Transport for London

New Tube for London

Sponsor's Programme Requirements

Piccadilly Line

		Signature	Date
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Reviewed by	**Simon Chung** Principal Systems Performance Engineering Manager		21/10/2016
Reviewed by	**Dave Hughes** Transport Strategy Manager		24/10/16
Reviewed by	**Kevin Moore** Lead Sponsor		21 Oct 2016

Approved by I confirm that this deliverable meets the requirements of the relevant Pathway Product Description and that all consultation comments have been addressed to the satisfaction of consultees.

Christian Fowler
Head of Line Upgrades Sponsorship

[redacted] 21-Oct-2016.

Version: 2.0
Date: 21st October 2016
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Document History

Revision	Date	Summary of changes
Version 1.0	26/02/2016	First Approved Issue
Version 2.0	21/10/2016	Updates following impact assessment outcome to Version 1.0 by the Programme (refer to Sponsor's Instruction #10). Key changes are: • Update to runtimes from the draught relief at 7 locations only – meaning a slight increase in some runtimes. • Update to the service expected at the Cockfosters end of the line. • Update to the reliability figures (and tabulated consolidate the number of requirements and to make it easier to do Verification & Validation). • Caveat put on the West London Services section whilst the feasibility study concludes via SI-016 (expected early 2017). • Update to energy usage figures, driven by the recent work of Systems Performance Engineering.

Table of Contents

1 Introduction

1.1 Purpose of this Document

This specification **defines the outputs and capabilities** that shall be delivered by the *New Tube for London (NTfL) Programme* (hereafter referred to as *the Programme*) with respect to the **Piccadilly line only**; it must be read in conjunction with the ***Sponsor's Remit***, document reference: NTfL-2344.1.1-LUL-RPT-00056 and supporting documentation.

Note that general programme wide requirements are contained within the *Sponsor's Remit*; this document focuses on line specific capabilities and constraints.

1.2 Change Control

The content of this document is subject to Change Control following the first approved version. Any updates to this document will be formally communicated to *the Programme* by *the Sponsor*.

1.3 About the NTfL Programme

Information about the NTfL Programme, its goals and objectives are detailed within the **NTfL Concept and Blueprint**, document reference: NTfL-2344.2.2-LUL-RPT-00035-01.

1.4 Abbreviations

GOA2 - Grade of Automation 2

GOA4 - Grade of Automation 4

GWh - GigaWatt Hours

LU - London Underground

NTfL - New Tube for London

OTT - On Train Time

PICU - Piccadilly Interim Control Upgrade

PTI - Platform Train Interface

PWT - Platform Wait Time

RTM - Remote Track Monitoring

RVAR - Rail Vehicle Accessibility Regulations

SAF - Service Affecting Failure

SDO - Selective Door Opening

SETT – South Ealing Test Track

TPAC - Tunnel and Public Area Cooling

tph - Trains per Hour

uwOTT - Unweighted On Train Time

uwPWT - Unweighted Platform Wait Time

1.5 Definitions

Terms defined below are denoted within this document using *italics*:

1.5.1 Piccadilly Line Benefit Stages

Some requirements within this document refer to the following *Key Benefit Stages* for the *Piccadilly line* which are defined below:

Key Benefit Stage P0:
First Piccadilly Line train in passenger service
Date: End of **May 2024**

Key Benefit Stage P1:
Piccadilly Line train replacement complete
Date: End of **Dec 2025**

Key Benefit Stage P2.1:
Service Enhancement: semi automated train operation - system capable of supporting 33tph
Date: End of **May 2026** Timetable Change

Key Benefit Stage P2.2:
Redundant assets recovered from post Piccadilly Line Service Enhancement stage P2.1
Date: End of **May 2028**

Key Benefit Stage P3.1:
Fully automated train operation – system capable of supporting 33tph
Date: **May 2037** Timetable change

Key Benefit Stage P3.2:
Redundant assets recovered from all previous Piccadilly Line upgrade stages
Date: End of **May 2039**

1.5.2 General Definitions

Terms defined below are denoted within this document using *italics*:

'73 Tube Stock:
The legacy 1973 Tube Stock that runs on the *Piccadilly line*, to be replaced by the *NTfL Trains*.

AM Peak:
The *AM Peak* times are: 7am to 10am weekdays.

Candidate System:
At this stage of Programme development, the business case has been generated using a set of assumptions around train performance, railway performance and subsequent benefits. This optimised set of assumptions produces a "Candidate System". It is intended that these assumptions will be tested during various procurement exercises, and once the business case is updated to confirm the optimum cost, risk and benefit, the "Candidate System" will be replaced by the "Proposed System".

Concept Documentation:
A list of Concept documentation is contained within the *Sponsor's Remit.*

Grade of Automation [#] (GOA[#]):
Grade of Automation. This is one of five grades (0 to 4) those of which are applicable to NTfL are

defined in The Operations and Maintenance Concept (NTfL-2344.1.1-LUL-RPT-00066).

Inter-Peak:
Inter-Peak refers to the 10am to 4pm period weekdays.

Key Benefit Stage(s):
Realisation of benefits is expected in a number of Key Benefit Stages; these stages are detailed within the **NTfL Concept and Blueprint document**, with the main changes to the railway at each stage categorised against four main Programme Goals:

1) Increase Capacity
2) Improve Railway Safety and Reliability
3) Improve Customer Experience
4) Reduce Whole Life Costs

NTfL Trains:
The new passenger trains that shall be procured for the *Piccadilly line.*

Off Peak:
Off Peak includes all the hours outside *AM and PM Peak* hours (inclusive of *Inter-Peak*).

[unweighted] On Train Time:
The unweighted On Train Time (uwOTT) is an aggregated and averaged figure for the whole of the Piccadilly Line. 'Unweighted' means that crowding on the train does not factor into this metric. Further information can be found within the document: **'NTfL Service Reliability Requirements'**.

Piccadilly line:
Includes all stations, infrastructure, stabling areas, maintenance areas and branches of the Piccadilly line including the interoperable section with the Metropolitan line, the District line and the future branch to Ealing Broadway.

[unweighted] Platform Wait Time:
The unweighted Platform Wait Time (uwPWT) is an aggregated and averaged figure for the whole of the *Piccadilly Line*. 'Unweighted' means that platform crowding does not factor into this metric. Further information regarding this metric can be found within the document: **'NTfL Service Reliability Requirements'**.

PM Peak:
The *PM Peak* times are 4pm to 7pm weekdays.

[Where] Practicable:
If "*where practicable*" has been used within a requirement statement, this is a requirement with an acknowledgement by *the Sponsor* that there is a possibility that the cost of implementation versus the benefit may be disproportional. Until a derogation is provided by *the Sponsor*, *the Programme* must meet the respective requirement.
These are still requirements on *the Programme* to deliver, but do not have a critical impact on the output; therefore where it is deemed by *the Programme* that the cost of meeting the requirement is disproportional to the benefits, *the Sponsor* shall be notified via an agreed process with a justification for why it is not in *the Programme's* best interest to deliver, or deliver fully. *The Sponsor* will decide the most appropriate course of action based on the information provided by *the Programme*.

Run Time:
Time taken from wheel start at station A to wheel stop at station B for a single train.

South Ealing Test Track (SETT):
The eastbound local road between Northfields and Acton Town contains facilities for wet/dry rail emergency brake performance testing and general rolling stock performance/type testing.

Service Affecting Failure (SAF):
A failure that causes an initial delay of two minutes or more to the service.

Sponsor:
The Client Organisation (including its nominated representatives) to which the outputs defined herein shall be delivered to by *the Programme*.

System:
A combination of assets, technology, people and processes that delivers a defined capability to a defined quality.

The Programme:
The (NTfL) Programme is responsible for the delivery of the outputs within the defined constraints and to the quality specified by the *Sponsor*. *The Programme* includes all sub-projects including any teams that are sub-contracted by *the Programme*.

Train Maintenance Areas:
A designated area where maintenance work can take place on a train in a suitable environment; In such areas the train needs to be placed in a safe state for the respective maintenance activity.

2 Piccadilly Line Candidate System

The ***Piccadilly line Candidate System*** is a suite of performance and capability metrics developed by *the Sponsor* through modelling. It represents a theoretical minimum NTfL service capability that is the aspiration of *the Sponsor*. The actual service capability is subject to a number of factors which *the Sponsor* cannot predict with a high degree of certainty such as performance constraints that depend on the various suppliers or solution, or other engineering trade-offs.

It is the intention of *the Sponsor* that the metrics defined via the system design will eventually become firm requirements; it is envisaged that this will occur once all key suppliers have been confirmed and the design has reached a reasonable state of maturity.

Requirement	Rationale	Business Level Trace
The Programme shall develop and implement an *NTfL System* design that optimises the baseline *Piccadilly Line Candidate System* to achieve an improved overall business case. **SPR-PL-266**	At the pre-delivery stage of the Programme the system is defined by a set of train and signalling performance assumptions; the optimal set of assumptions generate a Candidate System. Once the supply chain is confirmed, these assumptions will turn to fact and will no longer be a Candidate System.	BLR 06 - Provide Increased Service Levels BLR 09 - Enable Ops and Maintenance Cost Reduction BLR 10 - Reduce Energy Usage BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term
Supplementary text for SPR-PL-266: *The key factors to be evaluated in such an optimisation include (but are not limited to):* *a) Peak Service Levels* *b) Inter-station runtimes* *c) Boarding and Alighting times* *d) Train fleet size* *e) The marginal cost of the variant.* *Relevant data is tabulated within this section.*		
The Programme shall inform the *Sponsor* via an agreed process if *the Programme* is unable to develop a design that meets any of the capabilities or metrics defined within the *Piccadilly line Candidate System*. **SPR-PL-268**	This is to ensure that the Business Case remains positive whilst upholding the Programme Objectives.	BLR 06 - Provide Increased Service Levels BLR 09 - Enable Ops and Maintenance Cost Reduction BLR 10 - Reduce Energy Usage BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term

2.1 NTfL Peak Service Levels

This section denotes service level information for the upgraded NTfL railway. It currently only holds Piccadilly line data for the 'service enhancement' (GOA2) benefit configuration stage, but note that no additional capacity is expected to be made available by the implementation of fully automated GoA4 operation, so the overall performance predicted for the service enhancement GoA2 benefit configuration stage can be considered to be the end-state service level.

This is for a 33tph peak service pattern; there is ongoing work to optimise the service levels and this document will be updated to reflect any changes following the conclusion of that work.

Required Service Levels – Calculated as sum (Max, Interoperable, Degraded Mode tph), unless the notes column indicates otherwise.

Source Data:

- tph – Sponsors meeting with Transport Planning: 11/02/2016
- Night Tube tph – TfL Intranet (Dec 2015)
- Interoperable tph – 4LM SPRRD
- Degraded Mode tph – Sponsor & Transport Planning Meeting Minutes 14 December 2015.

2.1.1 Eastbound

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Heathrow T5 to Heathrow T123	7.5	-	7.5	-	-	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 tph will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, the whole 33tph service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields. * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not poss ble to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*

Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Heathrow T4 to Heathrow T123	7.5	-	7.5	-	-	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 tph will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, the whole 33tph service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields. * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not possible to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*

Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Heathrow T123 to Northfields	15	-	15	-	-	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 trains will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, the whole 33tph service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields. * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not possible to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*

Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Northfields to Acton Town	15	-	15	-	17	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 trains will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, the whole 33TPH service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not possible to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*
Uxbridge to Rayners Lane	8	12	6	6	-	4 (GOA2) 0 (GOA4)	Interoperable with Met between Uxbridge & Rayners Lane Junction (8-car S-Stock). Additionally, to be able to accommodate an additional 4tph reversing at a combination of Ruislip and Uxbridge under GOA2. 0 under GOA4 due to accommodation limitation at South Harrow.	24	Peak tph + Interoperable Peak + Degraded Mode	-
Rayners Lane to South Harrow	12	-	9	-	-	6 (GOA2) 0 (GOA4)	To be able to accommodate an additional 2tph reversing and 4tph through running when the Heathrow branch is unavailable under GOA2.	18	Peak tph + Degraded Mode	-

Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
South Harrow to Ealing Common	12	-	9	-	6	10 (GOA2) 8 (GOA4)	4 tph reversing and 6 tph additional through running under GOA2 8 tph reversing at South Harrow under GOA4.	22	Peak tph + Degraded Mode	-
Ealing Broadway to Ealing Common	6	-	6	-	16 District Stabling Trains	2.25	An additional 2.25tph to reverse in degraded mode (under degraded mode it will be required that Ealing Broadway can accommodate the headway of a quarter of the service - which is 8.25tph).	22	Peak tph + Positioning	-
Ealing Common to Acton Town	18	-	15	-	16 District Stabling Trains	12.25	The above means that Ealing Common needs to be able to accommodate an additional 12.25 tph when the Heathrow branch is unavailable for service.	31	Off-peak tph + Positioning	-
Acton Town to Barons Court	33	-	30	-	-	-	* Night Tube tph and days are subject to further development.	33	Peak tph	6*
Barons Court to Holborn	33	-	30	-	-	-	* Night Tube tph and days are subject to further development.	33	Peak tph	6*
Holborn to Wood Green	33	-	30	-	-	-	* Night Tube tph and days are subject to further development.	33	Peak tph	6*
Wood Green to Arnos Grove	33	-	30	-	4	-	* Night Tube tph and days are subject to further development.	33	Peak service from the positioning moves.	6*
Arnos Grove to Cockfosters	24.75	-	22.5	-	27	8.25 (peak) 10.5 (off-peak)	All 33 tph to Cockfosters if reversing at Arnos Grove is not possible. * Night Tube tph and days are subject to further development.	33	Positioning assumes Peak tph is made up from depot starters but maximum tph from Peak + Degraded Mode	6*

2.1.2 Westbound

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Cockfosters to Arnos Grove	22	-	22	-	27	11	All 33 tph to Cockfosters if reversing at Arnos Grove is not possible. * Night Tube tph and days are subject to further development.	33	Positioning assumes Peak tph is made up from depot starters but maximum tph from Peak + Degraded Mode	6*
Arnos Grove to Wood Green	33	-	30	-	4	-	* Night Tube tph and days are subject to further development.	33	Positioning moves from Cockfosters joining with positioning moves from Arnos Grove. Max is Peak tph.	6*
Wood Green to Holborn	33	-	30	-	-	-	* Night Tube tph and days are subject to further development.	33	Peak tph	6*
Holborn to Barons Court	33	-	30	-	-	-	* Night Tube tph and days are subject to further development.	33	Peak tph	6*
Barons Court to Acton Town	33	-	30	-	-	-	* Night Tube tph and days are subject to further development.	33	Peak tph	6*
Acton Town to Ealing Common	18	-	15	-	16 (District Stabling trains)	12.25	The above means that Ealing Common needs to be able to accommodate an additional 12.25 tph when the Heathrow branch is unavailable for service.	34	Peak tph + Positioning	-

Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Ealing Common to Ealing Broadway	6	-	6	-	16 (District Stabling trains)	2.25	An additional 2.25 tph to reverse in degraded mode (under degraded mode it will be required that Ealing Broadway can accommodate the headway of a quarter of the service - which is 8.25 tph).	16	Positioning moves make up the interoperable service	-
Ealing Common to South Harrow	12	-	9	-	6	10 (GOA2) 8 (GOA4)	4 tph reversing and 6 tph additional through running under GOA2 8 tph reversing at South Harrow under GOA4.	22	Peak tph + Degraded Mode	-
South Harrow to Rayners Lane	12	-	9	-	-	6 (GOA2) 0 (GOA4)	To be able to accommodate an additional 2 tph reversing and 4 tph through running when the Heathrow branch is unavailable under GOA2.	18	Peak tph + Degraded Mode	-
Rayners Lane to Uxbridge	8	12	6	6	-	4 (GOA2) 0 (GOA4)	Interoperable with Met between Uxbridge & Rayners Lane Junction (8-car S-Stock). Additionally To be able to accommodate an additional 4 tph reversing at a combination of Ruislip and Uxbridge under GOA2. 0 under GOA4 due to accommodation limitation at South Harrow.	24	Peak tph + Interoperable Peak + Degraded Mode	-

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Acton Town to Northfields	15	-	15	-	19	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 trains will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5 tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, The whole 33 tph service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields. * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not possible to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*

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Northfields to Hatton Cross	15	-	15	-	-	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 trains will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5 tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, the whole 33TPH service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields. * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not possible to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*

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Hatton Cross to Heathrow T4	7.5	-	7.5	-	-	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 trains will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5 tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, the whole 33TPH service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields. * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not possible to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*

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Hatton Cross to Heathrow T123	7.5	-	7.5	-	-	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 trains will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5 tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, The whole 33 tph service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields. * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not possible to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*

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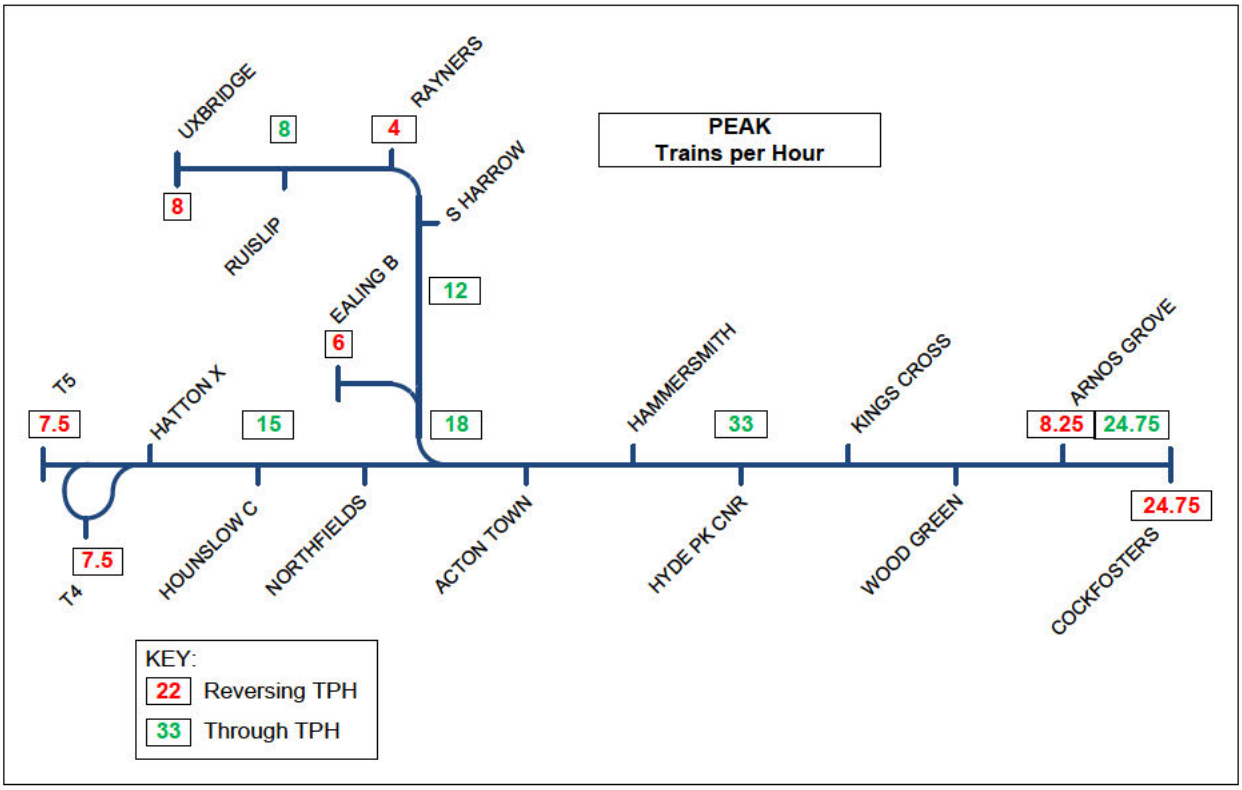
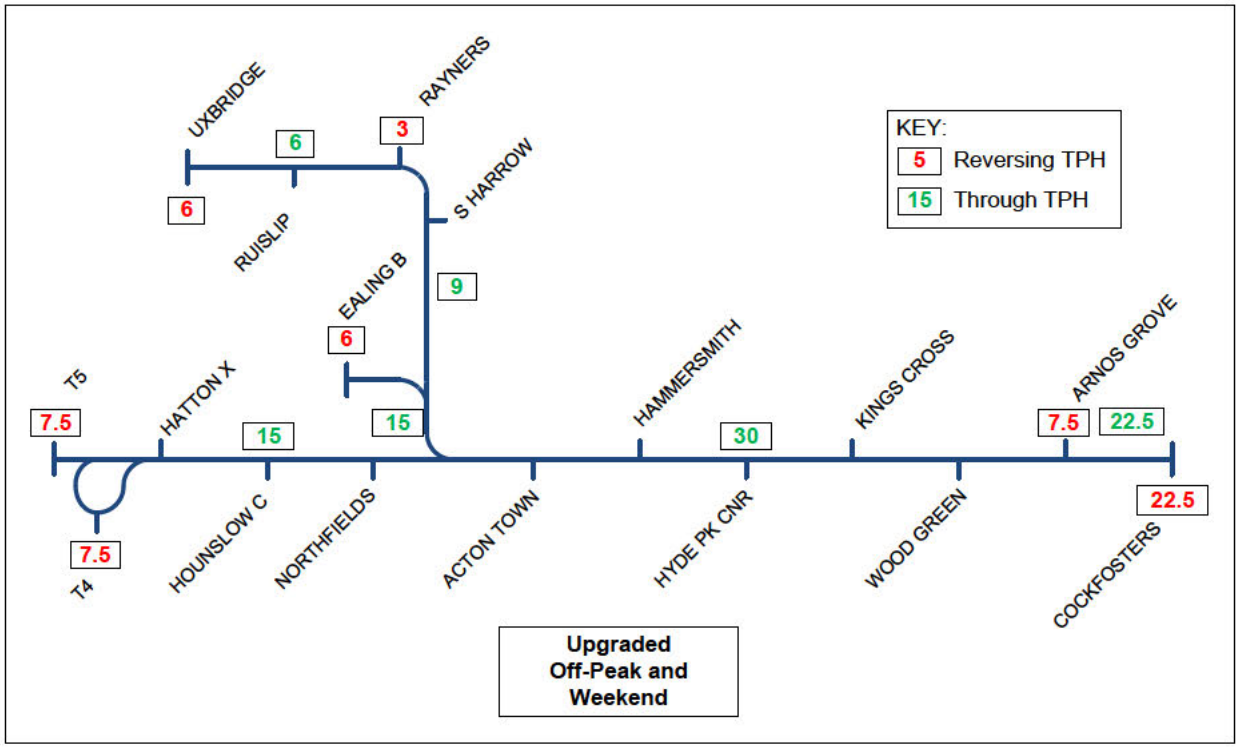
Heathrow T123 to Heathrow T5	7.5	-	7.5	-	-	18**	Trains will be required to reverse at T123 in degraded mode, the worst case of being when T5 and T4 are unavailable. In this case all 15 trains will need to reverse at T123. Note that when only T4 is unavailable, T123 should be capable of reversing the 7.5 tph in addition to the 7.5tph through service to T5. Additionally when it is not poss ble to run services to any of South Harrow, Rayners Lane and Uxbridge, The whole 33 tph service will need to be accommodated, with a mix of trains reversing at Heathrow terminals and Northfields. * Night Tube tph and days are subject to further development. ** The tph to Heathrow when it is not possible to run beyond Ealing Common should be optimised such that speeds are not reduced, but as much service as poss ble reverses at Heathrow. The remainder should reverse at Northfields.	33	Peak tph + Degraded Mode	6*

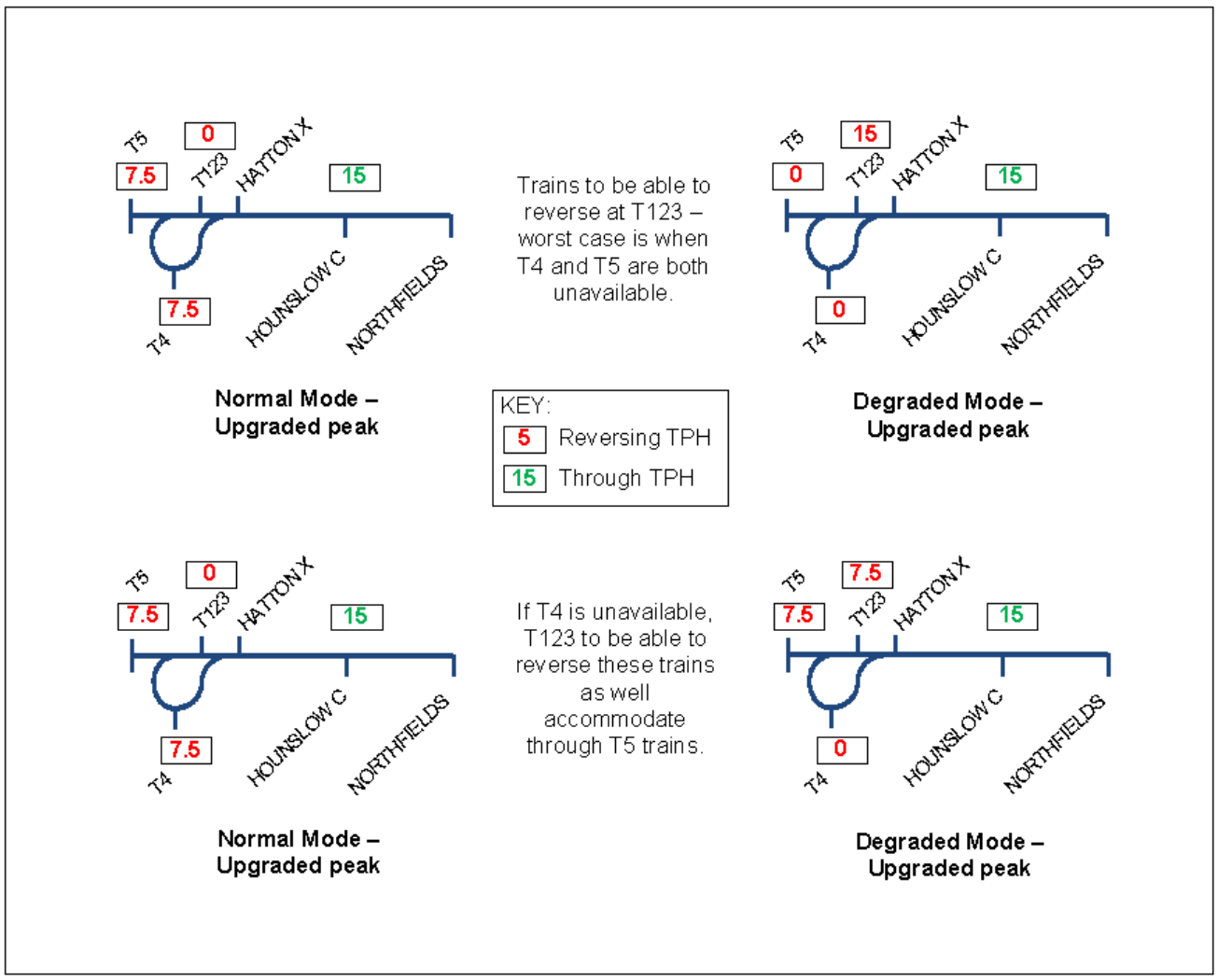
2.1.3 Tph Diagrams



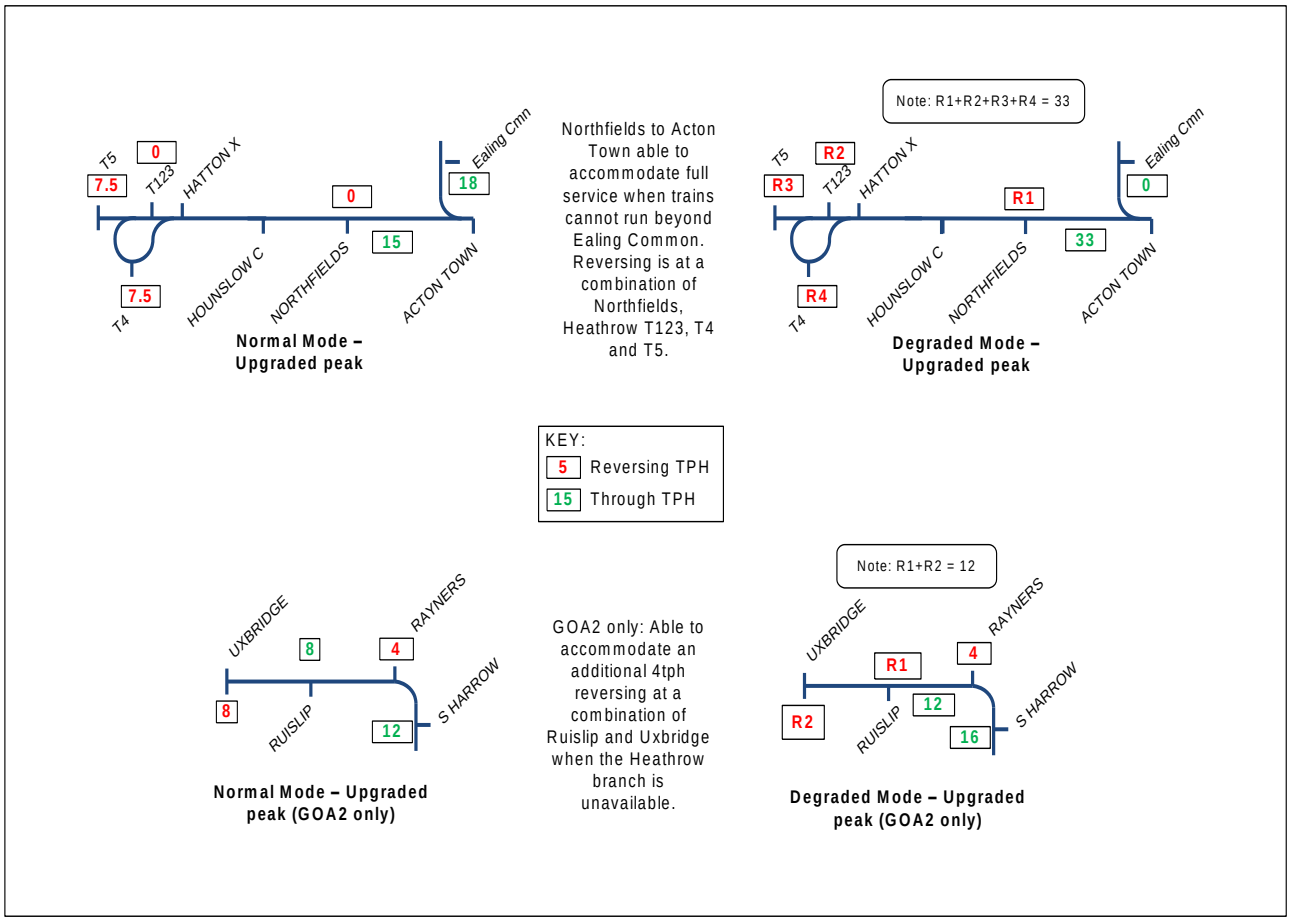
Upgraded Peak



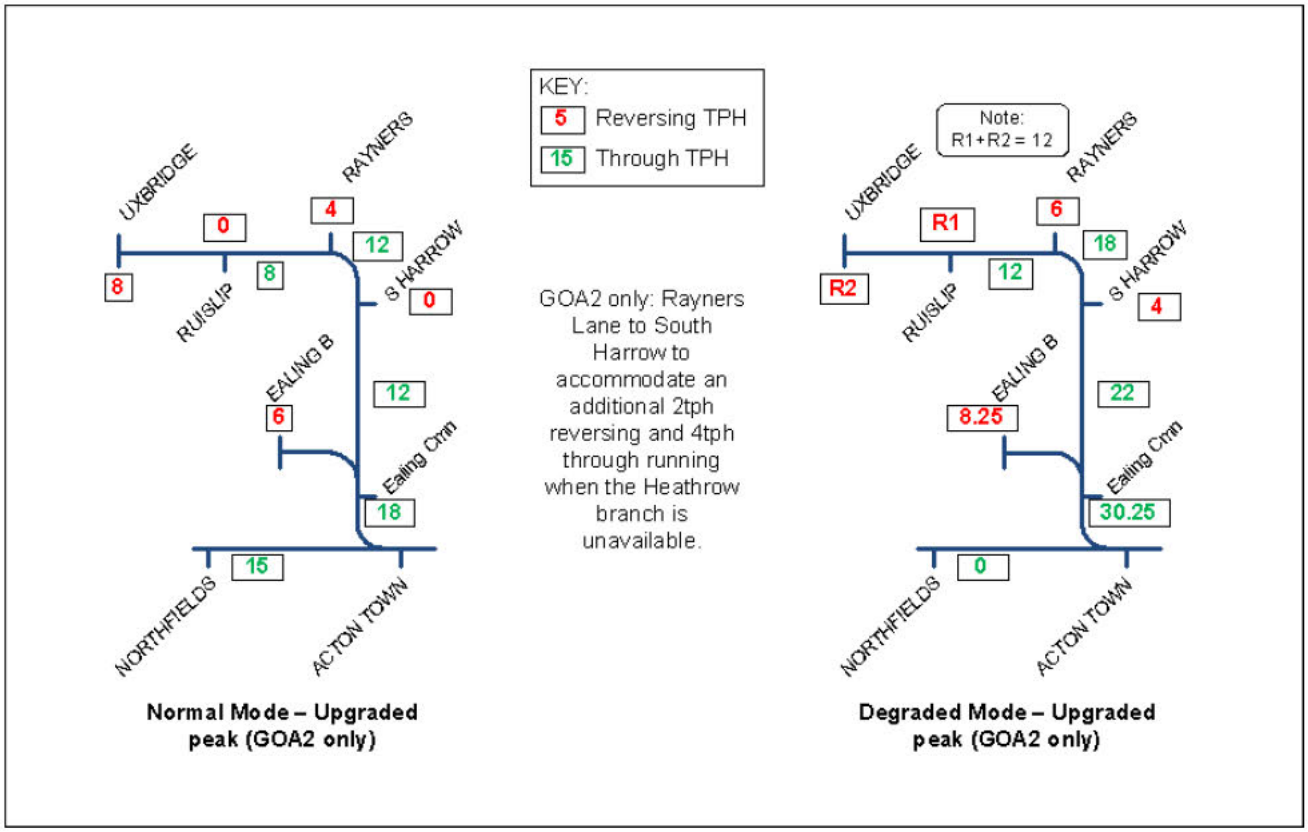
Upgraded Off Peak



Upgraded Degraded Modes (1 of 4)



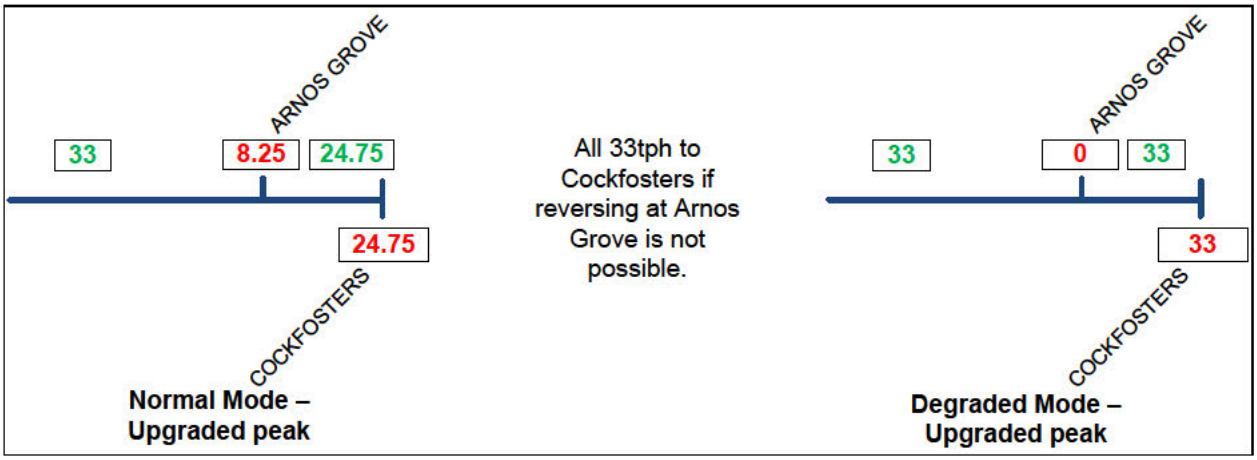
Upgraded Degraded Modes (2 of 4)



Normal Mode – Upgraded peak (GOA2 only)

Degraded Mode – Upgraded peak (GOA2 only)

Upgraded Degraded Modes (3 of 4)



Normal Mode – Upgraded peak

Degraded Mode – Upgraded peak

Upgraded Degraded Modes (4 of 4)

2.2 NTfL Inter-station Runtimes

This section denotes inter-station runtime information for the ***Key Benefit Stage P2.1***.

The runtimes in this section are indicative of *the Sponsor's* expectations to maximise runtime benefit. These values are based on **revision 14 of the Trains Data Assumptions Register** which at the time of writing, only considers typical performance characteristics associated with a generic moving block signalling system and candidate train. It should be noted that this data set does not include consideration of clearance infringement issues which could subsequently increase runtimes. It does however take into account initial forecasts of the impact of infrastructure mitigations to relieve air velocity impacts at the following seven locations; South Kensington, Knightsbridge, Green Park, Piccadilly Circus, Covent Garden, Russell Square and Caledonian Road. Further refinement of the impacts of these mitigations is currently being progressed and any resulting changes to the runtime set will be included in a future issue of this document.

In addition, as part of the signalling procurement, it may be necessary to trade off runtime to meet the reoccupation times required to achieve the desired service levels. This should be done in such a way that whole life cost and benefit are maximised. An allowance of 5% has been added to the simulated runtimes to cater for data input uncertainty which will be refined as performance attributes of the signalling and rolling stock systems become known as *the Programme* progresses.

Source Data:

- RT-PIC-008 Piccadilly Runtimes for TSM 24-09-2015.pdf modified with Picc SPR –IRIs – October 2016.xlxs.
- Picc SPR – IRIs – October 2016.xlsx reflects profile RS2; a combination of IB1 (the Vmax speed profile) and RS1 (where speeds were restricted for all in-tunnel links to maintain air speeds in line with today). From the West portal to South Kensington, the line would run at the RS1 profile; between South Kensington and Caledonian Road the line would run at IB1, then between Caledonian Road and the East portal the line would run at RS1. The only exception to this is between Eastbound between Barons Court and Earls Court where RS1 and IB1 are the same.
- Note: data includes a 5% allowance.

2.2.1 Eastbound

Link Name	NTfL Trip Time (Seconds) (Tare Weight) (5% Allowance)	NTfL Trip Time (Seconds) (4p/m2) (5% Allowance)	Pre-Upgrade Run Time (Seconds) (73TS, 575V, Tare Weight) (5% Allowance)
HeathrowTerminal5_P6 to HeathrowTerminals123_P2	134	135	187
HeathrowTerminals123_P2 to HattonCross_P2	126	129	176
HattonCross_P2 to HounslowWest_P2	160	161	209
HounslowWest_P2 to HounslowCentral_P2	102	103	124
HounslowCentral_P2 to HounslowEast_P2	73	73	75
HounslowEast_P2 to Osterley_2	80	80	91
Osterley_2 to BostonManor_2	139	140	170
BostonManor_2 to Northfields_3	91	92	109
Northfields_3 to South_Ealing_2	49	49	50
South_Ealing_2 to Acton_Town_3	145	146	186
Uxbridge_1 to Hillingdon_2	186	187	164
Uxbridge_2 to Hillingdon_2	170	170	N/A
Uxbridge_4 to Hillingdon_2	139	140	N/A
Hillingdon_2 to Ickenham_2	81	83	86
Ickenham_2 to Ruislip_2	113	115	127
Ruislip_2 to Ruislip_Manor_2	67	67	65
Ruislip_Manor_2 to Eastcote_2	84	85	92
Eastcote_2 to Rayners_Lane_2	107	108	119
Rayners_Lane_1 to South_Harrow_2	152	155	155

Sponsor's Programme Requirements – Piccadilly Line

Link Name	NTfL Trip Time (Seconds) (Tare Weight) (5% Allowance)	NTfL Trip Time (Seconds) (4p/m2) (5% Allowance)	Pre-Upgrade Run Time (Seconds) (73TS, 575V, Tare Weight) (5% Allowance)
Rayners_Lane_2 to South_Harrow_2	120	123	N/A
South_Harrow_2 to Sudbury_Hill_2	95	96	107
Sudbury_Hill_2 to Sudbury_Town_2	107	108	137
Sudbury_Town_2 to Alperton_2	100	102	120
Alperton_2 to Park_Royal_2	116	116	144
Park_Royal_2 to North_Ealing_2	79	80	92
North_Ealing_2 to Ealing_Common_2	86	86	98
Ealing_Common_2 to Acton_Town_3	86	87	106
Acton_Town_3 to Turnham_Green_3	141	141	N/A
Turnham_Green_3 to Hammersmith_3	145	146	N/A
Acton_Town_3 to Hammersmith_3	N/A	N/A	314
Hammersmith_3 to Barons_Court_3	74	75	73
Barons_Court_3 to Earls_Court_5	120	120	151
Earls_Court_5 to Gloucester_Road_5	71	71	81
Gloucester_Road_5 to South_Kensington_4	66	66	71
South_Kensington_4 to Knightsbridge_P1	121	122	144
Knightsbridge_P1 to HydeParkCorner_P1	53	53	63
HydeParkCorner_P1 to GreenPark_P2	85	85	106
GreenPark_P2 to PiccadillyCircus_P3	48	49	60
PiccadillyCircus_P3 to LeicesterSquare_P2	53	53	64
LeicesterSquare_P2 to CoventGarden_P2	33	34	41

Sponsor's Programme Requirements – Piccadilly Line

Link Name	NTfL Trip Time (Seconds) (Tare Weight) (5% Allowance)	NTfL Trip Time (Seconds) (4p/m2) (5% Allowance)	Pre-Upgrade Run Time (Seconds) (73TS, 575V, Tare Weight) (5% Allowance)
CoventGarden_P2 to Ho born_P4	59	59	78
Holborn_P4 to RussellSquare_P1	77	78	86
RussellSquare_P1 to KingsCross_P6	74	74	91
KingsCross_P6 to CaledonianRoad_P1	119	121	170
CaledonianRoad_P1 to HollowayRoad_P2	61	62	69
HollowayRoad_P2 to Arsenal_P1	69	70	78
Arsenal_P1 to FinsburyPark_P1	68	69	78
FinsburyPark_P1 to ManorHouse_P1	81	81	92
ManorHouse_P1 to TurnpikeLane_P1	138	139	169
TurnpikeLane_P1 to WoodGreen_P1	84	85	96
WoodGreen_P1 to BoundsGreen_P1	112	112	141
BoundsGreen_P1 to ArnosGrove_P1	130	130	140
BoundsGreen_P1 to ArnosGrove_P3	106	106	N/A
BoundsGreen_P1 to ArnosGrove_P4	131	131	N/A
ArnosGrove_P1 to Southgate_P1	155	157	178
ArnosGrove_P3 to Southgate_P1	130	131	N/A
Southgate_P1 to Oakwood_P2	118	120	163
Oakwood_P2 to Cockfosters_P1	105	106	N/A
Oakwood_P2 to Cockfosters_P2	119	120	N/A
Oakwood_P2 to Cockfosters_P4	137	138	153
Ealing_Broadway_7 to Ealing_Common_2	161	161	N/A

Link Name	NTfL Trip Time (Seconds) (Tare Weight) (5% Allowance)	NTfL Trip Time (Seconds) (4p/m2) (5% Allowance)	Pre-Upgrade Run Time (Seconds) (73TS, 575V, Tare Weight) (5% Allowance)
Ealing_Broadway_8 to Ealing_Common_2	158	158	N/A
Ealing_Broadway_9 to Ealing_Common_2	125	125	N/A

2.2.2 Westbound

Link Name	NTfL Trip Time (Seconds) (Tare Weight) (5% Allowance)	NTfL Trip Time (Seconds) (4p/m2) (5% Allowance)	Pre-Upgrade Run Time (Seconds) (73TS, 575V, Tare Weight) (5% Allowance)
Cockfosters_P1 to Oakwood_P1	124	124	N/A
Cockfosters_P2 to Oakwood_P1	96	97	N/A
Cockfosters_P4 to Oakwood_P1	112	113	120
Oakwood_P1 to Southgate_P2	115	115	132
Southgate_P2 to ArnosGrove_P3	130	130	N/A
Southgate_P2 to ArnosGrove_P4	122	122	150
ArnosGrove_P1 to BoundsGreen_P2	141	141	N/A
ArnosGrove_P3 to BoundsGreen_P2	133	133	N/A
ArnosGrove_P4 to BoundsGreen_P2	101	101	111
BoundsGreen_P2 to WoodGreen_P2	108	108	124
WoodGreen_P2 to TurnpikeLane_P2	78	78	88
TurnpikeLane_P2 to ManorHouse_P2	157	157	181
ManorHouse_P2 to FinsburyPark_P3	85	85	98
FinsburyPark_P3 to Arsenal_P2	70	71	75
Arsenal_P2 to HollowayRoad_P1	69	69	77
HollowayRoad_P1 to CaledonianRoad_P2	62	62	68
CaledonianRoad_P2 to KingsCross_P5	119	121	158
KingsCross_P5 to RussellSquare_P2	74	74	90
RussellSquare_P2 to Ho born_P3	67	67	75
Holborn_P3 to CoventGarden_P1	72	72	85
CoventGarden_P1 to LeicesterSquare_P1	33	33	41

Sponsor's Programme Requirements – Piccadilly Line

Link Name	NTfL Trip Time (Seconds) (Tare Weight) (5% Allowance)	NTfL Trip Time (Seconds) (4p/m2) (5% Allowance)	Pre-Upgrade Run Time (Seconds) (73TS, 575V, Tare Weight) (5% Allowance)
LeicesterSquare_P1 to PiccadillyCircus_P4	51	51	62
PiccadillyCircus_P4 to GreenPark_P1	52	52	67
GreenPark_P1 to HydeParkCorner_P2	81	82	101
HydeParkCorner_P2 to Knightsbridge_P2	50	50	63
Knightsbridge_P2 to South_Kensington_3	116	117	134
South_Kensington_3 to Gloucester_Road_4	73	74	77
Gloucester_Road_4 to Earls_Court_6	71	71	79
Earls_Court_6 to Barons_Court_2	144	144	159
Barons_Court_2 to Hammersmith_2	77	77	69
Hammersmith_2 to Acton_Town_2	N/A	N/A	319
Hammersmith_2 to Turnham_Green_2	151	152	N/A
Turnham_Green_2 to Acton_Town_2	156	158	N/A
Acton_Town_2 to Ealing_Common_1	110	110	113
Ealing_Common_1 to North_Ealing_1	89	89	102
North_Ealing_1 to Park_Royal_1	82	84	101
Park_Royal_1 to Alperton_1	115	117	143
Alperton_1 to Sudbury_Town_1	104	105	137
Sudbury_Town_1 to Sudbury_Hill_1	105	108	146
Sudbury_Hill_1 to South_Harrow_1	96	98	131
South_Harrow_1 to Rayners_Lane_1	115	116	137
Rayners_Lane_1 to Eastcote_1	111	112	120
Eastcote_1 to Ruislip_Manor_1	84	86	92

Link Name	NTfL Trip Time (Seconds) (Tare Weight) (5% Allowance)	NTfL Trip Time (Seconds) (4p/m2) (5% Allowance)	Pre-Upgrade Run Time (Seconds) (73TS, 575V, Tare Weight) (5% Allowance)
Ruislip_Manor_1 to Ruislip_1	64	65	65
Ruislip_1 to Ickenham_1	110	111	122
Ickenham_1 to Hillingdon_1	81	83	86
Hillingdon_1 to Uxbridge_1	171	173	190
Hillingdon_1 to Uxbridge_2	193	194	N/A
Hillingdon_1 to Uxbridge_4	182	184	N/A
Acton_Town_2 to South_Ealing_3	144	145	161
South_Ealing_3 to Northfields_2	48	48	50
Northfields_2 to BostonManor_1	87	87	92
BostonManor_1 to Osterley_1	142	144	175
Osterley_1 to HounslowEast_P1	79	80	92
HounslowEast_P1 to HounslowCentral_P1	66	67	75
HounslowCentral_P1 to HounslowWest_P1	97	98	112
HounslowWest_P1 to HattonCross_P1	160	160	205
HattonCross_P1 to HeathrowTerminals123_P1	134	136	171
HattonCross_P1 to HeathrowTerminal4_P1	99	100	136
HeathrowTerminal4_P1 to HeathrowTerminals123_P2	219	220	287
HeathrowTerminals123_P1 to HeathrowTerminal5_P5	134	135	194
Ealing_Common_1 to Ealing_Broadway_7	146	146	N/A
Ealing_Common_1 to Ealing_Broadway_8	108	109	N/A
Ealing_Common_1 to Ealing_Broadway_9	144	145	N/A

2.3 NTfL Boarding and Alighting Times

Tables in this section denote the Post-GOA2 implementation boarding and alighting times to be used in railway performance calculations.

Data in this section is measured in seconds and reflects both boarding and alighting times only and total stopping times which include static components. Static components included are shown below and may be optimised to reduce total stopping time.

Note that under GOA4 total stopping times would also include timings for PEDs and Gap Fillers which have not been included in the calculations below. These times should also be optimised to reduce total stopping time.

Note: Arnos Grove is currently a crew change location but may operate without Crew Change in the future in order to accommodate the higher service levels.

Note: For boarding and alighting times. at terminating stations more time may be required for layover.

Source Data:

- Transport Planning, S&SD (January 2016), based on forecast future demand.

2.3.1 Door Open/Close Times

Tabulated 'Total Stop Times' in this section, include the following static components which may be optimised for future performance:

Door Open Sequence:

Driver reacts to train stop and presses door open button: **0.62s**

Correct door Side Enable delay after train stop: **0s**

Driver presses door open button to doors open energised: **0.04s**

Doors fully energized to doors fully open: **1.90s**

Door Close / Train Start Sequence:

Driver presses door close, door alarm activated, door close enabled and doors full closed: **6.01s**

Driver reaction time to pressing start button: **0.89s**

Start button pressed to ATO demanding traction and brake release and motor effort overcomes brake effort: **1.60s**

2.3.2 Eastbound

Station	Boarding and Alighting Time Only (AM Peak) (Seconds)	Total Stop Time (AM Peak) (Seconds)	Boarding and Alighting Time Only (PM Peak) (Seconds)	Total Stop Time (PM Peak) (Seconds)	Boarding and Alighting Time Only (Off Peak) (Seconds)	Total Stop Time (Off Peak) (Seconds)
Hillingdon	10.1	21.1	10.1	21.1	10.1	21.1
Ickenham	10.1	21.1	10.1	21.1	10.1	21.1
Ruislip	11.0	22.1	10.1	21.1	10.1	21.1
Ruislip Manor	10.7	21.8	10.3	21.4	10.1	21.1
Eastcote	11.0	22.1	10.1	21.1	10.2	21.3
Rayners Lane	15.1	26.2	12.5	23.6	11.1	22.2
South Harrow	14.8	25.8	12.2	23.3	11.9	22.9
Sudbury Hill	14.5	25.6	12.1	23.1	11.6	22.6
Sudbury Town	15.4	26.4	11.1	22.2	11.0	22.0
Alperton	16.4	27.5	13.1	24.2	12.1	23.1
Park Royal	14.7	25.8	11.7	22.7	10.6	21.7
North Ealing	13.1	24.2	10.1	21.1	10.1	21.1
Ealing Common	18.3	29.4	13.0	24.0	12.4	23.4
Heathrow T5	11.5	22.6	12.0	23.1	12.2	23.2
Heathrow T123	11.6	22.7	11.9	23.0	12.8	23.8
Hatton Cross	11.7	22.8	11.9	22.9	10.8	21.9
Hounslow West	14.2	25.2	10.4	21.5	11.3	22.3
Hounslow Central	15.7	26.8	12.3	23.3	11.7	22.7
Hounslow East	14.1	25.2	11.8	22.8	11.1	22.2
Osterley	14.1	25.1	11.4	22.4	10.1	21.1

Sponsor's Programme Requirements – Piccadilly Line

Station	Boarding and Alighting Time Only (AM Peak) (Seconds)	Total Stop Time (AM Peak) (Seconds)	Boarding and Alighting Time Only (PM Peak) (Seconds)	Total Stop Time (PM Peak) (Seconds)	Boarding and Alighting Time Only (Off Peak) (Seconds)	Total Stop Time (Off Peak) (Seconds)
Boston Manor	14.2	25.2	11.1	22.2	10.1	21.1
Northfields	19.7	30.8	12.9	23.9	10.1	21.1
Northfields with Crew Change	32.1	43.1	32.1	43.1	32.1	43.1
South Ealing	18.0	29.1	12.6	23.7	10.1	21.1
Acton Town	21.1	32.1	15.3	26.3	14.2	25.2
Acton Town with Crew Change	32.1	43.1	32.1	43.1	32.1	43.1
Turnham Green	19.1	30.2	12.4	23.4	10.1	21.1
Hammersmith	29.8	40.8	21.5	32.6	16.7	27.8
Barons Court	18.8	29.9	14.8	25.9	12.7	23.8
Earl's Court	27.1	38.2	20.6	31.7	16.4	27.5
Gloucester Road	14.6	25.7	14.2	25.3	11.3	22.3
South Kensington	19.5	30.6	20.6	31.7	15.9	26.9
Knightsbridge	16.4	27.5	22.2	33.3	17.5	28.6
Hyde Park Corner	13.1	24.2	14.9	25.9	12.1	23.1
Green Park	24.1	35.1	25.2	36.3	18.8	29.9
Piccadilly Circus	16.9	27.9	23.6	34.7	18.8	29.8
Leicester Square	18.8	29.9	24.7	35.7	18.2	29.3
Covent Garden	12.8	23.8	19.4	30.4	16.1	27.1
Ho born	20.6	31.7	29.4	40.5	19.9	31.0
Russell Square	13.6	24.6	18.8	29.9	14.0	25.1
Kings Cross	20.3	31.4	30.6	41.7	20.1	31.1

Sponsor's Programme Requirements – Piccadilly Line

Station	Boarding and Alighting Time Only (AM Peak) (Seconds)	Total Stop Time (AM Peak) (Seconds)	Boarding and Alighting Time Only (PM Peak) (Seconds)	Total Stop Time (PM Peak) (Seconds)	Boarding and Alighting Time Only (Off Peak) (Seconds)	Total Stop Time (Off Peak) (Seconds)
Caledonian Road	12.6	23.6	14.4	25.5	11.2	22.2
Holloway Road	12.8	23.9	13.9	25.0	11.9	22.9
Arsenal	10.2	21.3	11.0	22.1	10.1	21.1
Finsbury Park	17.0	28.1	31.5	42.5	16.7	27.7
Manor House	12.4	23.5	15.2	26.3	11.6	22.7
Turnpike Lane	12.7	23.8	16.3	27.4	12.7	23.8
Wood Green	14.2	25.2	16.8	27.9	12.7	23.7
Bounds Green	11.4	22.5	13.2	24.3	10.1	21.1
Arnos Grove	11.4	22.4	12.6	23.7	10.6	21.7
Arnos Grove with Crew Change	32.1	43.1	32.1	43.1	32.1	43.1
Southgate	12.3	23.3	13.3	24.3	11.6	22.6
Oakwood	10.1	21.1	11.3	22.4	10.1	21.1
Cockfosters	13.1	24.2	13.0	24.1	11.3	22.3

2.3.3 Westbound

Station	Boarding and Alighting Time Only (AM Peak) (Seconds)	Total Stop Time (AM Peak) (Seconds)	Boarding and Alighting Time Only (PM Peak) (Seconds)	Total Stop Time (PM Peak) (Seconds)	Boarding and Alighting Time Only (Off Peak) (Seconds)	Total Stop Time (Off Peak) (Seconds)
Uxbridge	15.1	26.2	13.9	24.9	13.3	24.3
Hillingdon	10.1	21.1	10.2	21.2	10.1	21.1
Ickenham	10.1	21.1	10.1	21.1	10.1	21.1
Ruislip	10.1	21.1	10.1	21.1	10.1	21.1
Ruislip Manor	11.8	22.8	10.1	21.1	10.1	21.1
Eastcote	11.3	22.4	10.1	21.1	10.1	21.1
Rayners Lane	11.3	22.4	12.2	23.3	12.2	23.3
South Harrow	12.1	23.2	13.4	24.5	11.3	22.3
Sudbury Hill	12.3	23.3	13.8	24.8	10.5	21.6
Sudbury Town	10.7	21.7	13.4	24.4	10.9	21.9
Alperton	12.3	23.4	14.7	25.8	11.9	22.9
Park Royal	12.9	24.0	13.2	24.2	10.7	21.8
North Ealing	10.7	21.8	10.3	21.4	10.1	21.1
Ealing Common	13.4	24.5	16.0	27.0	11.3	22.4
Heathrow T4	10.1	21.1	14.8	25.9	12.1	23.2
Heathrow T5	12.5	23.6	12.6	23.7	12.7	23.7
Heathrow T123	15.3	26.4	15.2	26.3	15.8	26.9
Hatton Cross	13.2	24.2	13.3	24.4	10.8	21.9
Hounslow West	11.2	22.2	13.3	24.4	11.2	22.3
Hounslow Central	11.2	22.3	13.4	24.4	11.1	22.1

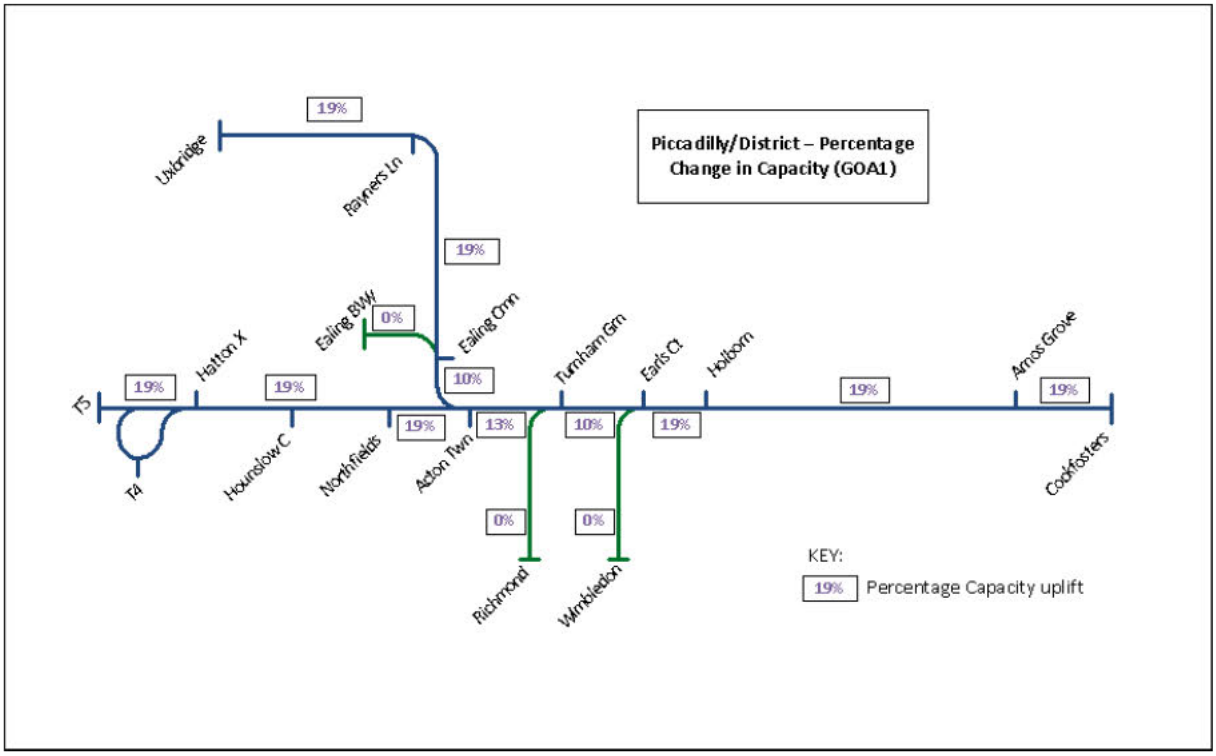
Sponsor's Programme Requirements – Piccadilly Line

Station	Boarding and Alighting Time Only (AM Peak) (Seconds)	Total Stop Time (AM Peak) (Seconds)	Boarding and Alighting Time Only (PM Peak) (Seconds)	Total Stop Time (PM Peak) (Seconds)	Boarding and Alighting Time Only (Off Peak) (Seconds)	Total Stop Time (Off Peak) (Seconds)
Hounslow East	15.2	26.2	15.4	26.4	12.3	23.4
Osterley	10.9	22.0	12.4	23.5	10.1	21.2
Boston Manor	12.6	23.7	12.1	23.2	10.1	21.1
Northfields with Crew Change	32.1	43.1	32.1	43.1	32.1	43.1
Northfields	11.7	22.8	14.3	25.3	10.1	21.1
South Ealing	12.6	23.7	14.4	25.4	10.1	21.1
Acton Town with Crew Change	32.1	43.1	32.1	43.1	32.1	43.1
Acton Town	15.2	26.2	16.5	27.5	12.9	23.9
Turnham Green	12.5	23.6	14.2	25.3	10.4	21.4
Hammersmith	19.1	30.1	23.9	34.9	15.9	27.0
Barons Court	15.6	26.6	15.5	26.5	12.2	23.2
Earl's Court	18.4	29.5	20.7	31.8	14.8	25.9
Gloucester Road	13.2	24.3	15.4	26.4	12.0	23.0
South Kensington	17.8	28.9	18.7	29.8	15.6	26.7
Knightsbridge	15.4	26.5	19.0	30.1	16.4	27.4
Hyde Park Corner	12.0	23.0	13.8	24.9	11.6	22.7
Green Park	24.4	35.5	26.9	38.0	17.8	28.8
Piccadilly Circus	17.5	28.6	23.9	34.9	18.3	29.3
Leicester Square	21.8	32.9	24.9	36.0	17.4	28.5
Covent Garden	13.7	24.7	19.6	30.6	16.1	27.1
Ho born	27.7	38.8	25.3	36.3	19.9	30.9

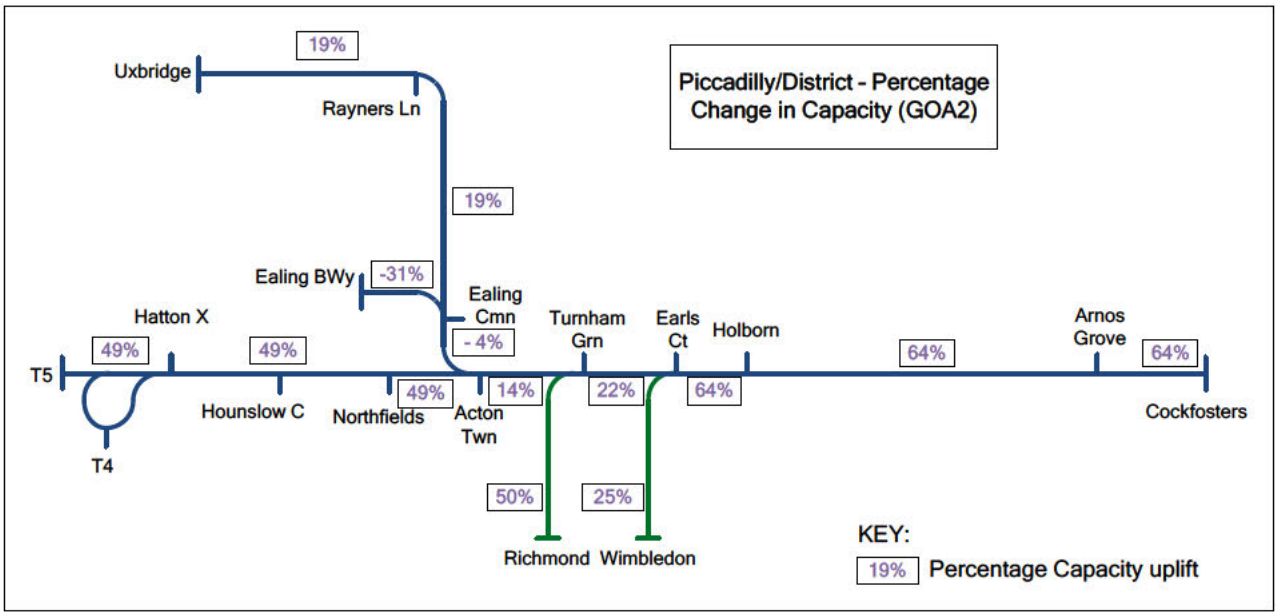
Sponsor's Programme Requirements – Piccadilly Line

Station	Boarding and Alighting Time Only (AM Peak) (Seconds)	Total Stop Time (AM Peak) (Seconds)	Boarding and Alighting Time Only (PM Peak) (Seconds)	Total Stop Time (PM Peak) (Seconds)	Boarding and Alighting Time Only (Off Peak) (Seconds)	Total Stop Time (Off Peak) (Seconds)
Russell Square	16.4	27.5	16.2	27.3	13.7	24.8
Kings Cross	36.9	48.0	27.9	38.9	22.2	33.3
Caledonian Road	17.3	28.3	11.3	22.4	10.5	21.6
Holloway Road	17.2	28.3	12.7	23.8	11.8	22.8
Arsenal	14.3	25.4	10.7	21.7	10.2	21.3
Finsbury Park	36.0	47.0	19.5	30.6	17.4	28.4
Manor House	19.4	30.4	12.1	23.2	12.2	23.2
Turnpike Lane	18.4	29.5	12.9	24.0	12.4	23.4
Wood Green	16.3	27.4	13.0	24.1	13.6	24.6
Bounds Green	14.1	25.2	11.0	22.1	10.4	21.4
Arnos Grove with Crew Change	32.1	43.1	32.1	43.1	32.1	43.1
Arnos Grove	13.6	24.7	12.8	23.9	11.1	22.2
Southgate	13.6	24.6	11.6	22.7	11.1	22.2
Oakwood	11.3	22.4	10.5	21.6	10.1	21.1

2.4 NTfL Capacity Uplift



GOA1 Percentage Capacity Uplift Diagram



GOA2 Percentage Capacity Uplift Diagram

3 Output Requirements

3.1 New Passenger Rolling Stock

Requirement	Rationale	Business Level Trace
The *Piccadilly line* passenger services shall be operated entirely by a new train fleet (hereafter referred to as *NTfL Trains*) by *Key Benefit Stage* ***P1***. **SPR-PL-31**	New trains are recognised as required to meet the core capacity uplift objective, and are required in time to meet the business case expectation of an uplift in the service in the May 2026 timetable change.	BLR 03 - Renew Passenger Rolling Stock
The *Piccadilly line NTfL Trains* shall be capable of boarding and alighting passengers at stations without needing to extend the length of platforms or needing to employ Selective Door Opening (SDO). **SPR-PL-38**	This requirement aims to avoid the need to extend existing platforms or introduce selective door opening (SDO) to the train for its operational life.	BLR 08 - Improve Customer Experience BLR 17 - Provide Value for Money
Supplementary Information for SPR-PL-38: *The lengths of Piccadilly line platforms shall not be extended.*		
The internal temperature of the *Piccadilly line NTfL Trains* shall be managed to not exceed 26°C. **SPR-PL-41**	Ambience improvements will be achieved by enhancements to the customer environment on board the train through the introduction of new cooling systems. 26 Degree figure extracted from the Air Cooling Summary Report - DTP-UIP1973-1.5-RPT-00009	BLR 07 - Provide Modern and Reconfigurable New Train Features BLR 08 - Improve Customer Experience
Supplementary Information for SPR-PL-41: *The conditions under which this is measured are: tunnel temperature at 30 °C and a passenger loading of all seats taken and standees at 2 per m^2.*		
Supplementary Information for SPR-PL-41: *The Programme is required to support the NTfL Train saloon cooling requirements.*		
The *Piccadilly Line NTfL Train* shall be provided with operator cabs that can be reconfigured into passenger space to match the internal aesthetic design of the saloon. **SPR-PL-344**	Once unattended operation is viable on a NTfL line the drivers space could be better utilised as passenger carrying capacity.	BLR 07 - Provide Modern and Reconfigurable New Train Features

Requirement	Rationale	Business Level Trace
The *Piccadilly line NTfL Trains* shall interface with the new NTfL signalling and command and control systems to facilitate *GOA2* and *GOA4* operation. **SPR-PL-33**	Aligns with the current control strategy.	BLR 01 - Renew Railway Control Systems
Supplementary Information for SPR-PL-33: *When the new trains are introduced in GOA1, the service and legacy signalling will be controlled by the PICU control system based at South Kensington.*		
The design of the *Piccadilly line NTfL Train* shall not prohibit the implementation of Customer accessible radio based networks (e.g. WiFi) across the *Piccadilly line*. **SPR-PL-240**	To align with and not impede the corporate LU strategy to provide customer data currently through wireless technology.	BLR 07 - Provide Modern and Reconfigurable New Train Features BLR 08 - Improve Customer Experience BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term
Supplementary Information for SPR-PL-240: *Customer accessible radio based networks will be provided by the Information Communications Telecoms (ICT) Transformation Programme.*		
Three *Piccadilly Line NTfL Trains* shall have space and power supply provision for Remote Track Monitoring (RTM) equipment to be fitted. **SPR-PL-251**	Improves safety by eliminating need for manual track patrol/inspection and improves data quality leading to reduced WLC for track maintenance.	BLR 12 - Improve System Reliability BLR 14 - Maintain or Enhance Pre-upgrade Levels of Safety and Security BLR 17 - Provide Value for Money
Supplementary Information for SPR-PL-251: *Remote Track Monitoring (RTM) equipment is currently being fitted by "Legacy Train Systems"; however this Project will be closed by the time NTfL Trains are available.* *The Sponsor will advise the Programme as to who will fit this equipment in due course. The NTfL Programme will be required to liaise with the respective Project once identified to acquire the relevant technical data to facilitate this requirement.*		

3.2 Automation

3.2.1 GOA2 Capability

Requirement	Rationale	Business Level Trace
Passenger services will be operated using *GOA2* train control across the entire *Piccadilly line* by *Key Benefit Stage* ***P2.1***. SPR-PL-50	Supports the benefits in the Business Case.	BLR 06 - Provide Increased Service Levels BLR 12 - Improve System Reliability BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term
Supplementary Information for SPR-PL-50: *This includes the interoperable section with the Metropolitan line. Where the Piccadilly line interoperates with the Metropolitan line, GOA2 shall be the end state capability as it is currently not possible to interoperate a GOA4 service with the Metropolitan line.*		

3.2.2 GOA4 Capability

Requirement	Rationale	Business Level Trace
Passenger services will be operated using *GOA4* train control across the entire *Piccadilly line* except for where it interoperates with the Metropolitan line by *Key Benefit Stage* ***P3.1.*** SPR-PL-47	Supports the benefits in the Business Case. Reduction in operational costs and improved reliability due to reduction in human error.	BLR 09 - Enable Ops and Maintenance Cost Reduction BLR 12 - Improve System Reliability
Supplementary Information for SPR-PL-47: *This includes all command and control, operational, maintenance and business supporting functions.*		

3.2.3 Signalling

Requirement	Rationale	Business Level Trace
A new signalling system shall be provided across the *Piccadilly line* to facilitate the capability requirements defined herein for *Key Benefit Stage* ***P2.1*** and beyond. SPR-PL-99	New signalling is recognised as required to meet the core capacity uplift objective, and as required in time to meet the business case expectation to uplift the service in the timetable change associated with ***P2.1***.	BLR 02 - Renew Signalling BLR 05 - Enable Service Pattern Changes BLR 06 - Provide Increased Service Levels BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term
The new signalling system shall contain capability for a future enhanced service offering.	It is envisaged that a 36tph peak (central section) Piccadilly line service offering may be desirable	BLR 02 – Renew Signalling BLR 06 – Provide Increased

Requirement	Rationale	Business Level Trace
SPR-PL-477	in the future.	Service Levels

3.2.4 Platform-Train Interface (PTI)

Requirement	Rationale	Business Level Trace
All *Piccadilly line* platform train interfaces shall comply with the Rail Vehicle Accessibility Regulations (RVAR) by *Key Benefit Stage* ***P1***. SPR-PL-68	RVAR compliance at the PTI allows the safe boarding and alighting of a mobility impaired customer. This is a legal requirement. An engineered solution is expected as this provides least whole life cost.	BLR 08 - Improve Customer Experience BLR 14 - Maintain or Enhance Pre-upgrade Levels of Safety and Security
Supplementary Information to SPR-PL-68: *Where possible, RVAR PTI solutions should be passive and not require maintenance intervention above pre-upgrade levels or require operator assistance that risks impacting the service levels.*		
A Safe PTI solution (or solutions) shall be provided at all NTfL platforms for all interim stages of migration including during *GOA2* operation and whilst *'73 Tube Stock* is interoperating with new *NTfL Trains*. SPR-PL-66	Experience of 4LM when introducing S-Stock provided a worsening of the PTI, the risks of which had to be mitigated retrospectively.	BLR 14 - Maintain or Enhance Pre-upgrade Levels of Safety and Security
A Safe PTI solution shall be provided for *Piccadilly line NTfL Trains* and Metropolitan line services at all interoperable Metropolitan line platforms. SPR-PL-67	Recognised that there are significant differences between S-Stock and the NTfL Trains for which PTI risks would need to be simultaneously mitigated.	BLR 14 - Maintain or Enhance Pre-upgrade Levels of Safety and Security
A safe automated PTI solution shall be provided at all platforms where *GOA4 Piccadilly line* services will operate. SPR-PL-65	Removing a train operator from the train introduces risks (such as dragging) to passengers at the PTI. The Programme is required to mitigate these risks through implementation of a technical solution such that the risk is no greater (or less) than today. Reliance on staff to manage or supervise the PTI negates the benefits of automating the service.	BLR 14 - Maintain or Enhance Pre-upgrade Levels of Safety and Security

Requirement	Rationale	Business Level Trace
At GOA4 *Piccadilly line* platforms the maximum horizontal stepping distance between the platform and the train at all doorways shall not exceed 100mm. **SPR-PL-189**	At curved platforms where level access is provided, horizontal stepping distances increase. Where this is significant, the risk of falling between the train and the platform edge increases. The risk of the hazard is required to be reduced at both curved and straight platforms. Note that the 100mm and 120mm safety limits were agreed at DRACCT (Log #01965) DTP-UIP1973-1.3-RPT-00031 Livelink: 322240319	BLR 14 - Maintain or Enhance Pre-upgrade Levels of Safety and Security
Supplementary Information to SPR-PL-189: *Where it is not reasonably practicable at a specific location to achieve a gap less than or equal to 100mm, the Programme Board will consider a derogation to this requirement, however the absolute maximum distance shall not exceed 120mm. This does not apply to wheelchair specific access doors which are covered by an RVAR requirement for a horizontal gap 75mm or less.*		

3.3 Service Capability

Requirement	Rationale	Business Level Trace
The Programme shall deliver the required ramp up and ramp down levels to meet the *Piccadilly line* peak service levels as defined within the *Candidate System*. **SPR-PL-296**	Provides assurance that the benefits aligned to the timetable can be achieved.	BLR 06 - Provide Increased Service Levels BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term

3.3.1 West London Services

The requirements cited in this section refer to the proposed service pattern change for the West London area whereby a 6tph Piccadilly line peak service will be routed to Ealing Broadway and the equivalent District line service will be re-distributed to the Richmond and Wimbledon branches providing much needed extra capacity. This service pattern change is both essential to enable future GOA4 operation on the Piccadilly line and financially positive in business case terms for GOA2 and GOA4 operation. It is therefore strongly recommended for implementation regardless of the final level of automation delivered on the Piccadilly line.

These requirements can be considered as 'pending' until the analysis requested by Sponsor Instruction #16 'Feasibility study: West London Services' concludes. This work is constrained by a dependence on delivery of Network Rail modelling and infrastructure analysis, which is expected in January 2017. Once the feasibility outcome is known the requirements in this section will be formalised. In the meantime, the Programme has accounted for an additional three trains of risk in case the service pattern change cannot be delivered. These additional trains are required to support service to other termini on the Piccadilly line, which are further away. Should the analysis under SI-016 demonstrate that the service pattern change is achievable (and deliverable) then the three trains of risk will not ne required (refer to Sponsor Instruction #21 'Sponsor's Direction for NTfL Programme Baseline').

Requirement	Rationale	Business Level Trace
GOA2 *Piccadilly line* passenger services shall be extended to Ealing Broadway by *Key Benefit Stage* ***P2.1***. **SPR-PL-182**	This service pattern change has a significant positive impact on the NTfL Business Case.	BLR 05 - Enable Service Pattern Changes
Supplementary Text for SPR-PL-182: *The District line service levels on the Wimbledon and Richmond branches will be augmented following the withdrawal of the Ealing Broadway service and its replacement by Piccadilly line trains.*		
Supplementary Text for SPR-PL-182: *District line passenger services shall no longer call at the following stations after the change has been enacted.* · *Acton Town* · *Ealing Common* · *Ealing Broadway*		
Supplementary Text for SPR-PL-182: *The service pattern change will be enacted via timetable change once a 30 tph peak (central section) Piccadilly line service is also timetabled.*		

Requirement	Rationale	Business Level Trace
Supplementary Text for SPR-PL-182: *The capacity uplifts to the Richmond and Wimbledon branches as a result of the service pattern change may involve the following mitigations, which could be applied cumulatively (in order of preference): No mitigations; best platform and scheduled move combination along each branch; standing over points; reduced recovery margin (this margin should be declared if applied); application of an at rest RORIT along each branch.*		
The *Piccadilly line* Ealing Broadway branch shall operate a ***GOA4*** passenger service by *Key Benefit Stage* ***P3.1***. **SPR-PL-60**	Supports the benefits in the Business Case. Reduction in operational costs and improved reliability due to reduction in human error.	BLR 09 - Enable Ops and Maintenance Cost Reduction BLR 12 - Improve System Reliability
A passenger service shall be retained at Chiswick Park at end state and during migration **SPR-PL-184**	To retain a passenger service to this location post service pattern change.	BLR 05 - Enable Service Pattern Changes
Supplementary Text for SPR-PL-184: *It is recognised that the platforms at Chiswick Park may need to be relocated to the Richmond Branch.*		
The District line Ealing Broadway service shall be distributed such that S-Stock trains are routed along the Wimbledon branch (taking the peak service to 20 tph total) and along the Richmond branch (taking the peak service pattern (including 4 tph LOROL) to 16 tph). **SPR-PL-376**	This service pattern change has a significant positive impact on the NTfL Business Case.	BLR 05 - Enable Service Pattern Changes
The Programme shall provide any additional power over and above the 4LM end state power solution necessary to support the District Line service pattern changes as described within SPR-PL-376. **SPR-PL-405**	This service pattern change has a significant positive impact on the NTfL Business Case.	BLR 05 - Enable Service Pattern Changes
Supplementary Text for SPR-PL-405: *The Programme should assume that 4LM deliver sufficient infrastructure and power to support the service levels at the end-state of the Thales signalling contract.*		
Access for entry to, and exit from, Ealing Common Depot (both east and west ends) for out of service District line S-Stock trains shall be retained at end state and during migration. **SPR-PL-198**	The NTfL programme must not introduce operational restrictions to other lines to deliver requirements and objectives.	BLR 05 - Enable Service Pattern Changes
Piccadilly line through services shall be upheld being cognisant of S-Stock trains accessing and exiting Ealing Common Depot at end state and during migration.	The NTfL programme must not introduce operational restrictions to other lines to deliver requirements and objectives.	BLR 05 - Enable Service Pattern Changes

Requirement	Rationale	Business Level Trace
SPR-PL-227		
Supplementary Text for SPR-PL-227: *The Programme will need to interface with the 4LM Programme to ensure that the Piccadilly line services and District line services are capable of operating together.*		
Safe systems of work, including guideway protection, shall be employed where *GOA4 Piccadilly line* services interoperate with the District line. SPR-PL-192	Recognised that the District Line cannot work with GOA4 PTI solution.	BLR 14 - Maintain or Enhance Pre-upgrade Levels of Safety and Security

Note that 4LM Signalling will remove the possibility of interoperation of Piccadilly and District line passenger trains between Acton Town and Barons Court (the two lines shall operate independently). The NTfL Programme is not required to re-introduce these line transfers. Engineering Vehicles will still be required to make signalled moves between lines as at present.

3.3.2 Continuation of Piccadilly Line Service

Requirement	Rationale	Business Level Trace
The *Piccadilly line* shall continue to provide a full passenger service throughout the duration of the *Programme* except where closures have been agreed with the *Sponsor* or as part of planned maintenance regimes. **SPR-PL-139**	Closures have a negative impact on the business both financially and reputational.	BLR 15 - Manage Access to Minimise Closures and Possessions

3.3.3 Recovery Margins

Requirement	Rationale	Business Level Trace
A **15 second** operational margin per headway reoccupation time shall be included in the *Piccadilly line NTfL System* design. **SPR-PL-245**	The margin is principally there to allow for the fact that when we do a static capacity calculation we use a single dwell time value, but in practice dwells actually vary on the railway – 15 seconds is a large enough margin that dwell variability will only rarely cause impedance, so the scheduled tph and scheduled (unimpeded) runtimes should be consistently achievable in normal service; designing the signalling capacity to support a 15 second margin at full-speed unimpeded running is therefore desirable if technologically possible.	BLR 06 - Provide Increased Service Levels

3.4 Infrastructure

3.4.1 End State Track Layout (ESTL)

Requirement	Rationale	Business Level Trace
The Programme shall modify track infrastructure on the Piccadilly line as per the detail provided in the latest version of the **NTfL Piccadilly line Track Vision** - Document Reference: NTfL-2344.5.15-LUL-DWG-00002. **SPR-PL-402**	This provides clarity of SR-233 in the Sponsor's Remit. By optimising and rationalising infrastructure, operational and maintenance costs should be reduced whilst improving reliability. ESTL Livelink reference: http://docmanager.onelondon.tfl.local/livelink/llisapi.dll?func=ll&objId=342391065&objAction=browse	BLR 04 - Renew or Upgrade Supporting Assets, Systems, Interfaces and Infrastructure BLR 09 - Enable Ops and Maintenance Cost Reduction BLR 12 - Improve System Reliability BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term
Any changes to be made by *the Programme* to the **NTfL Piccadilly line Track Vision** shall be approved by *the Sponsor*. **SPR-PL-461**	This aims to safeguard the whole life cost of the infrastructure. ESTL: Document Reference: NTfL-2344.5.15-LUL-DWG-00002. ESTL Livelink reference: http://docmanager.onelondon.tfl.local/livelink/llisapi.dll?func=ll&objId=342391065&objAction=browse	BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term BLR 17 - Provide Value for Money
The Programme shall ensure the continued availability (including retention of existing track access) of the ***South Ealing Test Track (SETT)*** for the purposes of LU passenger rolling stock brake testing. **SPR-PL-403**	The SETT provides the environment for all LU passenger rolling stock brake testing described in 'Passenger Rolling Stock' Cat 2 Standard S2180 (Issue A2) Section X3.4.2.	BLR 17 - Provide Value for Money
The Programme shall undertake the infrastructure work necessary to remove the pre-upgrade speed restriction in place on the *Piccadilly line* westbound road between Baron's Court and Hammersmith. **SPR-PL-455**	Removal of the speed restriction will enable the service level requirement to be achieved.	BLR 06 - Provide Increased Service Levels
Supplementary Information for SPR-PL-455: *This speed restriction is in place to due to a Chief Engineers Regulatory Notice (CERN).*		

3.4.2 Platform Cooling

Requirement	Rationale	Business Level Trace
Where Tunnel and Public Area Cooling (TPAC) solutions have been employed for *Piccadilly Line* platforms the respective platform temperature shall not exceed **30°C**. **SPR-PL-250**	Compliments LU Cat 1 Standard S1067.	BLR 08 - Improve Customer Experience BLR 13 - Provide Tunnel / Public Area Cooling Solutions
All *Piccadilly line* Tunnel and Public Area Cooling (TPAC) solutions shall be implemented by *Key Benefit Stage* ***P2.1*** where applicable. **SPR-PL-249**	Service levels will have increased at this point, and therefore cooling solutions need to be in place before P2.1.	BLR 08 - Improve Customer Experience BLR 13 - Provide Tunnel / Public Area Cooling Solutions

3.5 Service Reliability and Customer Experience

Requirement	Rationale	Business Level Trace
The *Piccadilly line* shall be capable of operating a degraded service in the event of failures as opposed to no service where practicable. **SPR-PL-195**	Aiming to retain a service, rather than no service upon asset/system failure for the customer.	BLR 08 - Improve Customer Experience BLR 12 - Improve System Reliability
The number of *Service Affecting Failures* (SAFs), *Platform Wait Times (uwPWTs)* and *On Train Times (uwOTTs)* on the *Piccadilly line* from *Key Benefit Stage* **P1** to *Key Benefit Stage* **P2.1** shall not exceed the targets and tolerances as per the table below (SPR-PL-474). **SPR-PL-59**	The introduction of new, more reliable rolling stock on the Piccadilly line will have a positive impact on system reliability as measured by SAFs. The bedding in period for the full fleet is not likely to be complete before the impacts of the new signalling take effect.	BLR 08 - Improve Customer Experience BLR 12 - Improve System Reliability
The number of *Service Affecting Failures* (SAFs), *Platform Wait Times (uwPWTs)* and *On Train Times (uwOTTs)* on the *Piccadilly line* from *Key Benefit Stage* **P2.1** to *Key Benefit Stage* **P3.1** shall not exceed the targets and tolerances as per the table below (SPR-PL-475). **SPR-PL-153**	The Introduction of new, reliable signalling in addition to the already more reliable rolling stock on the Piccadilly line will have a positive impact on system reliability as measured by SAFs.	BLR 08 - Improve Customer Experience BLR 12 - Improve System Reliability

Requirement	Rationale	Business Level Trace
The number of *Service Affecting Failures* (SAFs), *Platform Wait Times (uwPWTs)* and *On Train Times (uwOTTs)* on the *Piccadilly line* from *Key Benefit Stage* **P3.1** onward shall not exceed the targets and tolerances as per the table below (SPR-PL-476). **SPR-PL-150**	The introduction of fully automated systems on the Piccadilly line will remove potential for human error and human delay.	BLR 08 - Improve Customer Experience BLR 12 - Improve System Reliability

Supplementary Information for SPR-PL-59, 150 and 153: *Following the Victoria Line Upgrade, it was found that the service uplift resulted in increased problems with disturbance and accumulation of tunnel dust; this has an impact on equipment reliability. The Programme should ensure that the NTfL System provides sufficient resilience with respect to additional dust disturbance and generation as a result of the NTfL capacity uplifts.*

	SAFs	unPWTs	uwOTTs
AM Peak	623	2.07	17.49
Inter-Peak		2.13	14.51
PM Peak		2.08	15.66

Data in this table is cited in NTfL Service Reliability Requirements document: NTfL-2344.1.1-LUL-RPT-00064 (Livelink Reference 349724461). This is at Issue 3 as of September 2016.

SPR-PL-474

	SAFs	unPWTs	uwOTTs
AM Peak	230	1.46 + 0.8%	15.83 + 0.1%
Inter-Peak		1.38 + 0.8%	13.12 + 0.1%
PM Peak		1.42 + 0.8%	14.26 + 0.2%

Data in this table is cited in NTfL Service Reliability Requirements document: NTfL-2344.1.1-LUL-RPT-00064 (Livelink Reference 349724461). This is at Issue 3 as of September 2016.

SPR-PL-475

Requirement	Rationale	Business Level Trace

	SAFs	unPWTs	uwOTTs
AM Peak	272	1.47 + 1.6%	15.87 + 0.1%
Inter-Peak		1.39 + 0.8%	13.14 + 0.3%
PM Peak		1.44 + 1.6%	14.41 + 0.2%

Data in this table is cited in NTfL Service Reliability Requirements document: NTfL-2344.1.1-LUL-RPT-00064 (Livelink Reference 349724461). This is at Issue 3 as of September 2016.

SPR-PL-476

3.6 Service Life

Requirement	Rationale	Business Level Trace
The design life of the *Piccadilly line NTfL Trains* shall be not less than **40 (forty) years** from the commissioning of the **last train** into passenger service. **SPR-PL-34**	Operational costs and benefits over a forty year service life are used in the Business Case. This time period is a standard assumption used across LU for rolling stock.	BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term
The design life of the *Piccadilly line* NTfL Signalling system shall be not less than **40 (forty) years** from *Key Benefit Stage* ***P2.1*** or upon line wide commissioning of *GOA2* capability (whichever is greater). **SPR-PL-220**	Operational costs and benefits over a forty year service life are used in the Business Case.	BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term
The design life of *Piccadilly Line* GOA4 PTI Equipment shall be not less than **40 (forty) years** from full line installation. **SPR-PL-221**	Operational costs and benefits over a forty year service life are used in the Business Case.	BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term

3.7 Energy Usage

Requirement	Rationale	Business Level Trace

Requirement	Rationale	Business Level Trace
The *Piccadilly line* annual traction power energy usage shall not exceed **183 GWh** from *Key Benefit Stage* ***P2.1*** onwards. SPR-PL-179	TfL aims to be financially self-supporting; reducing energy usage and maximising energy recovery significantly contributes towards this. Whilst the programme cannot control the cost of energy, it can influence how much energy is consumed through system design. VLU currently leads LU best practice achieving an 'energy neutral' power solution set that has lowered overall energy usage from pre-upgrade levels. Extra Low Loss Composite conductor rails, reduced sectionalisation, and the use of 750V nominal supply voltage (1000V, 6000A regen braking capability) and inverting sub-stations are recognised energy reduction solutions.	BLR 10 - Reduce Energy Usage
Supplementary Information for SPR-PL-179: *183 GWh per annum has been derived by the Systems Performance Engineering team (October 2016) – refer to document reference:* SPG-VCP-RPT-PIC-0008.		
Supplementary Information for SPR-PL-179: *Energy usage of the pre-upgrade Piccadilly line associated with Working Timetable 54 is 152 GWh.*		
Supplementary Information for SPR-PL-179: *This figure includes the energy used by the NTfL Trains along the interoperable section of the Metropolitan Line but excludes energy used by the S-Stock Trains.*		
Supplementary Information for SPR-PL-179: *Traction power energy usage shall be calculated from the mean kWh per train km, derived from multi-train simulations of 6 hours peak service and 12 hours inter-peak service, factored by the annual train kilometerage.*		
The Programme shall provide *the Sponsor* with feasibility studies for solutions needed to meet the *Piccadilly line* energy usage target (defined within SPR-PL-179) prior to implementation. SPR-PL-451	This provides assurance that the line specific energy requirements can be met over the long term whilst maintaining a positive business case.	BLR 10 - Reduce Energy Usage BLR 16 - Provide Assurance that Benefits can be Achieved over the Long Term BLR 17 - Provide Value for Money

3.8 Operations and Maintenance

Requirement	Rationale	Business Level Trace
The *Piccadilly line* Control Room within the Operational Control Centre (OCC) shall be operational by *Key Benefit Stage* ***P2.1***. to support *GOA2* Operation.	This supports a whole life system approach to control of the Piccadilly line.	BLR 01 - Renew Railway Control Systems

Requirement	Rationale	Business Level Trace
SPR-PL-117		
Asset recovery and disposal following decommissioning by *the Programme* as part of the *Key Benefit Stage* ***P1 or P2.1*** delivery shall be undertaken in a time period to be agreed with LU Operations, but no later than *Key Benefit Stage* ***P2.2***. SPR-PL-410	This aims to optimise the asset base on the 'live railway' within a defined time period, and allows the programme to plan accordingly with all stakeholders having the same information. Benefits of removing redundant assets to be realised within two years of the primary benefit configuration stage P2.2 as detailed within the NTfL Blueprint and Concept document.	BLR 11 - Decommission and Dispose of Redundant Assets / Systems
Asset recovery and disposal following decommissioning by *the Programme* as part of the *Key Benefit Stage* ***P3.1*** delivery shall be undertaken in a time period to be agreed with LU Operations, but no later than *Key Benefit Stage* ***P3.2***. SPR-PL-438	This aims to optimise the asset base on the 'live railway' within a defined time period, and allows the programme to plan accordingly with all stakeholders having the same information. Benefits of removing redundant assets to be realised within two years of the primary benefit configuration stage P3.2 as detailed within the NTfL Blueprint and Concept document.	BLR 11 - Decommission and Dispose of Redundant Assets / Systems

3.8.1 Maintenance Labour Requirements

Requirement	Rationale	Business Level Trace
For **planned** maintenance on *Piccadilly line* **signalling and train control equipment**, labour effort shall be reduced by 20% (net) from pre-upgrade levels to such as to not exceed 40 hours per annum per line km. SPR-PL-441	Output from analysis of 2014/15 maintenance data held in Maximo for the Piccadilly line and improvement targets developed in the RCS WLC report of October 2015.	BLR 09 - Enable Ops and Maintenance Cost Reduction
Supplementary Information for SPR-PL-441: *This excludes points systems and the time required to get to the site of the planned maintenance task(s).*		

Requirement	Rationale	Business Level Trace
For **reactive** maintenance on *Piccadilly line* **signalling and train control equipment**, labour effort shall be reduced by 20% (net) from pre-upgrade levels to such as to not exceed 40 hours per annum per line km. **SPR-PL-443**	Output from analysis of 2014/15 maintenance data held in Maximo for the Piccadilly line and improvement targets developed in the RCS WLC report of October 2015.	BLR 09 - Enable Ops and Maintenance Cost Reduction
Supplementary Information for SPR-PL-443: *This excludes points systems and the time required to get to the site of the planned maintenance task(s).*		
For **planned** maintenance on *Piccadilly line* ***NTfL Trains***, labour effort shall be reduced by 30% (net) compared to that incurred for 73TS, such as to not exceed 850 hours per train per annum. **SPR-PL-445**	Output from analysis of 2013/14 rolling stock maintenance data. Note: Maximo 2014/15 data is under review.	BLR 09 - Enable Ops and Maintenance Cost Reduction
Supplementary Information for SPR-PL-445: *This net reduction is offset by an increase of 250 hours p.a. arising from air cooling system maintenance and an allowance of 100 hours per annum for train preparation activities.*		
For **reactive** maintenance on *Piccadilly line* ***NTfL Trains***, labour effort shall be reduced by 10% (net) compared to that incurred for 73TS, such as to not exceed 350 hours per train per annum. **SPR-PL-447**	Output from analysis of 2013/14 rolling stock maintenance data. Note: Maximo 2014/15 data is under review.	BLR 09 - Enable Ops and Maintenance Cost Reduction
Supplementary Information for SPR-PL-447: *This net reduction includes an increase by 50 hours per annum arising from the introduction of air cooling system reactive maintenance activities.*		

3.8.2 Reversing Capabilities

Requirement	Rationale	Business Level Trace
Scheduled and unscheduled reversing moves on the *Piccadilly line* shall be provided to meet the programme level User Requirements. **SPR-PL-453**	Provides system capability for turnaround and service reliability. Unscheduled reversing capability provides means for expedient service recovery from failure.	BLR 05 - Enable Service Pattern Changes BLR 06 - Provide Increased Service Levels BLR 08 - Improve Customer Experience BLR 12 - Improve System Reliability

4 Pre-Upgrade Performance Data

This section holds service level information prior to the NTfL upgrade; it is intended to be used to for comparative purposes only.

Source Data:

- tph – Piccadilly line WTT54 Cars Across Sections – Train Service Planning
- Night Tube tph – TfL Intranet (Dec 2015)
- Interoperable tph – 4LM SPRRD
- Degraded Mode tph – Sponsor & Transport Planning Meeting Minutes 14 December 2015

4.1 Peak Service Levels (P0)

4.1.1 Eastbound

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Heathrow T5 to Heathrow T123	6	-	6	-	-	6	Additional 6 trains (total 12 tph) to reverse at T5 when T4 is unavailable for service. * Night Tube tph and days are subject to further development.	12	Peak tph + Degraded Mode	6*
Heathrow T4 to Heathrow T123	6	-	6	-	-	-	In degraded mode, additional trains will reverse at T123 rather than T4. * Night Tube tph and days are subject to further development.	6	Peak tph	6*
Heathrow T123 to Northfields	12	-	12	-	-	-	All 12 trains to reverse at T123 when T5 and T4 are both out of operation. In addition, reverse 6tph at the same time as the through running 6tph from T4 when T5 is out of operation.	12	Peak tph	6*

Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Northfields to Acton Town	12	-	15 (Weekday) 18 (Weekend)	-	19	12 (Peak) 6 (Off Peak)	Able to accommodate the full service when trains cannot run beyond Ealing Common. All trains to reverse at a combination of Northfields, Heathrow T5, Heathrow T4 and Heathrow T123. The required service level is the max of the degraded mode tph on either weekday or weekend 24tph in both instances). * Night Tube tph and days are subject to further development.	24	Peak tph + Positioning (assuming some of peak service made up by positioning to deliver shortest headway required by existing WTT)	6*
Uxbridge to Rayners Lane	8	12	3	6	-	2	Interoperable with Met between Uxbridge & Rayners Lane Junction (8-car S-Stock). Additionally, able to accommodate an additional 2tph reversing (total 10tph).	22	Peak tph + Interoperable Peak + Degraded Mode	-
Rayners Lane to Ealing Common	12	-	6	-	3	2	Able to accommodate an additional 2 tph through running when the Heathrow branch is unavailable (Total 4 tph reversing and 10 tph through running).	15	Peak tph + Positioning (assumes positioning whilst also running through trains)	-
Ealing Broadway to Ealing Common	-	8	-	6	16 District Stabling Trains	-	-	16	Positioning moves make up the interoperable service	-
Ealing Common to Acton Town	12	8	6	6	16 District Stabling Trains	2	The above means that Ealing Common needs to be able to accommodate an additional 2 tph (total 14tph) when the Heathrow branch is unavailable for service.	28	Peak tph + Positioning (assumes positioning whilst also running through trains)	-

Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Acton Town to Barons Court	24	-	21 (Weekday) 24 (Weekend)	-	-	-	* Night Tube tph and days are subject to further development.	24	Peak tph	6*
Barons Court to Holborn	24	-	21 (Weekday) 24 (Weekend)	-	-	-	* Night Tube tph and days are subject to further development.	24	Peak tph	6*
Holborn to Wood Green	24	-	21 (Weekday) 24 (Weekend)	-	-	-	* Night Tube tph and days are subject to further development.	24	Peak tph	6*
Wood Green to Arnos Grove	24	-	21 (Weekday) 24 (Weekend)	-	4	-	* Night Tube tph and days are subject to further development.	24	Peak service from the positioning moves	6*
Arnos Grove to Cockfosters	18	-	18	-	23	6	All 24 TPH to Cockfosters if reversing at Arnos Grove is not possible. * Night Tube tph and days are subject to further development.	24	Positioning assumes Peak tph is made up from depot starters but max tph from Peak + Degraded Mode.	6*

4.1.2 Westbound

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Cockfosters to Arnos Grove	18	-	18	-	23	6	* Night Tube tph and days are subject to further development.	24	Positioning assumes Peak tph is made up from depot starters but max tph from Peak + Degraded Mode	6*
Arnos Grove to Wood Green	24	-	21 (Week day) 24 (Week day)	-	4	-	* Night Tube tph and days are subject to further development.	27	Positioning moves from Cockfosters joining with positioning moves from Arnos Grove	6*
Wood Green to Holborn	24	-	21 (Week day) 24 (Week day)	-	-	-	* Night Tube tph and days are subject to further development.	24	Peak tph	6*
Holborn to Barons Court	24	-	21 (Week day) 24 (Week day)	-	-	-	* Night Tube tph and days are subject to further development.	24	Peak tph	6*

Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Barons Court to Acton Town	24	-	21 (Week day) 24 (Week day)	-	-	-	* Night Tube tph and days are subject to further development.	24	Peak tph	6*
Acton Town to Ealing Common	12	8	6	6	16 (District Stabling trains)	2	The above means that Ealing Common needs to be able to accommodate an additional 2 tph (total 14tph) when the Heathrow branch is unavailable for service	28	Peak tph + Positioning (assumes positioning whilst also running through trains)	-
Ealing Common to Ealing Broadway	-	8	-	6	16 (District Stabling trains)	-	-	16	Positioning moves make up the interoperable service	-
Ealing Common to Rayners Lane	12	-	6	-	3	2	Able to accommodate an additional 2tph through running when the Heathrow branch is unavailable (Total 4tph reversing and 10tph through running)	15	Peak tph + Positioning	-
Rayners Lane to Uxbridge	8	12	3	6	-	2	Interoperable with Met between Uxbridge & Rayners Lane Junction (8-car S-Stock). Additionally, able to accommodate an additional 2tph reversing (total 10tph).	22	Peak tph + Interoperable Peak + Degraded Mode	-

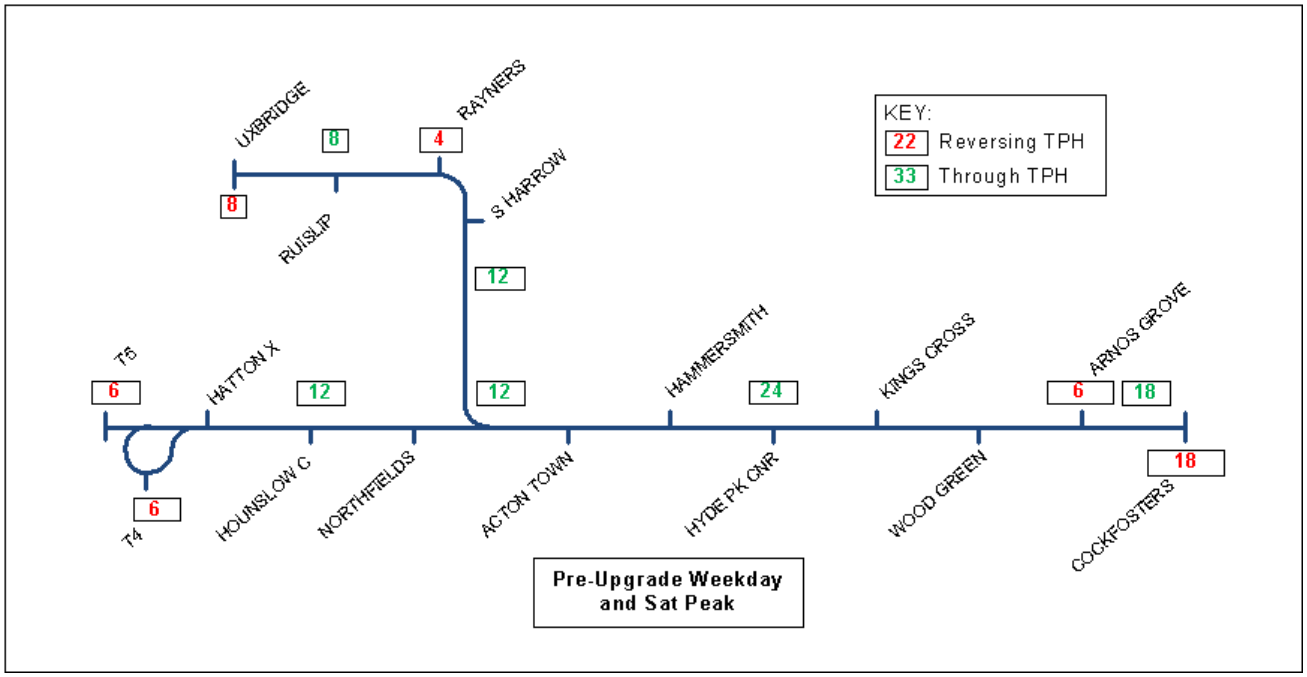
Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Acton Town to Northfields	12	-	15 (Week day) 18 (Week end)	-	-	12 (Peak) 6 (Offpeak)	Able to accommodate the full service when trains cannot run beyond Ealing Common. All trains to reverse at a combination of Northfields, Heathrow T5, Heathrow T4 and Heathrow T123. The required service level is the max of the degraded mode tph on either weekday or weekend 24tph in both instances). * Night Tube tph and days are subject to further development.	24	Peak + Peak Degraded	6*
Northfields to Hatton Cross	12	-	12	-	-	12 (Peak) 6 (Offpeak)	Able to accommodate the full service when trains cannot run beyond Ealing Common. All trains to reverse at a combination of Northfields, Heathrow T5, Heathrow T4 and Heathrow T123. The required service level is the max of the degraded mode tph on either weekday or weekend 24tph in both instances). * Night Tube tph and days are subject to further development.	24	No positioning as assuming Peak tph is made up from depot starters; Peak + Peak Degraded	6*
Hatton Cross to Heathrow T4	6	-	6	-	-	-	In degraded mode, additional trains will reverse at T123 rather than T4. * Night Tube tph and days are subject to further development.	6	Peak tph	6*

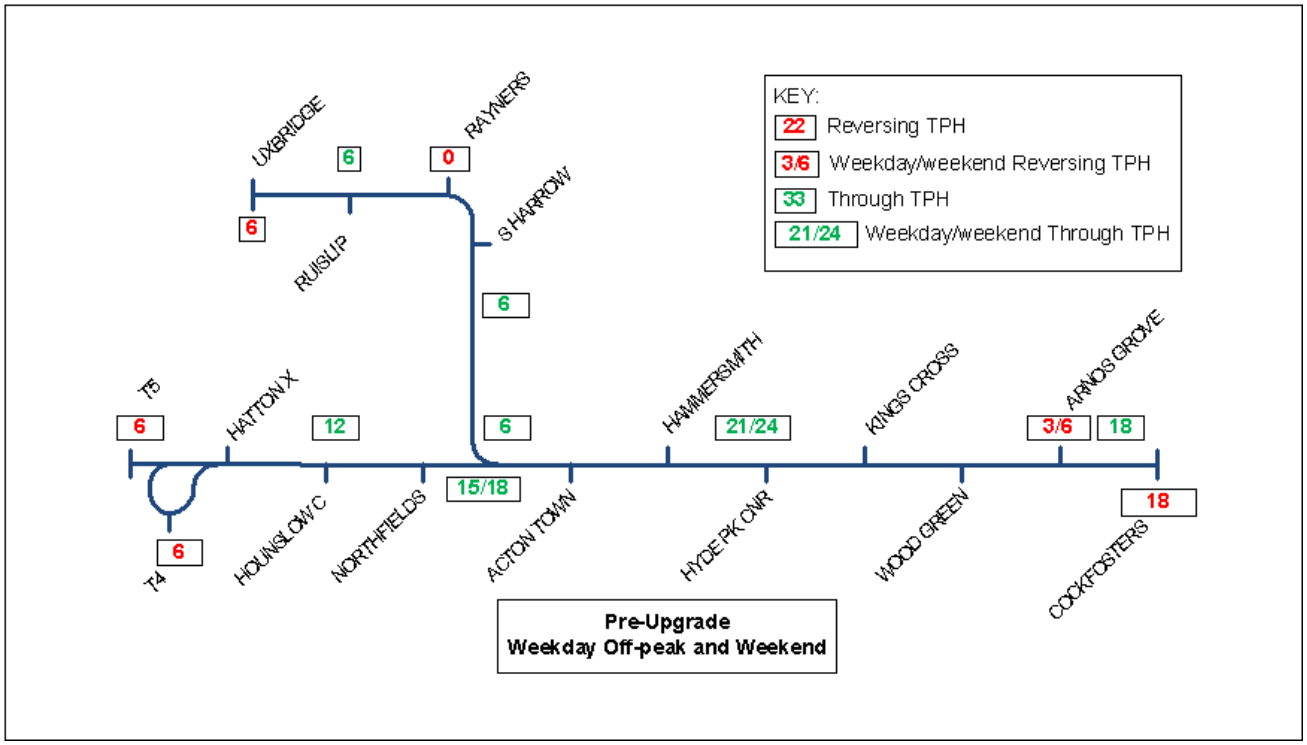
Sponsor's Programme Requirements – Piccadilly Line

Location	Peak tph (Monday to Friday)	Interoperable Peak tph	Weekend / Off Peak Maximum tph	Interoperable Weekend / Off Peak tph	Positioning tph	Degraded Mode (Additional tph)	Notes/Comments	Maximum tph Required	Maximum tph Justification	Night Tube
Hatton Cross to Heathrow T123	6	-	6	-	-	6	All 12 trains to reverse at T123 when T5 and T4 are both out of operation. When just T4 is out of operation an additional 6tph to run through to T5 (12tph total). When only T5 is out of operation 6tph to reverse at T123 * Night Tube tph and days are subject to further development.	12	Peak tph + Degraded Mode	6*
Heathrow T123 to Heathrow T5	6	-	6	-	-	6	Additional 6 trains (total 12 TPH) to reverse at T5 when T4 is unavailable for service. * Night Tube tph and days are subject to further development.	12	Peak tph + Degraded Mode	6*

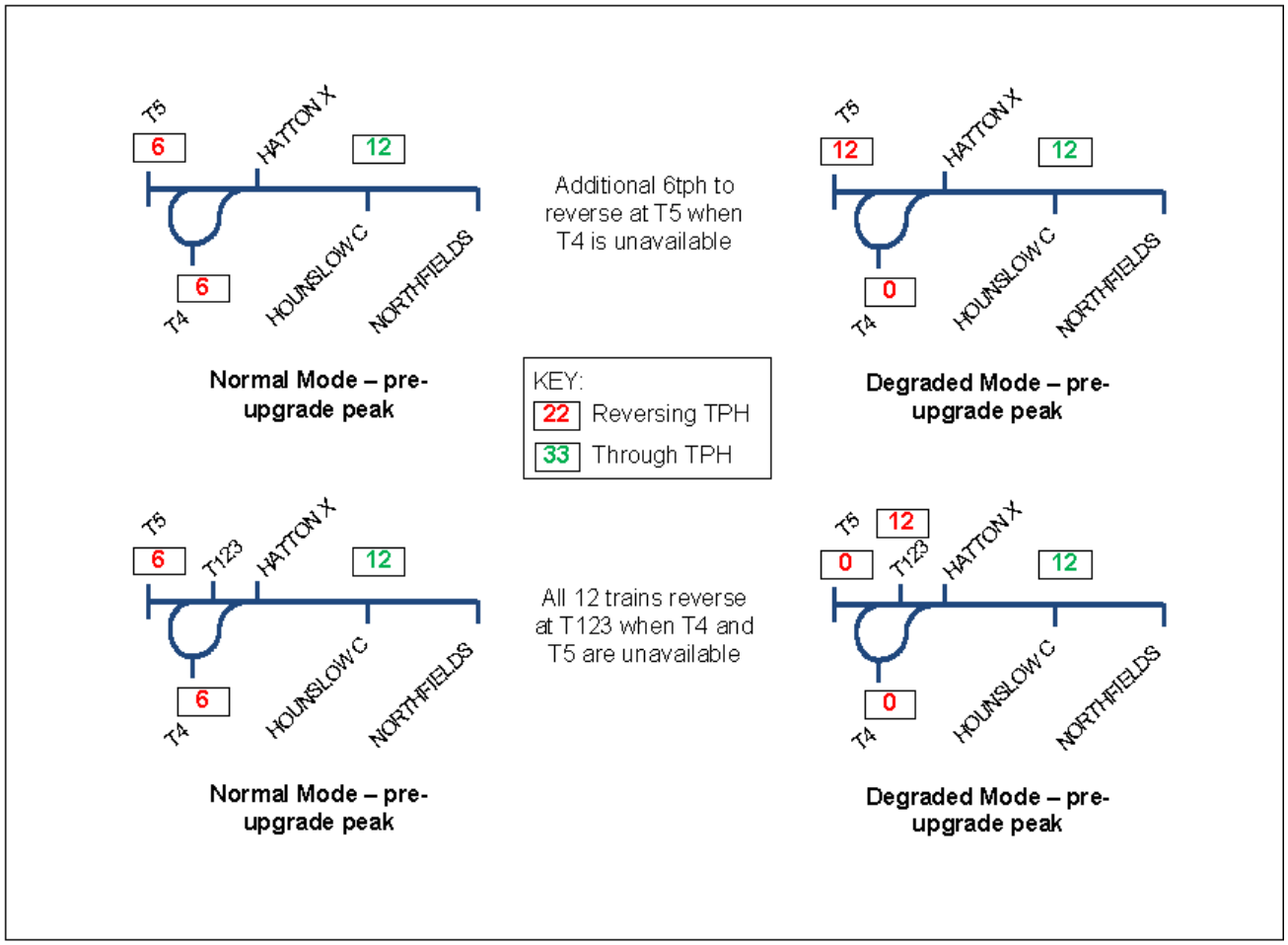
4.1.3 Tph Diagrams



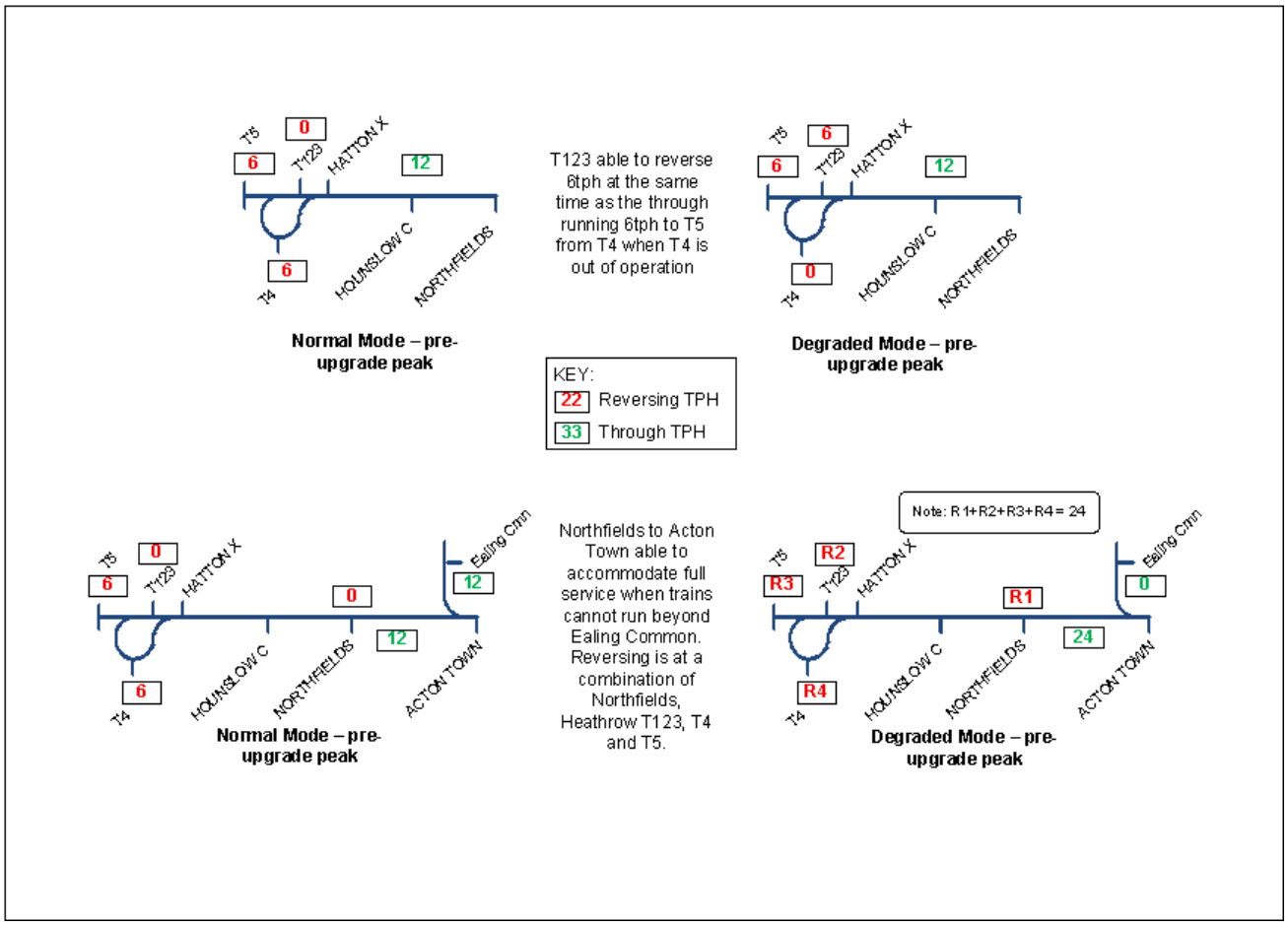
Pre-upgrade Weekday and Saturday Peak



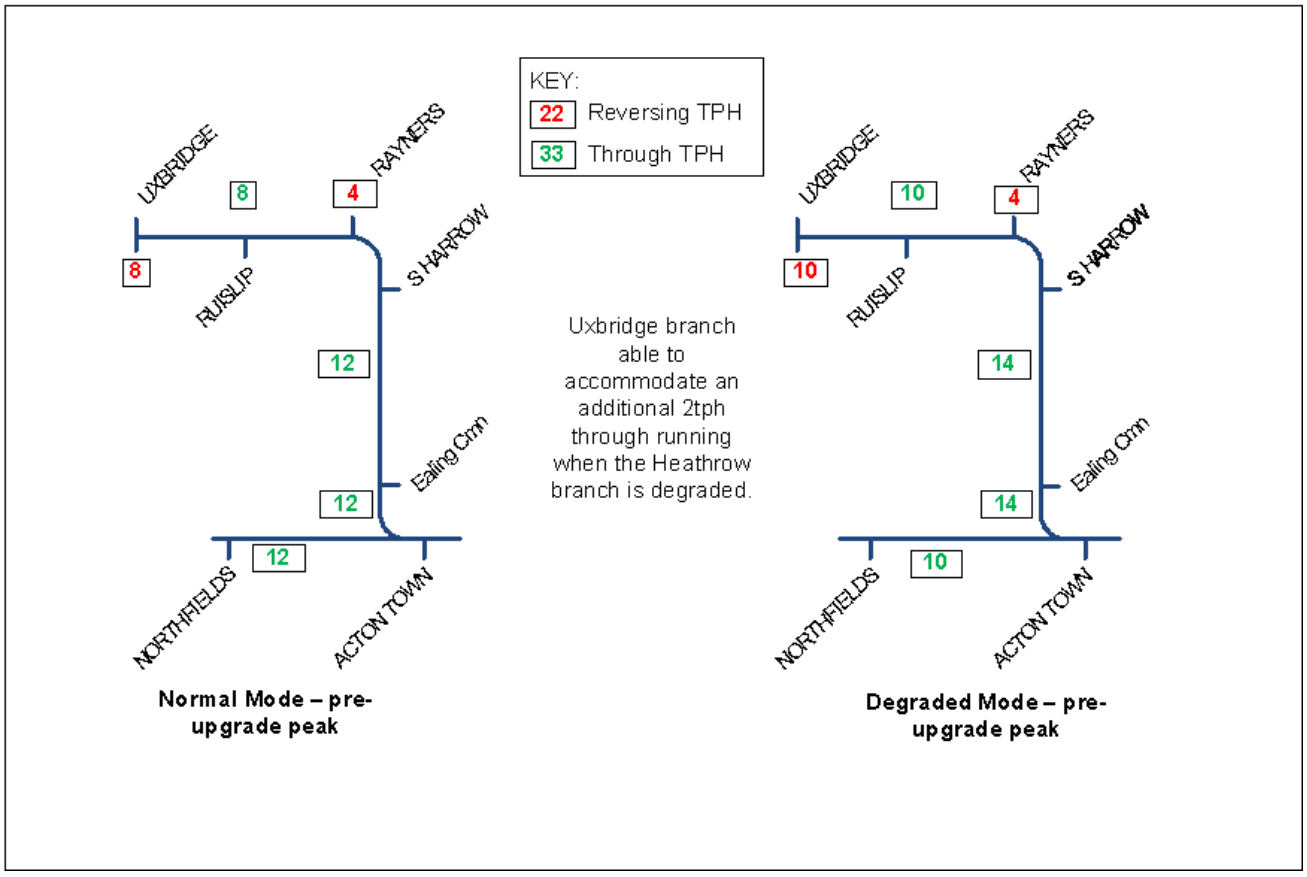
Pre-upgrade Weekday Off Peak and Weekend



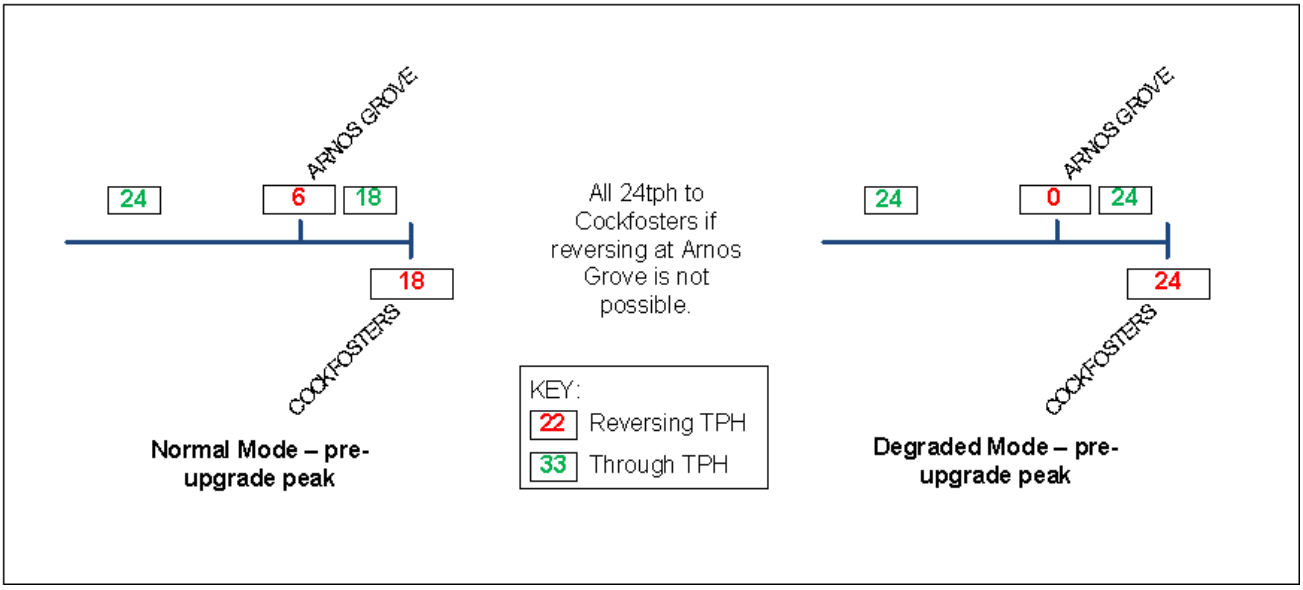
Pre-upgrade - Degraded Modes (1 of 4)



Pre-upgrade - Degraded Modes (2 of 4)



Pre-upgrade - Degraded Modes (3 of 4)



Pre-upgrade - Degraded Modes (4 of 4)

5 List of Consultees

The following table indicates consultees on the Draft versions of the Sponsor Programme Requirements leading up to the first approved version:

Name	Directorate / Organisation & Job Title
Alastair Baily	COO, NTfL Operations Representative
Andrew Tunnicliffe	CPD, Professional Head of Systems Software
Chris Ashcroft	CPD, Senior Project Manager
Chris Burke	CPD, Training and Operational Readiness Manager
Dave Hughes	S&SD, Transport Strategy Manager
David Rea	Programme Delivery Partner
Duncan Weir	COO, Head of Operational Upgrades & Asset Development
Elliot Ali	CPD, NTfL, Programme Delivery Engineer
Francesco Formica	CPD, Systems Integration Engineer
Gabriel Smith	CPD, Lead Systems Performance Engineer
Graeme Pate	CPD, Systems Integration Engineer
Grant Richardson	CPD, Senior Project Engineer
Imtithal Aziz	CPD, Systems Engineer
Ivan Gwynn	S&SD, Principal Sponsor
Jeff Done	CPD, Delivery Manager
Joanne Pettigrew	CPD, Project Manager
Kate O'Brien	S&SD, Principal Sponsor
Ken Lamacraft	CPD, Lead Systems Performance Engineer
Kevin Moore	S&SD, Lead Sponsor
Lee Gladstone	CPD, Senior Project Manager (Track Plant and Depot Portfolio)
Luke Fischer	CPD, Systems Integration Engineer
Mark Foster	CPD, Senior Project Manager
Martin Bayliss	HSE, Engineering Safety Manager
Michael Cowland	COO, Operational Development Manager
Mohamed Masood	CPD, Systems Integration Engineer
Nigel Hodgson	S&SD, Principal Sponsor
Paul Carpenter	CPD, Systems Assurance Engineer
Paul Thomas	CPD, Head of Engineering
Peter Terribili	CPD, Lead Project Engineer
Simon Chung	CPD, Principle Systems Performance Engineering Manager
Simon Ford	CPD, Programme Delivery Engineer
Stephen Porter	CPD, Rolling Stock Project Engineer
Stefan Krcmar	CPD, Lead Project Engineer, Infrastructure

Steve Fielding	CPD, Principal Systems Engineer
Steve Wilson	CPD, RAMS Engineer
Will Dennis	CPD, Project Manager, Power & Cooling Upgrades

6 Future Updates

There is a possibility that a future update to this document includes Piccadilly Line requirements related to interim capacity uplifts as specified in the Timetable Migration Plan.

The 'Candidate System' will eventually become a 'proposed system' once the various rolling stock and signalling and train control procurement exercises have completed and the Piccadilly line element of the business case is updated. This document is expected to be updated accordingly.

The conclusion of the West London Services feasibility study (Sponsor's Instruction #016) may result in an update to Section 3.3.1.

A future study on the effects of dust on reliability may be required once the details on the new train are known. The outcome of this study may impact the reliability targets in this document.