	21.5					120	80
						0	0		11.1	120	80
ARC	2.887	1143	90	75.2	16.6					120	80
						0	0		10.4	120	80
ARC	3.010	1220	90	64.8	21.2					120	80
						0	0		15.9	120	80
ARC	3.174	1360	90	48.9	28.3					120	80
CLOTH.	3.208					80.0	37.5	20.4		120	80
LINEAR	3.288	0	0	0.0	0.0					120	80
						0	0		1.9	120	80
ARC	4.314	100000	0	1.9	-0.8					120	80
						0	0		1.9	120	80
LINEAR	4.336	0	0	0.0	0.0					120	80
						0	0		0.6	120	80
ARC	4.443	300000	0	0.6	-0.3					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
						0	0		0.6	120	80
LINEAR	4.464	0	0	0.0	0.0					120	80
						0	0		4.7	120	80
ARC	5.187	40000	0	4.7	-2.1					120	80
						0	0		4.7	120	80
LINEAR	5.213	0	0	0.0	0.0					120	80
CLOTH.	5.408					133.4	30.0	14.0		120	80
ARC	5.542	1073	120	56.0	41.8					120	80
CLOTH.	5.596					110.5	36.2	16.9		120	80
LINEAR	5.706	0	0	0.0	0.0					120	80
						0	0		18.9	120	80
ARC	6.286	10000	0	18.9	-8.4					120	80
						0	0		18.9	120	80
LINEAR	6326.085	0	0	0.0	0.0					120	80
CLOTH.	6444.359					120.0	25.5	32.6		110	80
ARC	6564.698	696	100	128.0	-20.6					110	80
CLOTH.	6663.103					74.9	40.8	52.2		110	80
LINEAR	6738.013	0	0	0.0	0.0					120	80
						0.0	0.0			120	80
ARC	7063.368	10000	0	18.9	-8.4					120	80
						0.0	0.0			120	80
LINEAR	7082.909	0	0	0.0	0.0					120	80
CLOTH.	7271.366					87.0	46.0	44.4		120	80
ARC	7358.261	801	120	115.8	15.2					120	80
CLOTH.	7411.018					103.0	38.8	37.5		120	80

Kinematic parameters and speed of the track No.2 Section 7 are shown in the table below:

Table 39 Existing track No. 2 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.0	0.0					120	80
						0	0		39.3	120	80
ARC	0.086	4800	0	39.3	-17.5					120	80
						0	0		39.3	120	80
LINEAR	0.120	0	0	0.0	0.0					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
						0	0		37.8	120	80
ARC	0.184	5000	0	37.8	-16.8					120	80
						0	0		37.8	120	80
LINEAR	0.224	0	0	0.0	0.0					120	80
						0	0		6.3	120	80
ARC	0.353	30000	0	6.3	-2.8					120	80
						0	0		6.3	120	80
LINEAR	0.377	0	0	0.0	0.0					120	80
CLOTH.	0.537					87.8	15.2	15.2		120	80
ARC	0.625	2363	40	39.9	4.5					120	80
						0	0		1.6	120	80
ARC	0.753	2413	40	38.3	5.2					120	80
						0	0		5.6	120	80
ARC	2.843	2251	40	43.9	2.7					120	80
						0	0		24.3	120	80
ARC	2.902	1746	40	68.2	-8.1					120	80
CLOTH.	3.111					100.0	13.3	22.7		120	80
LINEAR	3.211	0	0	0.0	0.0					120	80
						0	0		1.3	120	80
ARC	3.304	150000	0	1.3	-0.6					120	80
						0	0		1.3	120	80
LINEAR	3.328	0	0	0.0	0.0					120	80
						0	0		1.9	120	80
ARC	3.738	100000	0	1.9	-0.8					120	80
						0	0		1.9	120	80
LINEAR	3.765	0	0	0.0	0.0					120	80
						0	0		1.9	120	80
ARC	4.258	100000	0	1.9	-0.8					120	80
						0	0		1.9	120	80
LINEAR	4.288	0	0	0.0	0.0					120	80
						0	0		3.8	120	80
ARC	4.616	50000	0	3.8	-1.7					120	80
						0	0		3.8	120	80
LINEAR	4.784	0	0	0.0	0.0					120	80
						0	0		18.9	120	80
ARC	5.244	10000	0	18.9	-8.4					120	80
						0	0		18.9	120	80
LINEAR	5.323	0	0	0.0	0.0					120	80
						0	0		31.5	120	80
ARC	5.413	6000	0	31.5	-14.0					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
						0	0		31.5	120	80
LINEAR	5.554	0	0	0.0	0.0					120	80
						0	0		18.9	120	80
ARC	5.790	10000	0	18.9	-8.4					120	80
						0	0		18.9	120	80
LINEAR	5.912	0	0	0.0	0.0					120	80
						0	0		3.8	120	80
ARC	6.370	50000	0	3.8	-1.7					120	80
						0	0		3.8	120	80
LINEAR	6.404	0	0	0.0	0.0					120	80
						0	0		2.4	120	80
ARC	6.472	80000	0	2.4	-1.0					120	80
						0	0		2.4	120	80
LINEAR	6.509	0	0	0.0	0.0					120	80
						0	0		0	120	80
LINEAR	6.918	0	0	0.0	0.0					120	80

- **Line 4 (Clonsilla – M3 Parkway) (Section 8)**

Kinematic parameters and speed of the track No.1 Section 8 are shown in the table below:

Table 40 Existing track No. 1 alignment parameters

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
BEG.	0.000	0	0	0.0	0.0					60	60
						0	0		53.4	60	60
ARC	0.105	885	0	53.4	-53.4					60	60
						0	0		53.4	60	60
LINEAR	0.152	0	0	0.0	0.0					60	60
						0	0		48.4	60	60
ARC	0.205	975	0	48.4	-48.4					60	60
						0	0		48.4	60	60
LINEAR	0.265	0	0	0.0	0.0					120	80
						0	0		37.8	120	80
ARC	0.441	5000	0	37.8	-16.8					120	80
						0	0		37.8	120	80
LINEAR	0.472	0	0	0.0	0.0					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
CLOTH.	0.758					96.0	13.9	14.4		120	80
ARC	0.854	2320	40	41.4	3.8					120	80
						0	0		3.0	120	80
ARC	0.978	2410	40	38.4	5.2					120	80
						0	0		30.5	120	80
ARC	3.109	1735	40	68.9	-8.4					120	80
CLOTH.	3.324					106.7	12.5	21.5		120	80
LINEAR	3.430	0	0	0.0	0.0					120	80
						0	0		1.3	120	80
ARC	3.610	150000	0	1.3	-0.6					120	80
						0	0		1.3	120	80
LINEAR	3.642	0	0	0.0	0.0					120	80
						0	0		1.3	120	80
ARC	3.957	150000	0	1.3	-0.6					120	80
						0	0		1.3	120	80
LINEAR	3.985	0	0	0.0	0.0					120	80
						0	0		1.3	120	80
ARC	4.377	150000	0	1.3	-0.6					120	80
						0	0		1.3	120	80
LINEAR	4.413	0	0	0.0	0.0					120	80
						0	0		3.8	120	80
ARC	4.826	50000	0	3.8	-1.7					120	80
						0	0		3.8	120	80
LINEAR	4.995	0	0	0.0	0.0					120	80
						0	0		18.9	120	80
ARC	5.461	10000	0	18.9	-8.4					120	80
						0	0		18.9	120	80
LINEAR	5.544	0	0	0.0	0.0					120	80
						0	0		31.5	120	80
ARC	5.629	6000	0	31.5	-14.0					120	80
						0	0		31.5	120	80
LINEAR	5.771	0	0	0.0	0.0					120	80
						0	0		18.9	120	80
ARC	6.002	10000	0	18.9	-8.4					120	80
						0	0		18.9	120	80
LINEAR	6.123	0	0	0.0	0.0					120	80
						0	0		1.6	120	80
ARC	6.634	120000	0	1.6	-0.7					120	80
						0	0		1.6	120	80
LINEAR	6.669	0	0	0.0	0.0					120	80

	PK	R	Cant	Cant Def.	Cant excess	L	Rate of change of cant	Rate of change of cant defic.	Abrupt change of cant defic.	V_{MAX} Passeng. trains	V_{MIN} Freight trains
			D	I	E	L_{KP}	dD/dt	dI/dt	DI		
		[m]	[mm]	[mm]	[mm]	[m]	[mm/s]	[mm/s]	[mm]	[km/h]	[km/h]
						0	0		1.6	120	80
ARC	6.807	120000	0	1.6	-0.7					120	80
						0	0		1.6	120	80
LINEAR	6.842	0	0	0.0	0.0					120	80

APPENDIX B. INVESTMENT OPTIONS DRAWINGS