Report
November 2018

Schedule 8 - National Recalibration Methodology (Control Period 6)

Rail Delivery Group
Our ref: 232019 01

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Version

This is the Draft Final version. Document saved on 2nd November.

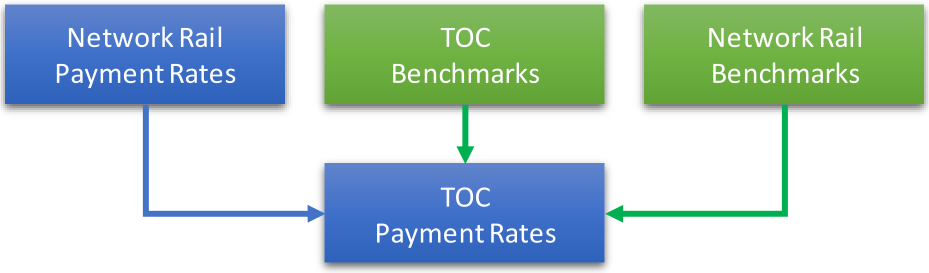
Overview

This report provides the methodology for the recalibration of Schedule 8 of the Track Access Agreement for Control Period (CP) 6. We have focused the methodology description on the core approach which applies to all TOCs, with the TOC-specific adaptions for individual TOCs provided in separate documentation. It covers:

- Network Rail Payment Rates (Section 2)
- TOC and NR Benchmarks (Section 3)
- TOC Payment Rates (Section 4)
- Sustained Poor Performance Regime (Section 5)
- Supporting Technical Appendices (Appendix)

The results from the Benchmarks and Network Rail Payment Rates calculations feed into inputs to the calculation of TOC Payment Rates as shown in Figure A.

Figure A: Interaction of report sections



Summary of modelling approach and assumptions

In Tables A to D, we provide a summary of the modelling approach and assumptions for each component of the calculation. This sign-posts the areas in the methodology for which a decision on the approach can affect the results. For each of these assumptions, Network Rail routes and operators have been given the opportunity to review and raise objections, both through the Schedule 8 Recalibration Working Group and through individual consultations. Where extra focus has been placed on an assumption, further details of industry engagement are listed below.

Table A: Summary of modelling approach and assumptions - Network Rail Payment Rates

Title	Reference	Description
Marginal Revenue Effect (MRE) Methods	Para 2.5, Para 2.6 Appendix 5	The Oxera study has been used for South East to/from London (SE&L-L) Flows. Decision made by ORR following submissions from NR and TOCs on 2 February 2018. The PDFH 5.1 parameters have been used for Great Britain Excluding SE&L-L Flows. Decision made by ORR following submissions from NR and TOCs on 2 February 2018.
MRE Formulae	Para 2.5, Para 2.6 Appendix 6	To calculate the MRE for each Flow we use the gradient of the MRE equations around a 0 minutes change to extrapolate for a 1-minute change. Methodology approach proposed by Steer consistent with CP5 approach, and discussed at the Schedule 8 Recalibration Work Group on 9 April 2018.
MRE Parameters	Para 2.5 Appendix 5	The Oxera study did not split the parameters into each sector (London to/from London and South East to/from London). This sector split had been done in the Peer Review of the study and it is these parameters that are used in this recalibration. Methodology approach proposed by Steer.
Use of Busyness Factor to create a daily NRPR rate.	Para 2.4 Appendix 4	Use Busyness Factors rather than an alternative annualisation factor (e.g. 365) as it is the Busyness Factors that are used during the regime to multiply the NRPRs. Methodology approach proposed by Steer. Unable to determine what was used in CP5.
Recalibration Timeframe	Para 2.3 Appendix 1	Use of two years: 2015/16 and 2016/17 as a Recalibration Timeframe consistent with approach used in CP5. Years proposed by Rail Delivery Group (RDG). Bespoke years for some TOCs as required.
Journey Purpose Profiles and Peak Split	Para 2.17 Appendix 9	Use of PDFH 6.0 Ticket Type to Journey Purpose splits. Peak Profiles based on MOIRA 2.2 inputs. Methodology approach proposed by Steer.
Area definition	Para 2.14 Appendix 8	South East definition aligns with definition in PDFH. A couple of modification have been agreed with TOCs and NR. Methodology approach proposed by Steer.
Mapping Area to Sector	Para 2.15 Appendix 8	This mapping follows the definition in PDFH 6.0 (as well as PDFH 5.1)
Residual Flows	Para 2.22 to 2.24	Approach to directly modelling the 'tail' of the distribution (rather than a pro-rata of the largest flows). This was proposed by Steer in their proposal for this work as a way of increasing the accuracy of the approach.

Table B: Summary of modelling approach and assumptions – TOC and NR Benchmarks

Title	Reference	Description
Monitoring Points	Para 3.6 (Part 1A)	Values used are the agreed Monitoring Points for CP6. Source: Rail Delivery Group
Historic Performance	Para 3.7 (Part 1B)	The source file for the historic performance is the PEARS Daily Data for 2015/16 and 2016/17 as at 2018P08 (i.e. August 2017). Data source: Network Rail Central Performance Team
In-fill performance for new MPs	Para 3.9 (Part 1C)	In the situations where the MPs do not have historic performance figures in PEARS, PSS data has been used to determine the historic performance. PSS Timing, Delay and Mileage data was provided by NR for 2015/16 and 2016/17. We understand from NR, that the PSS timing data should be relatively consistent with the PEARS data. As such, no calibration of the PEARS-PSS results has been undertaken.
Cancellation Minute Multipliers	Para 3.20 (Part 2B)	Values used are the agreed Cancellation Minute Multipliers for CP6. Source: Rail Delivery Group
Monitoring Point Weightings	Para 3.25 (Part 2C)	Values used are the agreed Monitoring Point Weightings for CP6. Source: Rail Delivery Group
Signal Berth Offsets	Para 3.31 (Part 2D)	Results have been adjusted to take account of changes in Signal Berth Offset assumptions that occurred since 1st April 2015. Data source: Network Rail
Service Group Remapping	Para 3.34 (Part 2E)	A small number of Service Groups (notably for ScotRail and East Coast) were remapped to take account of the update to Service Group structure from April 1st 2019. Information source: TOC and NR Routes
Reallocating disputed minutes	Para 3.37 Part 2F	Delays that were in Dispute at August 2017 are allocate to the TOC and NR in proportion to their allocated delays.

		Disputed AML are allocated to TOC and NR in proportion to the undisputed TOC AML and NR AML Disputed DML are allocated to TOC and NR in proportion to the undisputed TOC DML and NR DML Approach: Recalibration Working Group recommended approach
TOC-on-TOC uplift	Para 3.40 Part 3B	No uplift is applied to the TOC-on-TOC proportion of the NR Benchmark. Source: Rail Delivery Group
Freight-on-TOC uplift	Para 3.41 Part 3B	An uplift of 1.255 is applied to the Freight proportion of the NR Benchmark. This is applied consistently across each year of Control Period 6. Source: Rail Delivery Group
Charter-on-TOC uplift	Para 3.42 Part 3C	An uplift of 1.171 is applied to the Charter proportion of the NR Benchmark. This is applied consistently across each year of Control Period 6. Source: RDG Source: Rail Delivery Group
NR-on-TOC trajectories inputs	Para 3.43 Part 3D	The NR proportion of the NR Benchmark will vary in each year of Control Period 6. The overall methodology for how this variation in determined has been developed by NR. For each Service Group, the NR proportion of the NR Benchmark is determined according to the TOC-level trajectory on the level of NR Delay per 100kms as defined by the Consistent Route Measure-Performance (CRM-P) metric (Annual minutes of Network Rail attributed delay to passenger trains from incidents occurring within the route boundary normalised by the actual mileage travelled by passenger trains within that route). All TOCs except TfL Rail have one trajectory of CRM-P determined at a TOC level. Methodology discussed at the Recalibration Working Group. Source: Network Rail (Based on CRM_P Model V9 (14/09/18)) Methodology: Provided by Network Rail (Network Rail S8 Benchmarks Trajectories v2)
NR-on-TOC trajectory application	Para 3.47 Part 3D	The NR-on-TOC trajectory inputs at a TOC-level are applied at a Service Group-level through adjusting the TOC-level CRM-P by the following factor: $\text{Service Group CRM-P}_{Future} = \text{TOC-level CRM-P}_{Future} * \frac{\text{Service Group CRM-P}_{Actual}}{\text{TOC-level CRM-P}_{Actual}}$ The Service Group CRM-P is then applied to the NR proportion of the NR Benchmark using a regression between Actual Minutes Lateness and CRM-P. The regression relationship is determined by an Ordinary Least Squares at a Service Group level. Only when the regression is a "good fit" – where "good fit" is defined as adjusted R-squared is above 70% - does the regression get used. If the regression fit is not good then the regression is not applied unless agreement is reached between TOC and NR. The Deemed Minutes Lateness (DML) is assumed to have the same trajectory as Actual Minutes Lateness. This has been developed and applied by Steer.

Table C: Summary of modelling approach and assumptions – TOC Payment Rates

Title	Reference	Description
TOC Benchmark and NR Base Position	Para 4.4	In the TOC Payment Rate Model, the TOC Benchmark is used as a divisor of the Payment Rate Costs to convert to a per minute value In the TOC Payment Rate Model, The NR 'Base Position' – i.e. the what the NR Benchmark would be if no uplift or trajectories were applied is used as part of the calculation of Payment Rate Cost to a Victim Service Group. Methodology: As per Control Period 5
Freight and Charter Payment Rates	Para 4.6	The Freight and Charter Payment Rates are dependent on the daily mileage operated by Freight and Charter services. NR supplied the Annual Mileage for each of Freight and Charter. Steer have assumed an annualization factor of 365 to convert Annual Mileage into Daily Mileage. Data Source: Network Rail
Historic Performance and Recalibration Timeframe	Para 4.11	The Historic Performance datasets used are PSS Delay data and PSS Mileage data for 2015/16 and 2016/17. Data source: Network Rail

		The TOCs and NR Routes have agreed in some cases to recalibration timeframes that are a single year (i.e. either 2015/16 or 2016/17) rather than both years. Where there is no common timeframe between the Perpetrating Service Group and the Victim Service Group, then it is the timeframe of the Victim Service Group is used (this is to align better with the NR Benchmarks). The one exception being for GTR for which 2015/16 is used as both Perpetrator and Victim. This is because no data has been remapped for 2016/17 Methodology: Steer
Determining Peak Type	Para 4.15	The Peak Type field in PSS is deemed by NR to not be accurate enough for the Schedule 8 recalibration. We have determined Peak Type using PEARS Reference files (as at 2018 P08), and applying the Peak Type, Direction at a Monitoring Point level to the PSS Mileage Files. The PSS Mileage Files are then used to determine Peak Type for the PSS Delay Files. Data source: Network Rail Methodology: Steer
Allocating delays not attributed to a Service Group	Para 4.32	A small proportion of the delay minutes and cancellations in PSS are not allocated to an individual PEARS Service Group within a TOC. In these cases, we allocate the delay minutes and cancellations to individual Service Groups in proportion to the overall amount of delay caused by each individual Perpetrating Service Group to each Victim Service Group. Methodology: Steer
Service Group Remapping	Para 4.22 Appendix 14	Service Group remapping applies to: • ScotRail • East Coast • GTR • LSER • TfL Rail • GWR Arup undertook the remapping for GTR/LSER and GWR/TfL Rail. Steer undertook the remapping for East Coast and ScotRail. Steer consolidated the various remapped matrices into the overall TOC Responsibility Matrix. During the recalibration timeframe, there was also Service Group remapping for Northern, TPE, Greater Anglia and London Overground. However, the data for these TOCs was already remapped in the PEARS and PSS files provided.

Table D: Summary of modelling approach and assumptions – Sustained Poor Performance Regime

Title	Reference	Description
SPP Threshold	Para 5.4	Sustained Poor Performance Threshold has been set at 20% Source: ORR Determination
Busyness Factor	Para 5.4	Assumed Busyness Factor = 28 Source: Steer assumption based on equivalent factor used in Control Period 5

Terminology

In the main body of the report, we show newly defined terms in blue font. All defined terms are capitalised throughout. To maintain the flow of each report section, we have placed the theoretical background for the calculations and inputs into Technical Appendices.

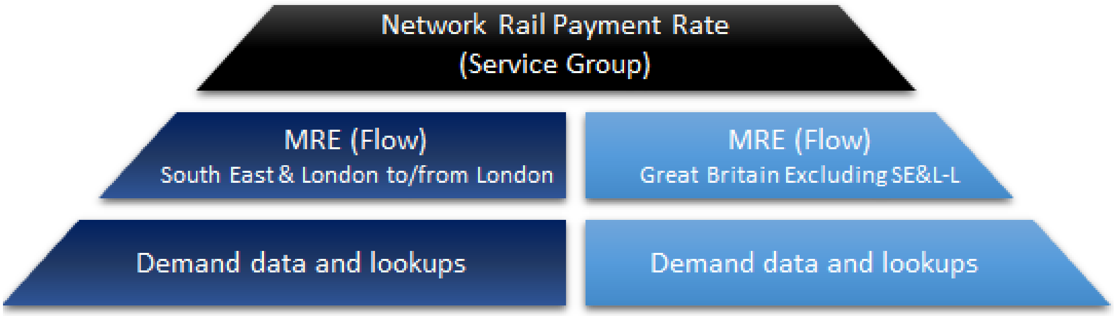
2 Network Rail Payment Rates

Introduction

2.1 The Network Rail Payment Rate (NRPR) for each Service Group is equivalent to the modelled change in the Service Group's revenue for a one-minute change in Performance Minutes for a single day. NRPR is based on the total Marginal Revenue Effect (MRE) for each Service Group, where the MRE is the modelled change in Revenue from a one-minute change in Performance Minutes across the Recalibration Period. Where Performance Minutes are a combination of the effect of delays and cancellations on passenger journeys.

2.2 In this section, we describe how the Service Group NRPRs and MREs have been determined and then work back to show how the information is derived from the input data sources. An overview of how this section of the report is structured is shown in Figure 2.1. There are two separate methods used for calculating MRE, with each method requiring a different set of inputs: South East and London to/from London (SE&L-L) and Great Britain Excluding SE&L-L (GBX) (see paragraph 2.15 for a description of these categories).

Figure 2.1: Organisation of the Network Rail Payment Rates section of this report



Recalibration Timeframe

2.3 The standard Recalibration Timeframe covers two Rail Years, 2015/16 and 2016/17. A Rail Year begins on 1st April and ends on 31st March in the following year. Two years are used to provide a larger sample of demand information than a single year, smoothing out short-term fluctuations in revenue. For some TOCs, only one Rail Year is used as the other is not considered representative of future demand, see Appendix 1 for a table by Recalibration Timeframe by operator.

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Network Rail Payment Rates

2.4 The Service Group Network Rail Payment Rate is calculated as follows:

$$NRPR = \text{Price Base Factor} \times \sum_{Flow=1}^{x} MRE_{Flow} \div \sum_{Period=1}^{n} \text{Busyness Factors}$$

Price Base Factor (PBF) is a multiplier converting the MREs in outturn prices from the Recalibration Timeframe to the values for the start of CP6 (more details in Appendix 2).

$\sum MRE_{Flow}$ is the sum of all the Flow-level MREs for a Service Group across the Recalibration Timeframe. (The Flow MREs calculations are described in paragraphs 2.5 and 2.6.)

A Flow is a combination of an Origin, Destination, Ticket Category (Full, Reduced or Seasons) and Service Code. In the LENNON data, Service Code (SC) is an identifier denoting a set of services in a service group, represented by four digits in LENNON and three digits in PEARS (these three digits are common with the first three digits of the LENNON code).

∑ Busyness Factors is the sum of all the Busyness Factors across the Recalibration Timeframe. Busyness Factors (BF) are a measure of the planned number of schedule stops (as defined by the Schedule 8 Monitoring Points and their weightings) in the timetable for a Rail Period compared to the average number scheduled in the Bi-annual timetable (see Appendix 4).

Service Group (SG) is a subset of the TOC's services denoted by a four-character code (e.g. HF01), typically based on geographical and/or operational characteristics. In many cases, Peak and Off-Peak Service Group NRPRs are calculated separately. Peak and Off-Peak are assigned based on the definitions provided in the Full PEARS Reference dataset.

Marginal Revenue Effect: South East & London to/from London

2.5 For South East and London to/from London, the Flow MRE is calculated as follows:

$$MRE = -1 \times \text{Revenue} \times \text{Semi-Elasticity}$$

Revenue is the total value of the tickets sold for the Recalibration Timeframe as allocated to a TOC in the LENNON Earnings data (with TOC specific adjustments – see paragraph 2.19).

A Semi-Elasticity is a parameter reflecting how passenger revenue is expected to vary with changes in Performance Minutes. Semi-Elasticities are defined by Sector (see paragraph 2.15) and Ticket Type, as shown in Table 2.1. The results are based on a study from Oxera ('The impact of unplanned disruption on train operator revenue, 2017). A Peer Review of this work (undertaken by Steer), split the Oxera results into Sector level parameters. (See Appendix 5).

Table 2.1: Semi-Elasticities (source: The impact of unplanned disruption on train operator revenue - Oxera 2017)

Sector	Full	Reduced	Seasons
London to/from London	-0.1133	-0.0645	-0.0437
London to/from South East	-0.0205	-0.0305	-0.0210

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Marginal Revenue Effect: Great Britain Excluding SE&L-L

2.6 For Great Britain Excluding SE&L-L journeys, the Flow MRE is calculated as follows:

$$MRE = \frac{-1 \times Revenue \times Delay\ Multiplier \times GJT\ Elasticity}{GJT}$$

Generalised Journey Time (GJT) is a metric that comprises three components that influence people's propensity to travel by rail: station-to-station journey time (including in-vehicle and interchange time), a service frequency interval penalty (a factor to account for gaps between consecutive services) and the sum of any interchange penalties (a factor to account for changing between services). PDFH 6.0 sets out different service frequency interval and interchange penalties for each Ticket Category. The GJT for each Flow is not TOC-specific, and all trains are included in the calculation of the service frequency interval, interchange penalty and in-vehicle time.

Delay Multipliers (also known as Late Time Multipliers) are parameters which converts one Performance Minute into one minute of GJT. They are defined by Sector and Journey Purpose, as shown in Table 2.2. South East Inner Suburban parameters are not required as these flows are dealt with in paragraph 2.5.

Table 2.2: Delay Multipliers (source: PDFH 5.1 Table B5.1)

Sector	Commuting	Non-Commuting
Long distance to/from London	2.5	3.0
Non-London (more than 20 miles)	3.9	3.4
Non-London (less than 20 miles)	3.0	2.3
South East Outer Suburban	2.5	2.3
Airport		6.0

Journey Purpose is a market segmentation that is used to group passenger journeys according to the reason for travel. We use the Journey Purpose definitions from Section B1 of PDFH 6.0:

- Commute: travel to/from work or education;
- Business: travel on employer's business; and
- Leisure: travel for other purposes.

GJT Elasticity is a parameter which accounts for passengers' sensitivity to changes in Generalised Journey Time, and are defined by Sector as shown in Table 2.3.

Table 2.3: Elasticity to GJT (source: PDFH 6.0, Table references in right-hand column of data)

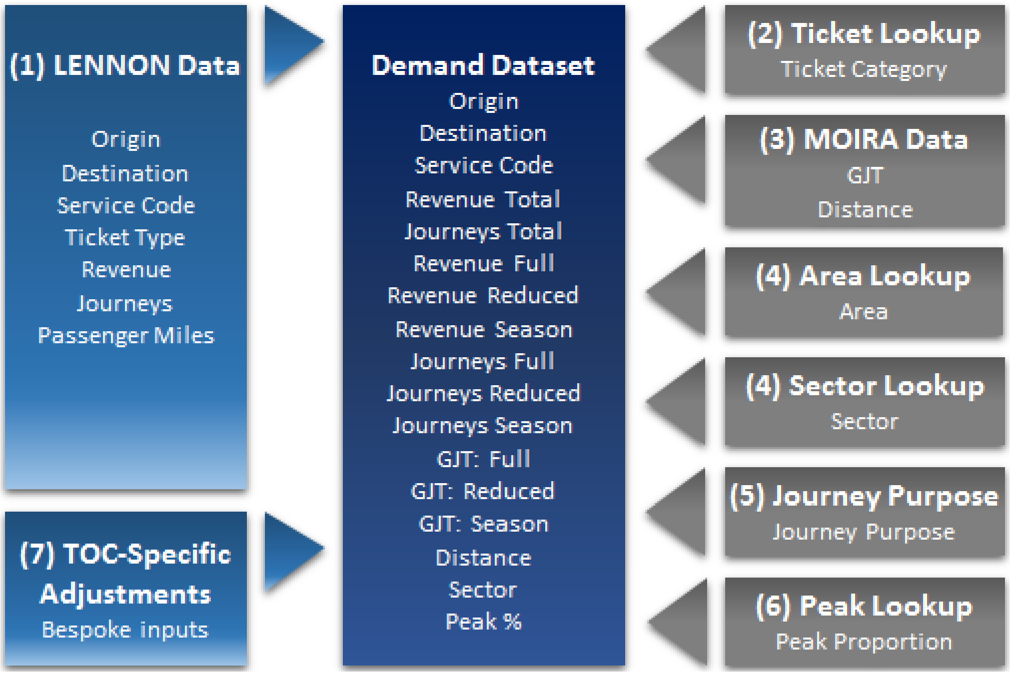
Sector	All Ticket Types	PDFH 6.0 Reference
Within South East	-1.25	B4.3
Long distance to/from London	-1.35	B4.4
Non-London (more than 20 miles)	-1.20	B4.5
Non-London (less than 20 miles)	-1.10	B4.5
Airport	-1.50	B4.6

Demand Data

Introduction

2.7 In this sub-section, we describe the process for processing the inputs to calculate the MRE for each Flow. We detail the inputs used and how they are combined and then allocated to a defined Sector, Peak Type and Ticket Category. Figure 2.2 provides an illustration of how we convert the input data into the component variables for the MRE equations, the numbers in brackets refer to the order of the steps undertaken.

Figure 2.2: Overview of demand data processing



2.8 Table 2.4 provides a description of each dataset used and the source of this information.

Table 2.4: Demand data inputs

Step	Input	Description	Source
1	LENNON	The rail industry's repository of demand and revenue data	Downloaded from RDG's LENNON terminal
2	Ticket Category	Lookup between Ticket Type (e.g. Standard Single) and Ticket Category (Full, Reduced, Seasons)	Downloaded from RDG's LENNON terminal
3	NLC-TLC Lookup	Lookup between NLC (National Location Codes used in LENNON) and TLC (Three letter codes used in MOIRA)	Steer lookup
3	GJT and Distance	Base-layer inputs to MOIRA 2.2 with record of the GJT and Distance between each pair of stations.	Supplied by Resonate
4	Area Lookup	A lookup between Location and the Area	Steer lookup based on PDFH
4	Sector Lookup	A lookup between Area and the Sector	Mapped to PDFH 5.1 and 6.0 requirements
5	Journey Purpose	A lookup for allocating revenue into Commuting and Non-Commuting	PDFH 6.0 B1
6	Peak Proportion	A lookup for allocating revenue into peak and off-peak	Calibrated Demand Profiles & Blueness

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Step 1: Processing LENNON data

2.9 We obtained LENNON Earnings (i.e. revenue allocated to each TOC and Service Code) data for each TOC for the Rail Years within that operator's Recalibration Timeframe. Every record was captured (even those with very small amounts of revenue). Table 2.5 shows the fields extracted and their purpose in the MRE calculation.

Table 2.5: Fields used in LENNON data extraction

Field	Purpose of field
Origin	To enable Sector to be determined. (To match with GJT and Distance matrices).
Destination	To enable Sector to be determined. (To match with GJT and Distance matrices).
Service Code	To enable the aggregation to Service Group. (4-digit Service Code equivalent to the 3rd, 4th, 5th and 6th digits of the 8-digit train service code)
Primary Product Group	To enable aggregation to Full, Reduced, Seasons and Other.
Adjusted Earnings Sterling	Revenue input to MRE calculation.
Journeys	To check the MOIRA distance inputs against Revenue per Journey.
Passenger Miles	To check the MOIRA distance inputs against Passenger Miles per Journey.

Step 2: Aggregating into Ticket Category

2.10 For the MRE calculations, we used the mapping in Table 2.6 to assign each Primary Product Group into Full, Reduced, Seasons and Other, where most of Other is non-marginal revenue (i.e. tickets for which the income is not dependent on the performance of the service, such as the purchase of Railcards). We confirmed with the TOCs whether any Other revenue should be considered as marginal revenue. Only marginal revenue is included in the MRE calculations.

Table 2.6: Ticket Category to Primary Product Group mapping

Ticket Category	Primary Product Group Description (Code)
Full	First Full (PG01) Standard Full (PG05)
Reduced	First Reduced (PG02) First Reduced - Advance Purchase (PG03) Standard Reduced (PG06) Standard Reduced – Advance Purchase (PG07)
Seasons	First Season (PG04) Standard Season (PG08)
Other	Other (PG09) Non-Specific (PG99) Null and N/A Primary Product Group entries

Step 3: Adding Generalised Journey Time and Distance information

2.11 RDG commissioned Resonate to produce a matrix of the GJTs and Distance between each pair of stations (a total of around 6.25 million records). GJT is shown separately for Full, Reduced and Seasons as the interchange and service frequency penalties differ by Ticket Type. The GJTs have been provided based on the May 2016 (Wednesday) Timetable.

2.12 The MOIRA data is provided at a station pair level using the TLC (Three-Letter-Codes) identifier for a station (e.g. London Euston is EUS). The LENNON data is provided at a Ticket Origin to Ticket Destination level (e.g. London Terminals to Manchester Piccadilly) and uses a NLC (National Location Code) identifier. We created a lookup to map each NLC to the most appropriate TLC. Where the LENNON data involves a 'BR' Group station for at least one of the Origin or Destination, we used the minimum GJT for any station in that BR Group to the other location, as this is most likely to represent the journey made (i.e. more likely to be a direct service).

Step 4: Sector, Area and Distance Band

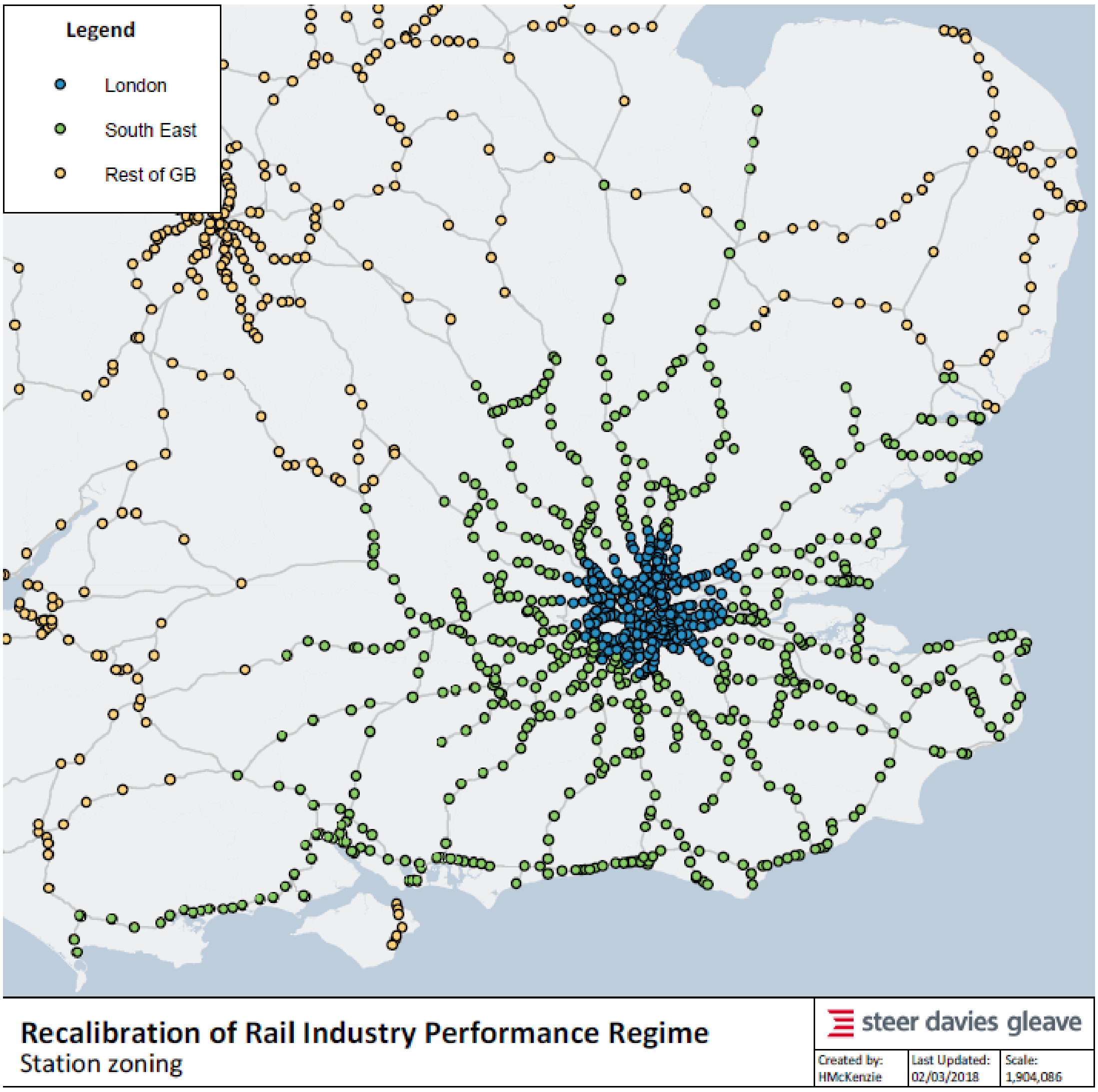
Sector

2.13 A Sector is a grouping of Flows based on Origin and Destination Areas, distance and opportunity to interchange with an airport. The Semi-Elasticities, Delay Multipliers and GJT Elasticities are all segmented by Sector. This segmentation reflects the findings of the research used in PDFH that passengers' sensitivity to changes in GJT and Performance varies in different parts of the rail market.

Area

2.14 For all locations, we add an Area field to the data, based on geographic Area definitions as shown in Figure 2.3. Areas not shown are in the map are all Rest of Country.

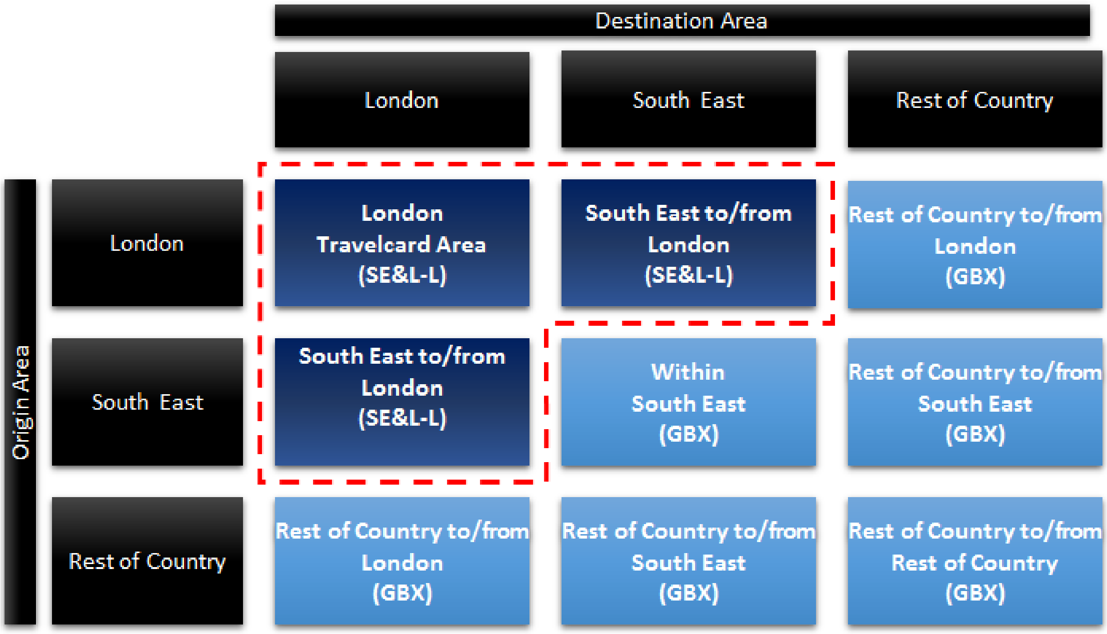
Figure 2.3: Map of areas



Mapping Sector to MRE Method

2.15 We use the allocation in Figure 2.4 to map combinations of Origin Area and Destination Area into the two categories for calculating MRE: South East and London to/from London (SE&L-L) and Great Britain Excluding SE&L-L (GBX). Airports flows are dealt with separately (see paragraph 2.20).

Figure 2.4: Sector mapping flowchart (Source: Steer input)



Distance Band

2.16 The journey distance is used as an additional criterion for defining some Sectors. We use four Distance Bands to map outputs to the correct segments for each set of parameters:

- **0-20 miles** (for Delay Multipliers and GJT Elasticities);
- **20-25 miles** (for Ticket Type to Journey Purpose mapping);
- **25-100 miles** (for Ticket Type to Journey Purpose mapping); and
- **100+ miles** (for Ticket Type to Journey Purpose mapping).

Step 5: Allocating revenue to a journey purpose

2.17 The Delay Multipliers for the Great Britain Excluding SE&L-L Flows are defined by Journey Purpose for each Sector. We also allocate revenue to a journey purpose as one step in the process for calculating Peak splits. We used Tables B1.1 to B1.9 of PDFH 6.0 to create a Ticket Type to Journey Purpose lookup for each Sector, which applies a percentage to Full, Reduced and Seasons tickets to give an allocation across Commuter, Business and Leisure journeys.

Step 6: Allocating revenue to a peak type

2.18 LENNON data does not provide any information on the actual time of travel. To convert the LENNON data into Peak and Off-Peak (for those Service Group which have this distinction), we use the Journey Purpose splits in combination with a Peak Proportion lookup that contains the percentage of journeys by 15-minute timeband. We use 'tblCapriPeak' from the PEARS reference data to aggregate the timebands into Peak and Off-Peak for each Service Code. Further information on this allocation is provided in Appendix 9.

Step 7: TOC-Specific Adjustments

2.19 We incorporate information provided by the operators to adjust the Flow data to account for places where the standard process (described in Steps 1 to 6) does not fully capture all the input information. These adjustments contain commercially sensitive information and are shown only in the TOC's Technical Report and not in this methodology document. TOC-Specific Adjustments can be classified as follows:

- adjustments to the Recalibration Timeframe;
- additional sources of revenue not captured in LENNON (i.e. tickets sold at airports);
- information to disaggregate non-geographic records (e.g. PTE tickets);
- adjustments to the modelled peak/off-peak splits calculated in Step 6;
- adjustments to the allocation of revenue to service codes;
- information on the proportion of journeys to Airport railway stations that connect with flights;
- information to ensure Refunds and Non-Issues are dealt with appropriately; and
- identification of Non-Marginal Revenues (i.e. those that are not affected by performance) that have significant amounts of revenue on Full, Reduced or Seasons rather than Other.

Processing Airport Flows

2.20 Passenger rail journeys to Airports are considered to have a higher sensitivity to lateness than other Flows, and this is reflected in higher Delay Multipliers and GJT Elasticity for these Flows. We use information provided by the TOCs to identify a proportion of journeys to Airport railway stations that are connecting with flights. Only the journeys connecting with flights are assigned the higher Delay Multipliers and GJT Elasticities, with the other journeys assigned the values indicated by their Sector allocation.

2.21 As the Oxera study did not provide specific parameters for airport passenger flows, we use the GBX MRE formulae. For airport flows within London and the South East (e.g. Gatwick Airport to London Victoria), then the journeys to the airport for flights are modelled using the GBX MRE formula and the journeys for other purposes (i.e. commuting) use the LSE-L MRE formula.

Dealing with Flows with small amounts of revenue

2.22 A very high proportion of the revenue (90%+) comes from the top 20,000 Flows. There is a long tail of Residual Flows, where Residual denotes records outside the top 20,000 revenue-earning Flows. To improve the efficiency of the calculations we have developed an approach to assign these Residual Flows into groups with similar GJT times, for that Service Code, Sector and Ticket Type.

2.23 Where the GJT is less than 60 minutes, the GJT Band Width is 5 minutes. For example, Flows with GJTs of 50-55 minutes are grouped together and assigned a GJT of the mid-point of that group (i.e. 52.5 minutes). A full table of Band Widths is shown in Appendix 7.

2.24 For the South East and London to/from London Flows, GJT is not part of the MRE formula, and this banding has no impact on the results. For Great Britain Excluding SE&L-L Flows, the banding only affects the GJT_{Flow} terms in the MRE equation Further discussion of how this banding of Residual flows affects the results is shown in Appendix 7.

3 TOC and NR Benchmarks

Introduction

3.1 In this section, we summarise the process for calculating the TOC Benchmarks (TOCBM) and Network Rail Benchmarks (NRBM) for each Service Group. The TOCBM is the average Performance Minutes (PM) on that Service Group during the Recalibration Timeframe. The NRBM consists of PM suffered by a Service Group from Network Rail (NR), TOC-on-TOC (TOT), Freight-on-TOC (FOT), and Charter-on-TOC (COT) and varies by year:

- Network Rail: varies each year in CP6 based on NR Route performance targets;
- TOC-on-TOC: average PM suffered in recalibration timeframe
- Freight-on-TOC[1]: average PM suffered in recalibration timeframe multiplied by 1.255
- Charter-on-TOC[2]: average PM suffered in recalibration timeframe multiplied by 1.171

3.2 The Benchmarks represents a neutral point at which no payments are made. Any deviation in actual PM from the Benchmark results in a payment between NR and the operator, in accordance to the level of variation from the Benchmark and the Payment Rates:

- If TOC PM is above the TOCBM then NR receives a payment from the TOC
- If TOC PM is below the TOCBM then NR makes a payment to the TOC
- If NR+TOT+FOT+COT PM is above the NRBM then NR makes a payment to the TOC
- If NR+TOT+FOT+COT PM is below the NRBM then NR receives a payment from the TOC

3.3 Performance is measured at specified Monitoring Points (MPs). The list of MPs and their weightings (MPWs) was developed by PwC as part of Phase 1 of the Recalibration. A MP is a combination of:

- a Location (e.g. Reading);
- a 3-digit Service Code (e.g. 456); and
- a Direction (i.e. Forward or Reverse)

Overview of calculation process

The calculation of the TOCBM for each Service Group involves three Stages (Table 3.1). We describe each stage in detail in the following sub-sections.

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[1] This number was provided to Steer by RDG as Determined by ORR.

[2] This number was provided to Steer by RDG as Determined by ORR.

Table 3.1: Stages in the calculation of Benchmarks

Stage	Overview	Applies to
Stage 1: Historic	Determine the average PM across the Recalibration Timeframe using the existing (i.e. CP5) Cancellation Minute Multipliers (CMMs) and Monitoring Point Weightings (MPWs). We also incorporate data for new Monitoring Points that were not in place throughout CP5.	TOC BM NR BM
Stage 2: Adjustment	Adjust the results calculated in Stage 1 by: • replacing the CP5 CMMs with the CP6 CMMs. • replacing the CP5 MPWs with the CP6 MPWs. • accounting for any changes in the assumptions for the Signal Berth Offsets made during and after the Recalibration Period. • adjusting the results to incorporate franchise and service group remapping that has occurred since the Benchmarks were previously set • adjusting the results for any changes to timetable differentials (the difference between Public and Working Timetable Times at destination). • re-allocating any performance minutes in dispute to TOC and NR.	TOC BM NR BM
Stage 3: Trajectories	Apply Freight-on-TOC and Charter Trajectories to account for assumptions on the increase in FOT and COT in CP6 compared with the Recalibration Timeframe. Apply Network Rail trajectories to account for assumptions made in the NR performance trajectories for CP6.	NR BM

Stage 1: Average Actual Historic Performance Minutes

3.4 Determine the average PM across the Recalibration Timeframe using the existing (i.e. CP5) Cancellation Minute Multipliers (CMMs) and Monitoring Point Weightings (MPWs). There are five Parts to Stage 1:

- Part 1A: Confirm CP6 Monitoring Points
- Part 1B: Daily PEARS data
- Part 1C: PSS Timing and Delay Data
- Part 1D: Accounting for remaining Monitoring Points
- Part 1E: Calculating the historic Performance Minutes

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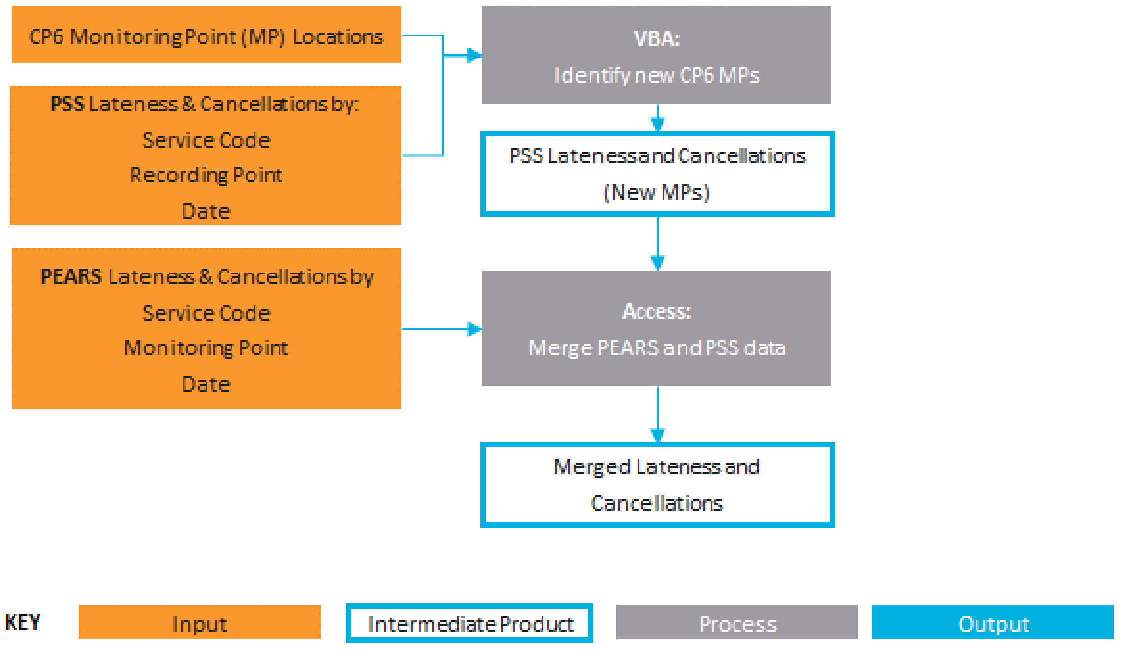
Figure 3.1: Stage 1 Process (intermediate products feed into next Stage)



Part 1A: Confirm CP6 Monitoring Points

3.5 The list of agreed CP6 MPs includes MPs for combinations of Stations/Service Codes which do not currently exist in PEARS (the industry system for calculating Schedule 8 payments). The PEARS data provides results only for the existing MPs, and where new MPs have been agreed for CP6, we need to use a different process. Table 3.2 shows the three cases we have dealt with.

Table 3.2: Cases for processing lateness data at Monitoring Points

Case	Process	% of MPs
Agreed MP already exists in Schedule 8	Use Daily PEARS data	84%
Agreed MP does not exist in Schedule 8 but services operate to the station/service code combination	Use Daily PSS data	12%
Agreed MP does not exist in Schedule 8 and no comparable services operate on the station/service code combination for the new MP	Normalise results on existing MPs	4%

Part 1B: Daily PEARS data

3.6 The Daily PEARS data only contains data at MPs that were valid in CP5. The main data source for lateness minutes and the number of cancellations at a MP level is the Daily PEARS data. Steer was provided with a download of the database by Network Rail for each of the relevant TOCs, covering the recalibration years of 2015/16 and 2016/17.

3.7 The data in this file matches the attributions in the periodic dataset from 2018P08, which has only a very small percentage of incidents from the Recalibration Timeframe still in dispute.

Part 1C: PSS Timing and Delay data

3.8 For locations at which data was not available in PEARS, we used the PSS Timing and Delay datasets, which provide information on lateness and cancellations at each Monitoring Point.

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PSS data was provided by Network Rail and we applied a calculation methodology to convert PSS data to a format consistent with PEARS.

Part 1D: Accounting for remaining Monitoring Points

3.9 The main reason for missing data is that the MPs represented planned future extensions to services and new services. The two categories of service change were dealt with differently:

- **Extensions** to existing services were dealt with by merging the MPW of the missing MP with a representative MP for which there was data. In the case of extensions this would generally be the last MP of the service before the missing section.
- For **New services** that were included in the CP6 Monitoring Point data, the MPWs were excluded from the benchmark calculations and the remaining MPWs in the Service Group were normalised to 1. This in effect assumes that the performance of existing services in the Service Group are representative of the expected performance of the new service.

Part 1E: Calculating results

3.10 We developed a Benchmark Database (in Access) to process the PEARS and PSS data. We undertake the following processes in this Database (Table 3.3).

Table 3.3: Database processes for TOC and NR Benchmarks

Process	Description
1E (i)	Import the PEARS data (period and daily)
1E (ii)	Filter for the data within the recalibration years
1E (iii)	Calculate the number of periods for which there is data by Service Group from the period PEARS data
1E (iv)	Split the daily lateness between NR and TOC based on the daily PEARS data
1E (v)	Calculate the CP5 CMM values from the daily PEARS data
1E (vi)	Add the CP5 CMM values to the processed PEARS data
1E (vii)	Process the PSS data to be in the same format as the PEARS data and calculate the lateness split between NR and TOC
1E (viii)	Combine the processed PEARS and PSS data
1E (ix)	Add the CP6 CMM data and CP6 MPW (without remapping) to the combined PEARS and PSS data
1E (x)	Export the combined PEARS and PSS data along with the period counts.

3.11 The outputs from the data processing model were then imported into the Benchmark Model which calculates for each Service Group:

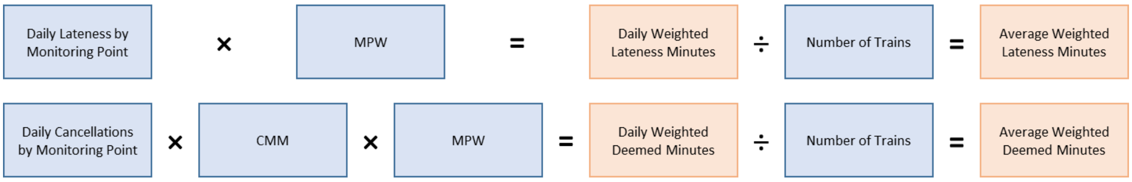
- Actual Minutes Lateness (AML)
- Deemed Minutes Lateness (DML)
- Performance Minutes (PM[3]) – the sum of AML and DML

[3] We use the term Performance Minutes (PM) to describe the sum of AML and DML rather than the often-used term Average Minutes Lateness (AML). We consider that the use of AML for both Actual and Average Minute Lateness may cause confusion.

3.12 The calculation of these values relies on the fact that the sum of the MPWs should equal one. At each MP, daily lateness and deemed minutes are weighted by the MPW and an average figure is calculated for the period being studied (in this case the one or two-year recalibration period). The sum of the average weighted figures for all the MPs in a Service Group is the AML, DML or PM figure (depending on whether the lateness minutes, deemed minutes or performance minutes are being summed).

3.13 The daily weighted lateness and deemed minutes figures could be calculated bottom-up using the total daily lateness and number of cancellations, or top-down from the daily average actual lateness minutes and average deemed lateness minutes. The relationship between the daily actual lateness minutes and the average weighted lateness minutes is shown in Figure 3.2, along with the relationship between the number of cancellations and deemed minutes.

Figure 3.2: Relationship between Daily, Weighted and Average Weighted Lateness and Deemed Minutes



3.14 More detail on the calculation for Step 1E is provided in Appendix 10.

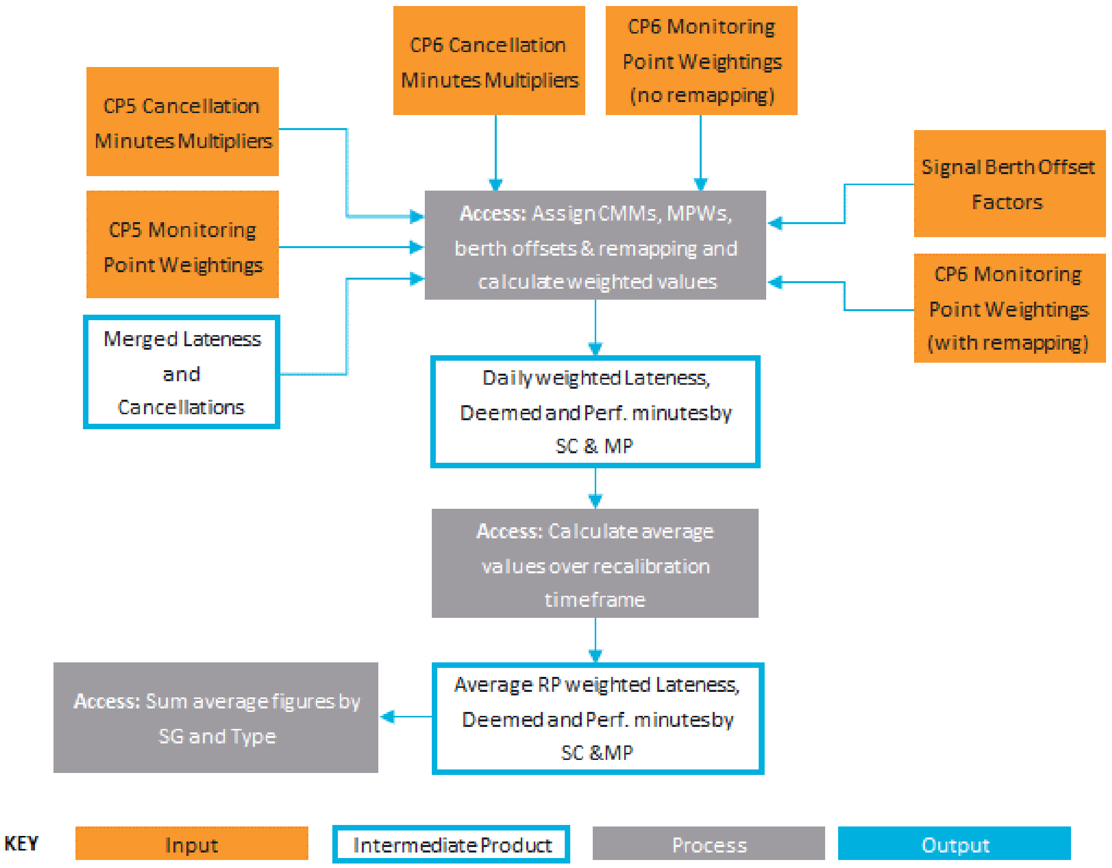
Stage 2: Adjustments to Historic Data for CP6 Benchmarks

3.15 In Stage 2, we adjust the Historic Data to ensure that the CP6 Benchmarks are applicable to the updated parameters and franchise re-mapping. There are six Parts to Stage 2:

- Part 2A: Set up 'Benchmark Model'
- Part 2B: Apply CP6 Cancellation Minute Multipliers
- Part 2C: Apply CP6 Monitoring Point Weightings
- Part 2D: Adjust for Signal Berth Offsets
- Part 2E: Adjust for Remapping
- Part 2F: Reallocate disputed minutes

3.16 A flowchart of the benchmark performance minutes calculation process is shown in Figure 3.3.

Figure 3.3: Stage 2 process (intermediate products feed into next Stage)



Part 2A: Set-up Benchmark Model

3.17 The calculation model contains the following processes

Table 3.4: Spreadsheet processes for Benchmarks

Process	Description
2E (i)	The combined PEARS and PSS data is imported with the period counts
2E (ii)	CP5 Daily Average Weighted Lateness and Deemed Minutes by MP are unaveraged to give the Daily Weighted Lateness and Deemed Minutes by MP
2E (iii)	Daily Weighted Lateness and Deemed Minutes for all other Processes are calculated by multiplying the Lateness Minutes and Deemed Minutes by the MPW of the MP
2E (iv)	The sum of weighted lateness minutes and deemed minutes and the sum of the number of trains per financial period and by Monitoring Point, Service Code and Direction are calculated
2E (v)	Signal berth offset factors are added to the financial period data and adjusted period weighted lateness minutes and deemed minutes are calculated
2E (vi)	The sum of weighted lateness minutes and deemed minutes (both with and without the signal berth offset factors) and the sum of the number of trains per one or two years (representing the recalibration period) by Monitoring Point, Service Code and Direction are calculated
2E (vii)	Average weighted lateness minutes and deemed minutes are calculated as is the average weighted performance minutes by Monitoring Point, Service Code and Direction
2E (viii)	The average weighted lateness, deemed and performance minutes are summed by Service Group and Service Group Type to give the AML, DML and PM values.

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Remapping of ScotRail and East Coast

3.18 In the case of ScotRail and East Coast, the signal berth offset factors (Process (2E (v)) were applied in the Benchmark Database, which in the case of ScotRail also added combined All Trains data for Service Group HA06. The calculation model also carried out the calculations of the AML, DML and PM for ScotRail and East Coast once remapping had taken place using the with remapping MPW values.

Part 2B: Apply CP6 Cancellation Minute Multipliers

3.19 Cancellation Minute Multipliers (CMM) convert train service cancellations into an equivalent 'Deemed' amount of lateness. This is based on the service frequency interval multiplied by a factor of 1.5 to account for issues such as the higher loading on subsequent services. For example, where the typical train service frequency interval on a flow is 30 minutes, a cancellation would lead to an additional 30-minute wait for passengers and would be deemed to be equivalent to a lateness of 45 minutes (i.e. 30 mins x 1.5).

3.20 Deemed Minutes Lateness (DML) at a Monitoring Point is the sum of the equivalent impact of lateness (i.e. typical service frequency interval multiplied by 1.5), caused by cancellations over a specified timeframe, divided by the number of services in that specified timeframe. DML at a Service Group level for a rail period, is the weighted sum of the DML at individual monitoring points.

3.21 The CMMs for CP6 were calculated by PwC in an earlier phase of the recalibration work. Differences between CP5 CMMs and CP6 CMMs reflect changes in the frequency of services. For example, where the service frequency interval reduces from 30 minutes to 15 minutes the CMMs would reduce from 45 minutes (30 mins x 1.5) to 22 minutes (15 mins x 1.5).

3.22 To incorporate changes to the Cancellation Minutes Multipliers (CMM), we divide the historic Deemed Minutes Lateness for each Monitoring Point by the CMM used in the CP5 regime and then multiply by the proposed CMM for CP6. For example:

- The CP5 CMM for a Service Group is 45 minutes
- The CP6 CMM for a Service Group is 22.5 minutes
- The Historic DML in the Recalibration Timeframe is 2.6 minutes
- The Adjusted DML for the Recalibration Timeframe is then 2.6 * 22.5 / 45 = 1.3 minutes

3.23 More detail on the calculation for Step 1E is provided in Appendix 11.

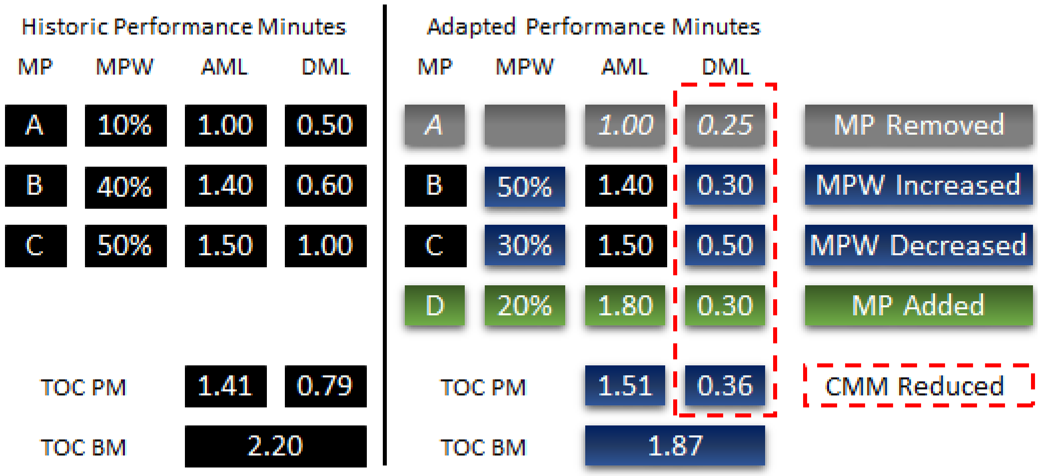
Part 2C: Apply CP6 Monitoring Point Weightings

3.24 To account for differences in the amount of people alighting at different points along the route, Monitoring Point Weights (MPWs) are used to weight the AML and DML according to the proportion of people alighting at stations between the previous Monitoring Point and the current Monitoring Point.

3.25 The MPWs for CP6 were calculated by PwC in an earlier phase of the recalibration work. Differences between CP5 MPWs and CP6 MPWs reflect changes in demand profiles and stopping patterns on a Service Group.

3.26 To incorporate changes to MPWs, we apply the new MPWs to the historic Performance Minutes (with the CMM adjustment). In Figure 3.4, we provide a simplified example, with three MPs (A, B and C). In the Adapted case, Station A is removed as a MP, Station B's MPW increased 50%, Station C's MPW is reduced to 30%, and a new MP (Station D) is added. The CMM falls by 50% due to a reduction in service interval from 30 to 15 minutes.

Figure 3.4: Simplified diagram of calculation of Adapted Performance Minutes



New Monitoring Points

3.27 In addition to the proposed CMM alterations, a list of new Monitoring Point Weightings (MPW) was provided by RDG by Service Group, Service Group Type, Service Code, Direction and Monitoring Point. This file contained MPWs for some new Monitoring Points and the first part of this stage required the calculation of lateness figures at the new Monitoring Points. This was undertaken using PSS daily train-by-train data, which had been processed to assign a direction and peak type to each train.

3.28 The PM for Station D in Figure 3.4 is determined using PSS Timings data, as there will be no record in PEARS for locations which are not current MPs for a particular service code. We process the PSS data to calculate an AML and DML equivalent for those location-service code combinations on a periodic basis.

3.29 More detail on the calculation for Step 2C is provided in Appendix 12.

Part 2D: Adjust for Signal Berth Offsets

3.30 Network Rail provided a series of Excel files which contained data on the expected impact of changes to signal berth offsets on performance benchmarks. The data, which was provided by service group and service group type, is given as a percentage increase or decrease in performance minutes, valid from a given reporting period.

3.31 The berth offset changes were included in the performance minutes calculations using a berth offset change factor. As no changes were proposed before the start of the recalibration period, a factor of one was applied in financial year 2016_01. For any periods with a berth offset change, the proposed change was added to the previous period's berth offset change factor and this new factor was used for subsequent reporting periods. If more than one change was proposed in a reporting period, both changes were added to the previous period's berth offset change.

3.32 More detail on the calculation for Step 2D is provided in Appendix 13.

Part 2E: Adjust for Remapping

3.33 Through the consultation process, TOCs and NR Routes have identified Service Codes which require remapping, in particular those Service Codes which have been transferred between TOCs during or after the Recalibration Timeframe. We then revised the splits for the NR&TOT and TOC-on-Self (TOS) as appropriate.

3.34 The spreadsheet model was also set up to take into account any remapping that was due to take place in or before CP6. Most instances of remapping that were identified had taken place before or during the recalibration period and therefore the PEARS and PSS data already took it into account. Table 3.5 summarises the Service Group remapping that was already included in PEARS.

Table 3.5: Service Group Remapping Included in PEARS data

Service	Service Group Remapping
West Anglia Inners	From Greater Anglia EB07 to London Overground EK04
Great Eastern Inners	From Greater Anglia EB01 to TfL Rail EX01
Romford – Upminster	From Greater Anglia EB01 to London Overground EK05
Manchester Airport – Blackpool North/Barrow/Windermere	From TPE EA07 to Northern ED11
Liverpool/Manchester – Blackpool North/Lancaster/Morecambe	From Northern ED02 to ED11

3.35 Remapping of services or Service Codes to Service Groups was therefore limited to ScotRail and East Coast. The ScotRail remapping was at a Service Code level, with individual Service Codes moving between Service Groups. See Appendix 14 for details of this remapping.

Part 2F: Reallocate disputed minutes

3.36 The final step is to reallocate the disputed minutes. Based on a methodology agreed by the Recalibration Working Group, any minutes in dispute (as at 2018 P08), will be allocated in line with the level of undisputed minutes. This is done separately for AML and DML. For example, on a Service Group:

- NR undisputed AML is 3.0 minutes (60% of the total undisputed AML)
- TOC undisputed AML is 2.0 minutes (40% of the total undisputed AML)
- The level of disputed AML is 0.5 minutes
- NR is assigned 0.3 (i.e. 0.5*60%) of disputed minutes, giving a NR AML of 3.3 minutes
- TOC is assigned 0.2 (i.e. 0.5*40%) of disputed minutes, giving a TOC AML of 2.2 minutes.

The same process was also carried out for DML.

3.37 The percentage of Performance Minutes that were in dispute for 2015/16 and 2016/17 as at 2017/18 P08 (i.e. October 2017) was 0.33%. The highest amount in dispute on any particular Service Group was 6.7%.

Stage 3: Apply trajectories to calculate NR Benchmarks

3.38 The NR Benchmarks consist of Performance Minutes (PM) suffered by a (Victim) Service Group from Network Rail, TOC-on-TOC, Freight-on-TOC, and Charter-on-TOC and varies by year. In this section we explain how each of the different categories of delay responsibility is applied to the Benchmarks:

- Part 3A: TOC-on-TOC (TOT)
- Part 3B: Freight-on-TOC (FOT)
- Part 3C: Charter-on-TOC (COT)
- Part 3D: Network Rail (NR)
- Part 3E: Combining each component

Part 3A: TOC-on-TOC

3.39 The TOC-on-TOC contribution to the NR Benchmark is kept constant throughout CP6. It is the average PM suffered by the Victim Service Group within the Recalibration Timeframe.

Part 3B: Apply Freight-on-TOC Trajectories

3.40 The Freight-on-TOC (FOT) contribution to the NR Benchmarks is uplifted by 1.255. This is based on an assumption provided to Steer by Rail Delivery Group and Determined by the ORR.

Part 3C: Application of Charter-on-TOC Trajectories

3.41 The Charter-on-TOC (COT) contribution to the NR Benchmarks is uplift by 1.171. This is based on an assumption provided to Steer by Rail Delivery Group and Determined by the ORR.

Part 3D: **Apply Network Rail Trajectories**

3.42 We begin Part 3D by providing definitions of the key inputs to the Network Rail Trajectory Process:

- Consistent Route Measure – Performance (CRM-P)
- Network Rail Delay per 100km (NRDp100k)

Definition: Consistent Route Measure – Performance (CRM-P)

3.43 The NR Trajectories are developed by relating AML to an input metric called Consistent Route Measure – Performance (CRM-P). CRM-P is defined as follows: “CRM-P is the Annual minutes of Network Rail attributed delay to passenger trains from incidents occurring within the route boundary normalised by the actual mileage travelled by passenger trains within that route.” (source: Network Rail document “Network Rail S8 Benchmarks trajectories v2”). CRM-P can be expressed as:

CRM-P = Total attributed delay to the NR Route ÷ 100 * Train kms in the route

Where:

Total attributed delay to the NR Route includes both primary and reactionary delay, and delay suffered in other routes from incidents occurring in the origin route. All attributed delay minutes are included to in-service passenger train services (i.e. Empty Coaching Stock moves are not counted, but delays to passenger operators such as NYMR, Tyne & Wear metro and London Underground are included). The measure is assessed after all disputed minutes have been settled.

Train kms in the route is the distance as calculated by PSS for in-service passenger train movements within the route boundary. The distance is based on actual rather than planned train movements. Distance is measured in 100 train kilometres. The planned distance of a train that did not run is <u>not</u> part of the Train km part of the equation. Delay minutes and the distance operated by part cancelled trains are included in the measure.

Definition: Network Rail Delay per 100km (NRDp100km)

3.44 Network Rail Delay per 100km follows a similar definition to that of CRM-P. The only differences are:

- It is calculated at a TOC-level and at a Service Group-level rather than a route level
- Network Rail Delay per 100km at a TOC-level or Service Group level is not a Regulatory measure (it is only a Regulatory measure at Route level).

Phases of work

3.45 There is are five Phases for applying the NR Trajectories, which are outlined in document "Network Rail S8 Benchmarks trajectories v2" (Table 3.6). Phases 1 to 3 have been determined by the industry (i.e. NR, TOCs and ORR) and are outside the scope of this report. Phases 4 and 5 have been developed by Steer.

Table 3.6: Phases in applying NR Trajectories

Phase	Description	Organisation
Phase 1	Route Strategic Plans (RSP) including operator trajectories developed by NR routes	NR
Phase 2	Convert into Consistent Route Measure – Performance (CRM-P) for each route (included in the RSP)	NR
Phase 3	ORR review the RSPs and Determine the CRM-P level	ORR
Phase 4	Covert NR Delay per 100 train kms at a TOC-level to a Service Group-level	Steer
Phase 5	Converted into a NR caused AML for each service group	Steer

Phase 4: Converting TOC-level Network Rail Trajectories to Service Group-level

3.46 The Network Rail Delay per 100km (NRDp100k) trajectory inputs at a TOC-level are applied at a Service Group (SG) level through adjusting the TOC-level CRM-P by the following factor:

$$\text{SG-level NRDp100km}_{\text{Future}} = \text{TOC-level NRDp100km}_{\text{Future}} * \frac{\text{(SG-level NRDp100km}_{\text{Actual}})}{\text{TOC-level NRDp100km}_{\text{Actual}}}$$

Where:

TOC-level NRDp100k $_{\text{Actual}}$ = The TOC NRDP100km in the Recalibration Timeframe. Where the Recalibration Timeframe is two years then it is an average of the TOC-level NRDp100k $_{2015/16}$ and TOC-level NRDp100km $_{2016/17}$.

SG-level NRDp100k $_{\text{Actual}}$ = The Service Group NRDP100km in the Recalibration Timeframe. Where the Recalibration Timeframe is two years then it is an average of the Service Group-level NRDp100k $_{2015/16}$ and Service Group-level NRDp100km $_{2016/17}$.

TOC-level NRDp100k $_{\text{Future}}$ = The NRDp100km at a TOC-level as provided to Steer by Network Rail for each year in Control Period 6.

SG-level NRDp100k $_{\text{Future}}$ = The NRDp100km at a Service Group-level as calculated by Steer for each year in Control Period 6.

Phase 5: Converting Service Group-level NR Delay per 100km Trajectories to AML

3.47 The Service Group-level NRDp100km is then applied to the NR proportion of the NR Benchmark using a regression between NR proportion of Actual Minutes Lateness and NRDp100k.

3.48 We estimate the NR proportion of Actual Minutes Lateness for each Service Group and Period through the following formula:

AML $_{\text{NR only}}$ = AML $_{\text{NR+TOT+FOT+COT}}$ * (Delay Minutes $_{\text{NR}}$) ÷ Delay Minutes $_{\text{NR+TOT+FOT+COT}}$

Where:

AML $_{\text{NR+TOT+FOT+COT}}$ = The recorded, official Schedule 8 NR AML in each period attributed to NR, which includes NR, TOT, FOT and COT.

AML $_{\text{NR only}}$ = The estimated AML assigned to just the NR component of the NR AML

Delay Minutes $_{\text{NR}}$ = The delay minutes attributed to NR

Delay Minutes $_{\text{NR+TOT+FOT+COT}}$ = The delay minutes attributed to NR, TOT, FOT, and COT.

3.49 Regression analysis was undertaken to evaluate the relationship between AML $_{\text{NR only}}$ and NRDp100km at a Service Group-level:

- Independent variable (also known as X variable): NRDp100km at a Service Group level
- Dependent variable (also known as Y variable): NR proportion of NR AML

3.50 The regression relationship is determined by Ordinary Least Squares estimation at a Service Group level. The following model was estimated for each service group.

$$Actual\ Minutes\ Lateness\ (NR\ Only)_{i,t} = \alpha_0 + \alpha_1 NRDp100k_{i,t} + \varepsilon_{i,t}$$

Where:

'i' represented service groups and 't' represented time (Period);

$Average\ minutes\ lateness\ (NR\ Only)_{i,t}$ measured Actual Minutes Lateness (NR only) for Service Group 'i' at time 't'.

$NRDp100k_{i,t}$ measures NRDp100k for Service Group 'i' at time 't'; and

α_1 is the coefficient of the independent variable.

3.51 In the first stage of the estimation process, we estimated the coefficient of correlation. We found high positive correlation between the two variables for most Service Groups. The model was then estimated using Ordinary Least Square approach for each service group. The coefficients for 'Route Performance Measure' were generally as we expected i.e. positive and statistically significant at 5 percent level of significance, meaning that the delay in a service would increase average minutes lateness.

3.52 Where the regression did not provide a good fit, we did not apply this to the trajectory calculation. The regression was regarded as inappropriate if the R-squared value was below 70%. For those slightly below 70%, we discussed the options with the TOC and Route. Where there was no agreement we did not use the regressions if it was below 70%

3.53 The Deemed Minutes Lateness is assumed to have the same trajectory as Actual Minutes Lateness. No alternative suggestions were offered by the Recalibration Working Group.

Note on use of Delay trajectories at a TOC-level for Schedule 8

3.54 The input trajectory for the NR BM profile across CP6 is NR Delay per 100km at a TOC-level. If we assume that Network Rail meet their NR Delay per 100km target exactly, this does not necessarily mean that the Schedule 8 payments from the NR part of the regime between NR and a TOC will be zero. The use of this trajectory may lead to three types of divergence:

- **TOC Delay to Service Group Delay:** If the rate of change at a Service Group level diverges from the TOC-level NR trajectory and Service Groups with a lower NR Payment Rate improve at a greater rate than Service Groups with a higher NR Payment Rate, this would lead to a net pay-out by NR.
- **Service Group Delay to Service Group AML:** If the ratio between AML and Delay per 100km changes such that there is a higher rate of AML per NRDp100km it would lead to a net pay-out by NR.
- **Service Group AML to Service Group DML:** If DML increases at a higher rate than AML then it would lead to a net pay-out by NR.

In each of the three situations above, if the reverse case is true (e.g. DML increases at a lower rate than AML), then this would lead to a net pay-out from the TOC to NR.

Part 3E: Combining each component

3.55 The NR Benchmarks (NR BM) for each Service Group in each year are calculated as follows:

$NRBM_{Year\ x} = NRAML_{Year\ x} + NRDML_{Year\ x}$

$NRAML_{Year\ x} = TOTAML_{Base} + NRAML_{Year\ x} + 1.255 * FOTAML_{Base} + 1.171 * COTAML_{Base}$

$NRDML_{Year\ x} = TOTDML_{Base} + NRDML_{Year\ x} + 1.255 * FOTDML_{Base} + 1.171 * COTDML_{Base}$

Where:

$TOTAML_{Base}$ = TOC-on-TOC AML suffered by the Victim Service Group during the Recalibration Timeframe

$NRAML_{Year\ x}$ = NR-on-TOC AML suffered by the Victim Service Group during the Recalibration Timeframe, ratcheted according to the application of the CRM-P trajectory for that Service Group.

$FOTAML_{Base}$ = Freight-on-TOC AML suffered by the Victim Service Group during the Recalibration Timeframe

$COTAML_{Base}$ = Charter-on-TOC AML suffered by the Victim Service Group during the Recalibration Timeframe

Equivalent definitions apply to $TOTDML_{Base}$, $NRDML_{Year\ x}$, $FOTDML_{Base}$ and $COTDML_{Base}$

4 TOC Payment Rates

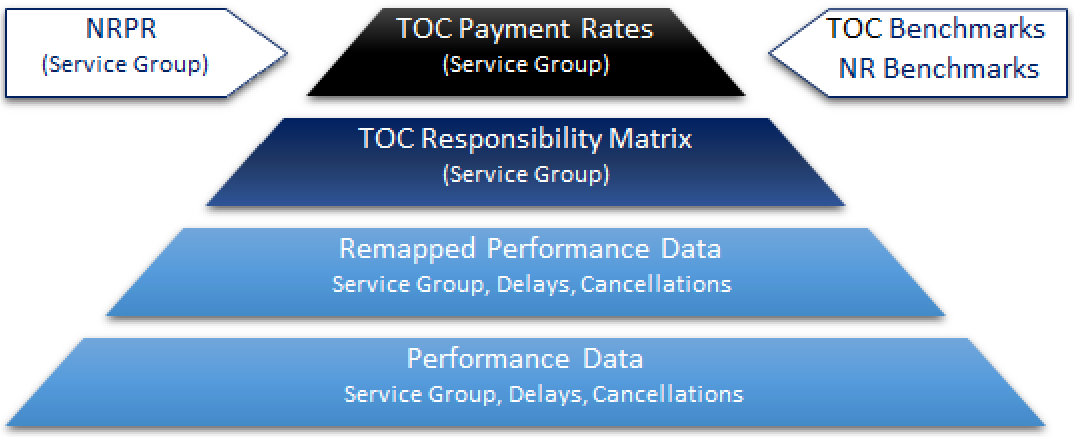
Introduction

4.1 In this section, we detail the process of calculating the Schedule 8 TOC Payment Rates for each Service Group. The TOC Payment Rate (TOCPR) is the amount an operator pays to/receives from Network Rail in respect of disruption caused by a Perpetrating Service Group (PSG) (i.e. the Service Group which causes the performance incident) and experienced by Victim Service Groups (VSGs) (i.e. the Service Groups which suffer delays and/or cancellations from the performance incident).

4.2 The TOCPRs are intended to (on average) hold Network Rail financially neutral to TOC-on-TOC (TOT) delays through the application of the VSG's NRPR to the proportion of the total NR and TOT delays for the VSG that is caused by each Perpetrating Service Group.

4.3 We begin this section by describing how the Service Group TOCPRs have been determined and then work back to show how the information is derived from the input data sources, along with the process for applying TOC-specific adjustments. Figure 4.1 provides an illustration of how this section of the report is structured.

Figure 4.1: Organisation of the TOC Payment Rate methodology



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TOC Payment Rates

4.4 The TOC PR for a (Perpetrating) Service Group is calculated as follows:

$$\text{TOC PR} = \frac{\sum_{VSG=1}^{n} \left(\text{PRC Delay}_{VSG:\,PSG} + \text{PRC Cancellations}_{VSG:\,PSG} \right)}{\text{TOC BM}}$$

Where:

$$\text{PRC Delay}_{VSG:\,PSG} = \frac{\text{Delay Minutes}_{VSG:\,PSG}}{\text{NR\&TOT Delay Minutes}_{VSG}} \times \text{NR AML}_{VSG} \times \text{NRPR}_{VSG}$$

$$\text{PRC Cancellations}_{VSG:\,PSG} = \frac{\text{Cancellations}_{VSG:\,PSG}}{\text{NR\&TOT Cancellations}_{VSG}} \times \text{NR DML}_{VSG} \times \text{NRPR}_{VSG}$$

The Payment Rate Cost (PRC) between a Victim Service Group and Perpetrating Service Group pair (denoted VSG: PSG) is the amount of money Network Rail is assumed to pay to a Victim Service Group (VSG) as a result of Delays and Cancellations caused by a PSG.

PRC Delay $_{VSG:\,PSG}$ is the contribution to PRC $_{VSG:\,PSG}$ from the PSG's Delay Minutes.

PRC Cancellations $_{VSG:\,PSG}$ is the contribution to PRC $_{VSG:\,PSG}$ from the PSG's Cancellations.

The TOC BM is the TOC Benchmark for the Perpetrating Service Group (as per Section 3). This is used as a divisor to convert the PRC which is an absolute value into the TOC PR which is a per minute value.

Delay Minutes are the above-threshold PfPI performance minutes from PSS Delay Data.

Delay Minutes $_{VSG:\,PSG}$ is the Delay Minutes caused by the PSG on the VSG.

NR&TOT Delay Minutes $_{VSG}$ is the total Delay Minutes caused by Network Rail and TOT on the VSG.

Cancellations are derived from the PSS Delay and Mileage Datasets. A factor is applied to Part Cancellations to adjust for their lower impact on DML than that caused by Full Cancellations.

Cancellations $_{VSG:\,PSG}$ is the Cancellations caused by the PSG on the VSG.

NR&TOT Cancellations $_{VSG}$ is the total Cancellations caused by Network Rail and TOT on the VSG.

The NR AML $_{VSG}$ are the portion of the NR+TOT PM for the VSG (as calculated in Section 3) due to NR+TOT Actual Minutes Lateness.

The NR DML $_{VSG}$ are the portion of the NR+TOT PM for the VSG (as per Section 3) due to NR+TOT Deemed Minutes Lateness.

The NRPR $_{VSG}$ are the NRPR for the VSG (as per Section 2).

The calculation for Freight and Charter as Victim is slightly different (see 4.6).

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Example of TOC Payment Rate calculation

4.5 A simplified illustration of TOC Payment Rates calculations is shown in Figure 4.2.

Figure 4.2: Simplified example of TOC Payment Rates

$$PRC\ Delay_{VSG:PSG} = \frac{Delay\ Minutes_{VSG:PSG}}{NR\&TOT\ Delay\ Minutes_{VSG}} \times NR\ AML_{VSG} \times NRPR_{VSG}$$

			Delay Minutes suffered by VSG			
TOC	VSG	PRC Delay VSG: AA01	Caused by AA01	Caused by NR&TOT	NR AML	NRPR
BB	BB01	£475	5,000	20,000	1.9	£1,000
BB	BB02	£40	250	10,000	0.8	£2,000
BB	BB03	£643	2,000	14,000	1.5	£3,000
CC	CC01	£0	0	25,000	2.2	£5,000
CC	CC02	£1,448	3,000	58,000	2.8	£10,000

PRC Delay = Σ PRC Delay VSG: AA01

PRC Delay £2,606

$$PRC\ Cancellations_{VSG:PSG} = \frac{Cancellations_{VSG:PSG}}{NR\&TOT\ Cancellations_{VSG}} \times NR\ DML_{VSG} \times NRPR_{VSG}$$

			Cancellations suffered by VSG			
TOC	VSG	PRC Cancs VSG: AA01	Caused by AA01	Caused by NR&TOT	NR DML	NRPR
BB	BB01	£475	35	240	1.2	£1,000
BB	BB02	£40	5	120	0.9	£2,000
BB	BB03	£643	15	100	0.7	£3,000
CC	CC01	£0	0	400	0.3	£5,000
CC	CC02	£1,448	35	600	0.5	£10,000

PRC Cancellations = Σ PRC Cancs VSG: AA01

PRC Cancellatio £857

$$TOC\ PR = \frac{\sum_{VSG=1}^{n}\left(PRC\ Delay_{VSG:PSG} + PRC\ Cancellations_{VSG:PSG}\right)}{TOC\ BM}$$

	PRC Total		PRC Delay		PRC Cancs
PRC Total	£3,463	=	£2,606	+	£857

	TOC PR		PRC Total		TOC Benchmark
TOC PR	£2,309	=	£3,463	÷	1.5

Freight as Victim and Charter as Victim

4.6 The Freight as Victim and Charter as Victim calculations differ from the TOC as Victim calculations for:

- Payment Rate Cost Delay
- Payment Rate Cost Cancellations.

Freight and Charter: Payment Rate Cost Delay

4.7 The Freight and Charter Payment Rates for Delays are calculated as follows:

Freight PR_{Delay} = Freight delay values * Freight mileage ÷ (100 * annualisation factor)

Charter PR_{Delay} = Charter delay values * Charter mileage ÷ (100 * annualisation factor)

4.8 The Payment Rate Cost Delay calculations are then carried out in the same way for Freight and Charter as Victim as they are for TOC as Victim.

Freight and Charter: Payment Rate Cost Cancellations

4.9 The Freight and Charter Payment Rates for Cancellations are calculated as follows:

Freight PR_{Cancs} = Freight cancellation values ÷ annualisation factor

Charter PR_{Cancs} = Charter cancellation values ÷ annualisation factor

4.10 The Payment Rate Cost (PRC) Cancellations calculations are as follows:

Freight PRC Cancellation = Cancellations caused by perpetrator * Freight PR_{Cancs}

Charter PRC Cancellation = Cancellations caused by perpetrator * Charter PR_{Cancs}

Dealing with different Recalibration Timeframes for different PSG:VSG pairs

4.11 For GTR Perpetrating Service Groups and GTR Victim Service Groups, we use 2015/16 as the Recalibration Timeframe. No data for GTR is provided for 2016/17. For all other operators, we use the Recalibration Timeframe for the Victim Service Group.

TOC Responsibility Matrix

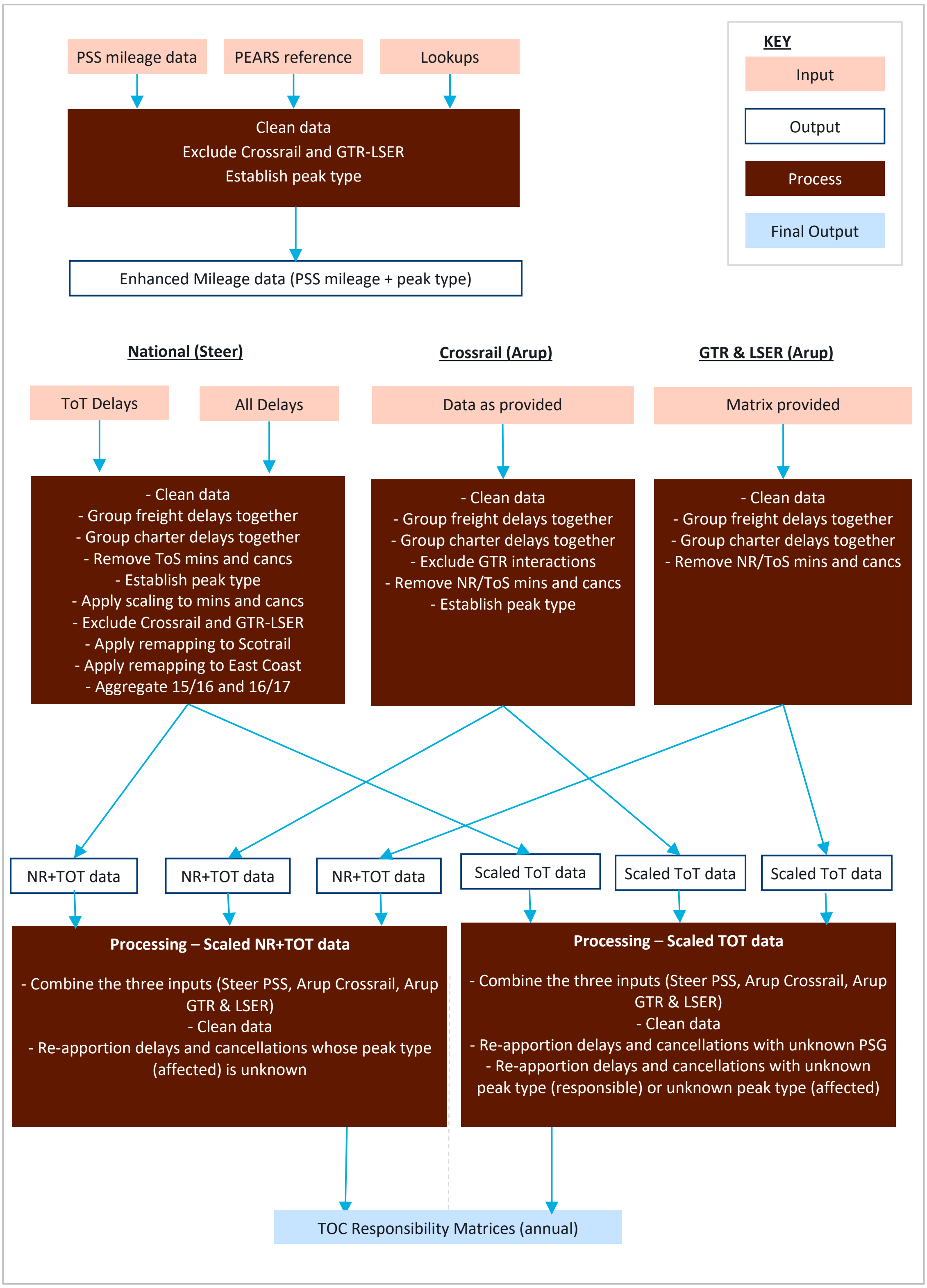
4.12 The TOC Responsibility Matrix (TRM) summarises the degree to which each Service Group (SG) causes delays and cancellations to the others. For each Responsible Service Group, we generate a table of Delays and Cancellations by Day Type, Victim SG and Peak Type based on PSS Delays data measured over the calibration period of 2015/16 to 2016/17.

4.13 The key steps in the process are:

- Establishing Peak Type
- Processing data
- Merging Responsibility Matrices

4.14 Figure 4.3 summarises the process of generating annual TOC Responsibility Matrices.

Figure 4.3: TOC Responsibility Matrix data flows



Establishing Peak Type

4.15 We have been advised by Network Rail that the 'Service Group Type' field in PSS does not at this point in time exactly map to the PEARS definition of peak timebands. We therefore use a combination of PEARS reference data, PSS Mileage data, PSS Delays data and an electronic version of the train timetable.

4.16 The PEARS reference data is used as the definitive source of what constitutes a peak service, and where applicable, the point at which a train changes from between peak and off-peak on route. The reference data is detailed at a Train Service Code level and gives a list of Key Stations which are used to define the Peak Type of a service and the time band for which that Peak Type applies.

4.17 The PSS Mileage data has fields showing the train origin and destination stations and the departure and arrival times at these terminal locations. In most cases, this is sufficient information to enable us to match to the PEARS reference data. However, where the peak type is defined at Intermediate Key Stations (i.e. on through services calling at Birmingham New Street) or where the peak type changes on route, more information is required as the PSS Mileage data does not provide the relevant information on the departure/arrival times.

4.18 We use an electronic version of the timetable to estimate the time that a train is scheduled to call at Intermediate Key Stations based on the expected Minutes From Origin from each Train Service Code and Day Type (Weekday, Saturday, Sunday). Based on the calculated expected time at Intermediate Key Stations we can then apply the PEARS information on Peak Type. The Minutes From Origin for Intermediate Key Stations should be relatively consistent across a Train Service Code as these will have similar calling patterns and journey times.

4.19 A step-by-step process for calculating Peak Type is provided in Appendix 15.

Processing data

4.20 The National Recalibration of Schedule 8 was completed in conjunction with two 'Bespoke' Recalibrations which were then integrated into a consistent, complete matrix. Arup completed the Bespoke Recalibrations for:

- Crossrail Recalibration
- GTR/Southeastern Recalibration

4.21 The remit for the Bespoke Recalibration covered more than just the Responsibility Matrix for Control Period 6. Arup's work also involved developing Responsibility Matrices for intermediate timetables (e.g. December 2018) to ensure consistency of the TOC PR in each step of the process as well as the development of TOC Benchmarks, NR Base Position for all Bespoke Operators and NR Payment Rates for GTR and LSER.

Allocating data to each Recalibration

4.22 The PSS delay data was provided by Network Rail, with one national csv file provided per financial period. This data has been pre-filtered, by Network Rail to only include delay minutes and cancellations that were caused by the 24 'Template' operators. Table 4.1 shows how the Template Operators align with each Recalibration (National, Crossrail, GTR/LSER). Note that, the Bespoke Recalibrations include all delay and cancellations caused *and suffered* by the TOC in their list in Table 4.1, these are then excluded from the National Recalibration data processing and combined at a later stage once they have been remapped.

Table 4.1: The 24 Template Operators

National Recalibration	Crossrail Recalibration	GTR/LSER Recalibration
Transpennine Express (EA)	Great Western Railway (EF)	Govia Thameslink Railway (ET)
Greater Anglia (EB)	Heathrow Connect (EE)	Southeastern (HU)
Grand Central (EC)	Heathrow Express[4] (HM)	
Northern (ED)	TfL Rail (EX)	
CrossCountry (EH)		
West Midlands Trains (EJ)		
London Overground (EK)		
East Midlands Trains (EM)		
Caledonian Sleeper (ES)		
ScotRail (HA)		
LNER (HB)		
Merseyrail (HE)		
Virgin Trains West Coast (HF)		
Arriva Trains Wales (HL)		
Chiltern Railway (HO)		
c2c (HT)		
South Western Railway (HY)		
Hull Trains (PF)		

4.23 Delays and cancellations caused by freight operators, charter operators, and non-template TOCs (e.g. LUL, Tyne & Wear Metro) are not required for the TOC Responsibility Matrix. (Note: they are use when calculating the Total NR+TOT for each Victim Service Group.)

Data Manipulation and Remapping

4.24 Table 4.2 shows the steps in the process for cleaning and manipulating the data as well as the remapping of ScotRail and East Coast.

Table 4.2: Steps for cleaning and manipulating the data along with ScotRail and East Coast remapping

Step	Description
Data cleaning	We have performed the following steps to filter/cleanse the raw data: • Remove trains that were not part of the applicable timetable (i.e. are not planned trains for performance calculations). • Remove affected trains identified as Empty Coaching Stock (ECS) • Remove cases where Attribution is Not Agreed. (There are very few of these TOC-on-TOC Attribution Not Agreed incidents in the database). • Exclude scheduled cancellations • Exclude sub-threshold delays (<3 mins) • Exclude delays/cancs to Eurostar and Heathrow Express

[4] Although Heathrow Express forms part of the Crossrail scope it isn't a Schedule 8 operator, so are only reference in delay and cancellations for Heathrow Express as a Victim TOC and not as a Perpetrator.

Step	Description
	• Exclude 'deemed' minutes for cancellations from the Delay dataset
Classifying services	Services are classified into the following types: • **Passenger** Schedule 8 passenger operators • **Freight** Freight operators • **Charter** Charter operators • **Other** Engineering trains, non-Schedule 8 TOCs
Aggregation of Freight	There is a single payment rate for all Freight delays. We aggregate all delays and cancellations suffered by freight into a single 'Freight Victim Service Group'.
Aggregation of Charter	There is a single payment rate for all Charter delays. We aggregate all delays and cancellations suffered by freight into a single 'Freight Victim Service Group'.
Scaling Cancellations	The cancellations need to be scaled according to the Performance Event Code, to ensure they are summed correctly. For cancellations, the count of cancellation events also needs to be scaled according to the Performance Event Code category. The same scale factors have been applied to Crossrail Recalibration and the GTR-LSER Recalibration. They are also the same scale factors that were used in the CP5 Recalibration. **Type** **Scale Factor** Cancelled (C) 1.00 Diverted (D) 0.45 Pined (P) (terminated short) 0.45 Amended Origin (A) 0.15 Failed to Stop (F) 0.15 Scheduled (S) 0.00
Remapping Scotrail	The ScotRail remapping involved mapping Service Code (i.e. 8-digit codes) from one of HA06 or HA07 to HA05-HA06-HA07-HA08 as per an input mapping provided by ScotRail. The HA06 Service Group, which was previously Peak / Off-Peak was adjusted to be All Trains.
Remapping East Coast	The East Coast services were remapped to take account of allocation changes of services on 2-hourly patterns. This meant the changing of individual trains as the changes impacted at a more granular level than Service Code.
Removing TOC-on-Self delays and cancellations	The delay data is filtered to only retain delays and cancellations where the Responsible Operator differs from the Affected Operator.

Combine the three Recalibration matrices

4.31 All records from the three processes (National, Crossrail, GTR-LSER) are appended to create one master file containing all records.

Reapportioning 'Unknown' delays and cancellations

4.32 All TOT minutes suffered by a Victim Service Group are assigned to a Perpetrating TOC. However, not all the minutes within a Perpetrating TOC can be assigned to a Perpetrating Service Group. In addition, for Victim and Perpetrating Service Groups with a Peak/Off-Peak type, not all the Delays and Cancellations can be exactly assigned to either Peak or Off-Peak, some are left "unknown". We have developed a process to allocate the unknown delays and cancellations to known Victim and Perpetrating Peak Types. This process is conducted in three stages:

- Reapportion delays and cancellations whose Perpetrating Peak Type is unknown
- Reapportion delays and cancellations whose Victim Peak Type is unknown

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- Reapportion delays and cancellations whose Perpetrating Service Group is unknown

We describe the process using Delays but this is equally applicable to Cancellations.

4.33 The first step is to reapportion delays whose Perpetrating Peak Type is unknown. Within the Perpetrating Service Group (PSG), the delays with unknown responsible peak type are reapportioned pro-rata amongst the known peak types based on the amount of known delay caused by Peak and Off-Peak services within the PSG. We ensure that the total delay caused by a PSG is maintained with no delay minutes being lost or gained.

4.34 We perform a similar process for reapportioning delays whose affected Peak Type is unknown. Within the Victim Service Group (VSG), the delays with unknown affected Peak Type are reapportioned pro-rata amongst the known Peak Types based on the amount of known delay suffered by Peak and Off-Peak services within the VSG. We ensure that the total delay suffered by a VSG is maintained with no delay minutes being lost or gained.

4.35 Delays with an unknown PSG are reapportioned amongst the known PSGs pro-rata in accordance with the known delays caused by the PSGs on any given TOC. This ensures that the total TOC-on-TOC delay is maintained, and that no delay is lost or gained.

4.36 At this point the data is can be uploaded in the TOC Payment Rate Model.

5 Sustained Poor Performance

Introduction

5.1 The ORR states that[5]: "The Sustained Poor Performance regime is intended to provide additional compensation to a TOC when lateness and cancellations attributable to Network Rail reach a specified threshold, beyond which it is considered the liquidated sums nature of Schedule 8 could start significantly to undercompensate the TOC. That additional compensation is measured in relation to the benchmark level of Network Rail's performance."

Calculation

5.2 There are three steps of calculation:

- Step 1: Service Group Period SPP
- Step 2: TOC Period SPP
- Step 3: Annual Periodic Liability TOC

5.3 The difference between 'Annual Value' and 'Annual Periodic Liability' is explained in Step 3.

Step 1: Service Group Period SPP

5.4 The Service Group Period SPP is calculated as follows:

$SPP_{SG,\ Period} = NR\ BM_{SG} * NRPR_{SG} * Busyness\ Factor * Threshold_{SPP}$

Where:

$NR\ BM_{SG}$ = Network Rail Benchmark for the Service Group in a year

$NRPR_{SG}$ = Network Rail Payment Rate for the Service Group in a year

Busyness Factor = A parameter to convert daily NR Payment Rates to a periodic figure. This is a constant value of 28.

$Threshold_{SPP}$ = The constant parameter that defines at what deviation from the Benchmarks should the Sustained Poor Performance regime be triggered. For Control Period 6, this value has been set at an absolute deviation of 20% above the benchmark.

Step 2: TOC Period SPP

5.5 The TOC Period SPP is calculated as follows:

$SPP_{TOC,\ Period} = \sum SPP_{SG,\ Period}$

[5] Source of definition: http://orr.gov.uk/__data/assets/pdf_file/0004/16429/sustained-poor-performance-2014-11-14.pdf

5.6 The Period data is summed across the Service Groups by year to give the annual cost of being 20% above the Trajectory Benchmark across the entire TOC.

Step 3: Annual Periodic Liability

5.7 Annual Periodic Liability (APL) is provided for the third, sixth, tenth and thirteenth reporting period and gives a moving annual cost of being 20% above the Trajectory Benchmark based on the number of the 13 periods that fell in the previous year (multiplied by that year's rate) and the number in the current year (multiplied by that year's rate). This is done as follows:

$APL_{Year\ X,\ Period\ 3} = 10 * SPP_{Year\ X-1} + 3 * SPP_{Year\ X}$

$APL_{Year\ X,\ Period\ 6} = 7 * SPP_{Year\ X-1} + 6 * SPP_{Year\ X}$

$APL_{Year\ X,\ Period\ 10} = 3 * SPP_{Year\ X-1} + 10 * SPP_{Year\ X}$

$APL_{Year\ X,\ Period\ 13} = 0 * SPP_{Year\ X-1} + 13 * SPP_{Year\ X}$

5.8 In the first year of Control Period 6, the $APL_{Year\ 2019/20,\ Period\ Y} = 13 * SPP_{Year\ 2019/20}$

A Appendices

Appendix 1: TOC-Specific recalibration years

A.1 For some operators, a different recalibration timeframe has been used in the calculation of Payment Rates and Benchmarks (Table A1.1).

Table A1.1 Recalibration Timeframe by TOC

TOC	Recalibration Timeframe	Principal reason for changes to default
Arriva Rail London	2015/16: Gospel Oak - Barking 2015/16 – 2016/17: all others	Line closures on Gospel Oak – Barking during 2016/17
Transport for Wales	2015/16 – 2016/17	
Caledonian Sleeper	2016/17	Impact of Lamington in 2015/16
c2c	2016/17	Significant timetable change in Dec '15
Chiltern Railways	2016/17	Significant timetable change in Dec '15
CrossCountry	2015/16 – 2016/17	
Crossrail	2019/20 forecast	Crossrail service changes from May 19 TT
LNER	2015/16 – 2016/17	
East Midlands	2015/16 – 2016/17	
Grand Central	2015/16 – 2016/17	
Great Western Railway	2015/16 – 2016/17 2016/17 only 2015/16 only 2014/15 only BMs and TOC PR will use 2015/16 and 2016/17	EF03, EF04, EF05, EF06, EF09, EF11 EF01, EF08, EF12 EF02, EF07 EF10, EF13 Different timeframes for different Services Groups due to major blockades on route.
Greater Anglia	2015/16 – 2016/17	
GTR	2015/16	Major disruption in 2016/17
Hull Trains	2015/16 – 2016/17	
Merseyrail	2015/16	Disruption on Wirral Line
Northern	2016/17 TOC BM, NR BM & TOC PR 2018/19 forecast for NRPR	2016/17 used as a base year then apply adjustment for May 18
Scotrail	2015/16	Queen Street works in 2016/17
South Western Railway	2015/16 – 2016/17	
Southeastern	2015/16 – 2016/17	
Transpennine Express	2015/16 – 2016/17 2016/17	EA01 and EA02 EA07 – data was not complete for EA07 in 2016/17 for TOC BM, NR BM and TOC PR
Virgin West Coast	2015/16 – 2016/17	
West Midlands Trains	2015/16 – 2016/17	

Appendix 2: Price Base Factor

A.2 All MREs were calculated in outturn prices (i.e. the value of the ticket sold). The Price Base Factor uplifts these outturn MREs into values expressed in 2016/17 prices. The Price Base Factor for each historic year is shown in Table A2.1.

Table A2.1 Price Base Factors

Recalibration Year	Outturn MREs Assumed 'Price Base'	Price Base Factor
2016/17	November 2016	1.00000
2015/16	November 2015	1.02142
2014/15	November 2014	1.03244

A.3 The majority of fare changes occur in January of each year, with prices calculated according to the preceding year's July RPI value. We use the mid-points of the Rail Year (November), as these are representative of the January changes plus any intermediate change in prices. We are assuming the same timing of annual fare changes in CP6 as in the past.

A.4 The Price Base Factor only adjusts for changes in RPI up to the NRPR Price Base. It does not adjust for any other impact (i.e. revenue growth).

A.5 At the time of undertaking this calculation, ORR was consulting on, among other things, the potential use of CPI during CP6. For the purposes of calculating the NRPR in a consistent price base (2017/18), we have opted to use RPI as this is consistent with the way that the CP5 NRPRs have been uplifted to 2017/18.

Appendix 3: Implicit weighting of NRPRs by revenue in each year.

A.6 Where the Recalibration Timeframe covers two years, the MREs are calculated using the sum of revenue across those two years. The NRPRs are calculated by dividing the MREs by the sum of the Busyness Factors (∑BF) across the Recalibration Timeframe. Hence, the NRPRs are implicitly weighted by the revenue in each year. (We do NOT calculate a NRPR for 2015/16 and 2016/17 separately and then divide by two.)

Appendix 4: Use of Busyness Factors to convert MREs to NRPRs

A.7 We use the sum of Busyness Factors (∑BF) across the Recalibration Timeframe as the divisor in the NRPR equation. We use ∑BF rather than number of days as ∑BF is better aligned with the formula for the calculation of performance payments.

A.8 By way of example, taking a given year in CP6 and assuming that NR Performance Minutes for a Service Group exceed the NR benchmark for the year by one minute:

- (a) The amount of revenue lost would be the MRE for that Service Group.
- (b) The total amount paid out will be Service Group NRPRs x ∑BF for that Service Group.
- If (a) equals (b), then MRE = NRPRs x ∑BF
- Rearranging this equation gives NRPRs = MRE ÷ ∑BF

A.9 If the Busyness Factor is increased in CP6 compared to CP5 for any reason (e.g. there are fewer engineering possessions), then it would be reasonable to assume that revenue would increase in the same proportion to the Busyness Factors. Therefore, there should be a higher amount paid out per minute over the Benchmarks (i.e. while NRPRS is constant the ∑BF increases).

Appendix 5: Semi-Elasticities for SE&L-L Flows

Source

A.10 PDFC commissioned Oxera to carry out a study of "The impact of unplanned disruption on train operator revenue", which reported on 2nd August 2017. The report provided one set of semi-elasticities for Seasons and Non-Seasons for "London Flows", but did not split out South East to/from London and within London Flows. The relevant results were shown in Table 3 of

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the Oxera report. For Schedule 8, we use the Long-Run semi-elasticities shown in Table A5.1 as the most appropriate set for MREs (the report also identified Short-Run semi-elasticities).

Table A5.1 Long-Run Elasticities (Table 3 in Oxera: Impact of unplanned disruption on train operator revenue)

	Full	Reduced	Seasons
"London" Flows	-0.0394	-0.0347	-0.0195

A.11 PDFC commissioned Steer to Peer Review the Oxera study. As part of this work, Steer undertook some separate analysis using the datasets developed in the Oxera study. This split out the London flows into South East to/from London and London Travelcard Area. We have used these disaggregated results to define SE&L-L parameters (see Table 2.1 of main report), as there is a significant difference in the parameter values for each of these Sectors.

Table A5.2 Long-Run Elasticities (Table 8 in Steer Peer Review of Oxera report)

Sector	Full	Reduced	Seasons
South East to/from London	-0.0205	-0.0305	-0.0210
London TravelCard Area	-0.1133	-0.0645	-0.0437

A.12 We reference the source of these parameters as Oxera, as it was Oxera who have developed the methodology and datasets from which the results in the Peer Review were derived.

Rationale

A.13 The Rationale for using the Oxera study results for SE&L-L rather than the PDFH approach can be summarised as follows (summary produced by Rail Delivery Group):

1. The Oxera study is very recent, being undertaken less than a year ago with up-to-date data.

2. It focusses specifically on London and South East flows. During PR13, these were identified as an area of concern for the industry and consequently ORR had to make an arbitrary 10% adjustment to the Payment Rates for these flows. We commissioned the work so that the industry would have some evidence to inform this type of decision for CP6.

3. The Oxera study has been independently audited by Steer. The audit confirmed that the Oxera findings were sound, and that the approach suggested in the Oxera study was appropriate for London and South East commuter flows.

4. The industry has discussed this at length (ORR was largely present and involved in these conversations), and the industry has agreed that the Oxera study should be used for London and South East flows.

5. It seems likely that the next iteration of PDFH may include the findings from the Oxera study, which is further evidence that this study is considered to be robust by a wide range of stakeholders.

Appendix 6: MRE formula

A.14 Marginal Revenue Effect (MRE) is "the revenue impact of a one-minute change in Performance Minutes". The Performance to Revenue relationship is non-linear and the slope of the curve is dependent on the level of performance. For PDFH 5.1, the relationship is calculated as shown in Figure A6.1, where 'Δ Perf' is the change in Performance Minutes. By putting the one-minute change in Performance Minutes into the equation (i.e. Δ Perf = 1), the MRE formula will give the change in revenue for this one-minute change.

Figure A6.1: PDFH 5.1 GJT

$$MRE = Revenue \times \left(\left(\frac{GJT}{GJT + \Delta Perf * Delay\ Multiplier} \right) ^\wedge GJT\ Elasticity - 1 \right)$$

A.15 The NRPRs to apply a set payment rate per minute of change in Performance Minutes compared to the Benchmarks. In practice, this rate is applied to a range of actual variations in Performance Minutes compared to the Benchmark, these actual variations could be as small as a 0.001 – 0.005 minutes or as large as 5-10 minutes (in extreme circumstances). In reality, the variations are more likely to be an increment closer to 0 minutes than 1 minute. We therefore need to consider the definition of MRE for a smaller increment than 1 minute. To do so, we use the gradient of the MRE equation at a 0-minute change in Performance Minutes. We apply the slope at this point (i.e. where Δ Perf is very close to zero) to work out the MRE for a 1-minute change in Performance Minutes. The gradient at this point (derived using differentiation) is shown in Figure A6.2 It is this equation that is used in the MRE equations in section 1.

Figure A6.2: MRE equation used for South East and London to/from London Flows

$$MRE = \frac{-1 \times Revenue \times Delay\ Multiplier \times GJT\ Elasticity}{GJT}$$

A.16 For the Oxera Semi-Elasticities applied to South East to/from London flows, the relationship between revenue and performance is defined as shown in Figure A6.3.

Figure A6.3: Relationship between Revenue and Performance for South East and London to/from London Flows

$$MRE = Revenue \times \left(Exponent \left(Semi\text{-}Elasticity \times (-1) \right) - 1 \right)$$

A.17 Applying the same principles (i.e. slope of this equation very close to a 0 minutes change in Performance Minutes), the equation is as shown in Figure A6.4. It is this equation that is used in the MRE equations in section 1.

Figure A6.4: MRE equation used for South East and London to/from London Flows

$$MRE = -1 \times Revenue \times Semi\text{-}Elasticity$$

Appendix 7: Dealing with Residual Flows

A.18 In the demand processing, we explain how we treat 'Residual' flows outside the Top 20,000 flows. Residual Revenue for each Service Code, Sector and Ticket Type is aggregated into Flows with similar GJTs. The GJT Bands Widths are as per Table A7.1.

Table A7.1 GJT Band Widths used for Residual Flows (Source: Steer input)

GJT Lower Bound	GJT Upper Bound	Band Widths	Number of bands
0	60	5	12
60	120	10	12
120	240	15	16
240	480	30	16
480	840	60	14
840	1440	120	12
1440	9440	Not Applicable	Not Applicable

A.19 In this Appendix, we explain the impact of the GJT Banding of the Residual flows. This is best explained using the manipulation of the MRE formula shown in Figure A7.1.

Figure A7.1 Manipulation of CP6 MRE formula

$$MRE = \frac{-1 \times Revenue \times Delay\ Multiplier \times GJT\ Elasticity}{GJT}$$

A.20 The Delay Multiplier and GJT Elasticity are constant within a Sector and the Revenue is aggregated across all flows within that Sector. The only component of this term that is affected by the GJT Banding is the GJT term. Small bands are used for lower values of GJT, with larger bands width deployed for higher GJT values.

A.21 To illustrate the effect this could have on the overall MRE, we have assumed that a Service Group has 95% of its revenue captured in the top 20,000 flows for the TOC and shown the impact that would occur if the actual GJTs were closer to the lower end (i.e. the first quartile) of the GJT band than the mid-point (i.e. for the 120 to 130 minutes band, the mid-point is 125 minutes and the first quartile of GJT band is assumed to 122.5 minutes). The impact of the banding on the overall results will be very small (around 0.01% to 0.04% at the maximum).

Appendix 8: Extent of South East geography

A.22 In B1.3 of PDFH 6.0 the South East is defined as *"The South East is sometimes referred to as Network SouthEast or Network Area, and refers to one of the passenger sectors of British Rail that mainly covers London commuter services. It mainly coincides with the South East and East of England Government Office Regions, except Norfolk."*

A.23 Whilst this definition appears reasonable, there are issues with using it for distinguishing between different MRE methods and parameters values. For example, Network SouthEast (NSE) extended as far as Exeter and the Isle of Wight. It was also defined by train service rather than location, one location could be on a NSE service, a Regional service and a Long-Distance service.

A.24 To ensure there is no ambiguity of the geographic extent of South East defined in this recalibration, we have specified our assumptions on the extent of the definition of South East, on a route basis in Table A8.1 using Boundary Stations as the limit. Any station between the Boundary Station and London (including branches) would be considered to be in South East.

Table A8.1: Boundary Stations for South East Area

Route	Boundary Stations
Kent	All stations
Sussex	All stations

Wessex	Weymouth, Portsmouth Harbour, Basingstoke, Reading, Reading West, Salisbury Note: North Downs Line included in South East
Western	Bedwyn, Didcot, Banbury, Oxford
Chiltern	Banbury, Oxford (this includes link from Bicester to Oxford in the South East Area)
West Coast Main Line	Northampton
Midland Main Line	Bedford
East Coast Main Line	Peterborough, Cambridge, King's Lynn
West Anglia Main Line	Cambridge, King's Lynn
Great Eastern	Ipswich
Essex Thameslink	All stations

Appendix 9: Peak Proportions

A.25 LENNON data does not provide any information on the actual time of travel. To allocate Revenue to PEARS Peak and Off-Peak categories, we applied modelling assumptions on the proportion of Commuting, Business and Leisure journeys that are made on services at Peak times of the day. We considered both the PEARS Peak hour definitions as well as the variation in daily distribution of travel demand for London, 'Core Cities' and Other Stations (note that other stations is not applied in the modelling). Peak flows are defined in specific directions i.e. to Manchester in the am peak and from Manchester in the pm peak. Contra-peak flows are considered as off-peak. Table A9.1 shows the Service Group, City and City Type.

Table A9.1 Cities, City Type, Peak Hours of Operation and Service Groups

City	City Type	AM Peak	PM Peak	Service Groups
London	London	07:00 - 09:59	16:00 - 18:59	EB02, EB03, EB04, EB06, EB07 EF05, EF06 EJ05 EK01, EK02, EK03, EK04 EX01 HO01, HO02, HO03, HO04 HT01 HY01, HY03, HY04, HY05, HY06, HY06, HY07, HY08
Manchester	Core	06:00 - 09:30	16:00 - 18:30	ED08, ED10
Birmingham	Core	07:30 - 09:00	16:30 - 18:00	EJ01, EJ03
Glasgow	Core	07:00 - 09:59	16:00 - 18:59	HA06 (CP5). Note, Peak and Off-Peak will be combined into All Trains for HA06 in CP6.
Cardiff*	Core	06:31 – 09:00	16:01 – 18:00	HL05

A.26 Cardiff Valleys (HL05) also has a Saturday Peak, which includes departures and arrivals from Cardiff (i.e. Cardiff Central, Cardiff Queen Street or Cardiff Bay) from 09:01 to 17:00.

A.27 In the situations where a Service Group has more than one timing for the Peak we have assumed that the definition of Peak at the locations accounting for the highest proportion of revenue. This provides a proportionate approach to processing the data.

A.28 We used "Calibrated Demand Profiles" and "Calibrated Day of Week Splits" from MOIRA2.2. These are based on more recent information than that used in MOIRA 1. The Calibrated Demand Profiles table defines peak profiles in terms of the percentage of the total number of passengers that are travelling in 15 minutes time bands throughout the day. This is segmented by journey purpose, flow type and journey length. The Calibrated Day of Week Splits", apportions demand into Weekday, Saturday and Sunday by Ticket Type.

A.29 For am peak journeys to the Cities shown in Table A9.1, the Peak Type is defined based on the arrival time at the City terminal station. However, the Calibrated Demand Profiles are based on departures times from the origin station. Therefore, we adjust the demand profiles to account for the journey length so that they are reflective of the arrival time at the City terminal station.

Appendix 10: Calculation in our Benchmark Database

A.30 To compare actual service group performance over the recalibration timeframe against the current CP5 benchmarks, annual and biennial average performance minutes figures were calculated for both Network Rail and the TOC.

A.31 PEARS data on a daily basis had been provided to Steer by Network Rail and this daily data was the base for the bottom-up calculation. This data is contained in table tbl_H_MP_Headers in the PEARS database and is grouped in the following way.

Figure A10.1: PEARS data hierarchy

└Service Group	e.g. EA01
└Service Group Type	Peak, Off-peak, All Trains
└Service Code	e.g. 731
└Direction	Forward or Reverse
└Monitoring Point	MP Identification Number

A.32 For each date and combination of the above, figures for the total lateness, total number of cancellations and total number of trains at the Monitoring Point are provided. From these inputs, the average cancellation minutes, average lateness minutes and average performance minutes are calculated and these figures are also provided in the data. Each of these three calculated figures is given for Network Rail and the TOC and based on Network Rail and TOC bias.

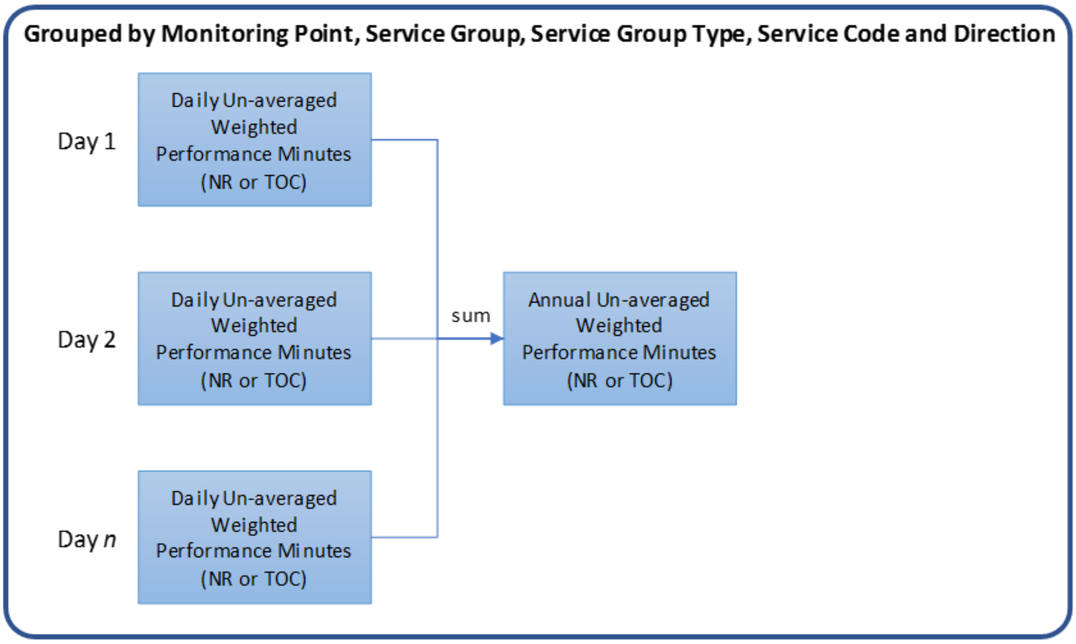
A.33 The methodology that has been used to calculate the annual and biennial figures follows the methodology used in the calculation of the period data in PEARS, the only difference being the duration over which the data was summed.

A.34 The first process of the calculation was to un-average the Network Rail or TOC daily average weighted performance figures for each record in tbl_H_MP_Headers, in the following way.

Figure A10.2: Calculation of daily un-averaged weighted performance minutes

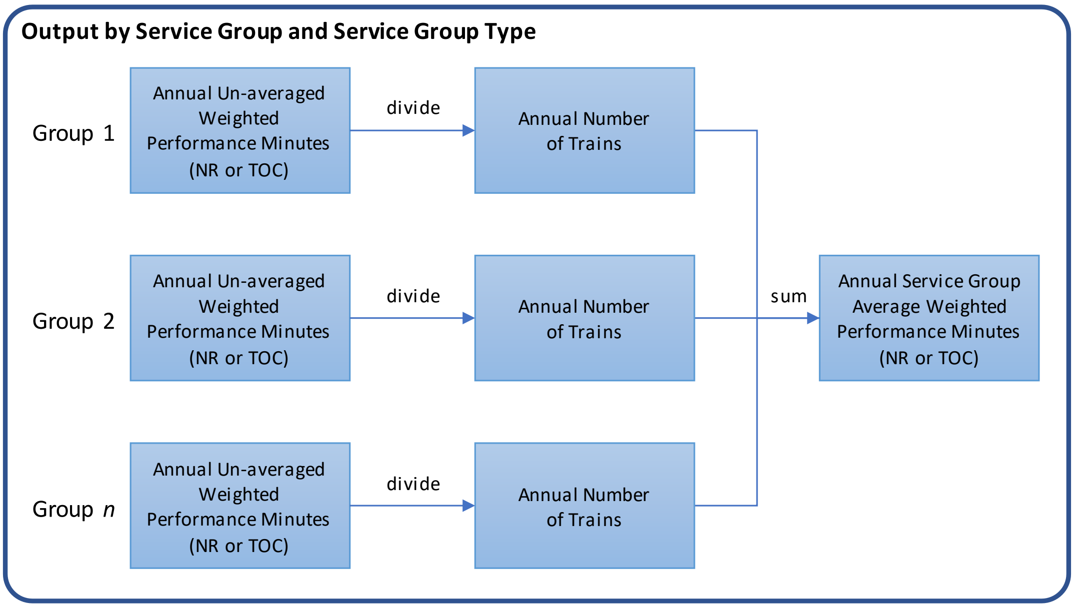
A.35 The second process required both the daily un-averaged weighted performance minutes and the number of trains to be summed across the time period being studied (in this case one or two financial years). This was completed for each combination of Monitoring Point, Direction, Service Code, Service Group Type and Service Group.

Figure A10.3: Calculation of Annual un-averaged weighted performance minutes



A.36 The number of trains in the time period being studied was summed in a similar way. The final stage was to average the annual weighted performance minutes by dividing the annual un-averaged weighted performance minutes by the annual number of trains. The average figures were then summed by Service Group and Service Group type to give the final annual average performance minutes figure.

Figure A10.4: Calculation of Annual Average Weighted Performance Minutes by Service Group



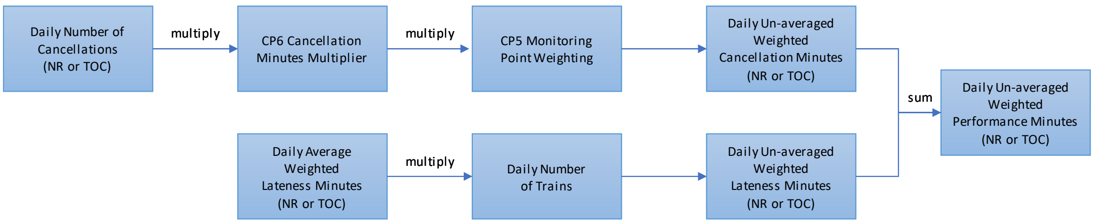
Appendix 11 Calculation for Cancellation Minute Multipliers

A.37 A list of proposed changes in CP6 to Cancellation Minutes Multipliers (CMM) was provided by RDG at a Service Group and Type level. In this stage of the process, the performance minutes were recalculated based on the new CMMs, with the Monitoring Point Weightings remaining at their CP5 values.

A.38 To recalculate the un-averaged weighted performance minutes with the new CMMs, the two constituent parts of the performance minutes needed to be calculated, the un-averaged weighted lateness minutes and the un-averaged weighted cancellation minutes. The former was calculated in a similar way to the un-averaged weighted performance minutes in Stage 1, by multiplying the daily average weighted lateness minutes by the daily number of trains.

A.39 The daily un-averaged weighted cancellation minutes was calculated by multiplying the daily number of cancelations by the new CP6 CMM figure and then multiplying the product of this by the CP5 Monitoring Point Weighting. The daily un-averaged weighted lateness and cancellation minutes were then summed.

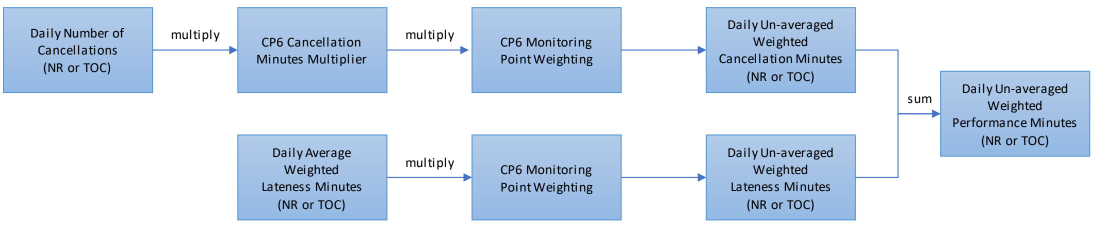
Figure A11.1: Updated Cancellation Minutes Multiplier – Calculation of Un-averaged Weighted PMs



Appendix 12 Calculation for Monitoring Point Weightings

A.40 Once the PEARS database had been overlaid with PSS lateness data for new Monitoring Points, new un-averaged weighted cancellation and lateness minutes were calculated using the CP6 CMMs and MPWs. The new un-averaged weighted cancellation minutes were calculated in a similar way to Stage 2, but using the CP6 MPW figures. The calculation method for the un-averaged weighted lateness minutes was to multiply the lateness minutes (either from PEARS of PSS) by the CP6 MPW. The sum of these values was the un-averaged weighted performance minutes and the methodology from Stage 1, was then used to calculate the annual service group average weighted performance minutes.

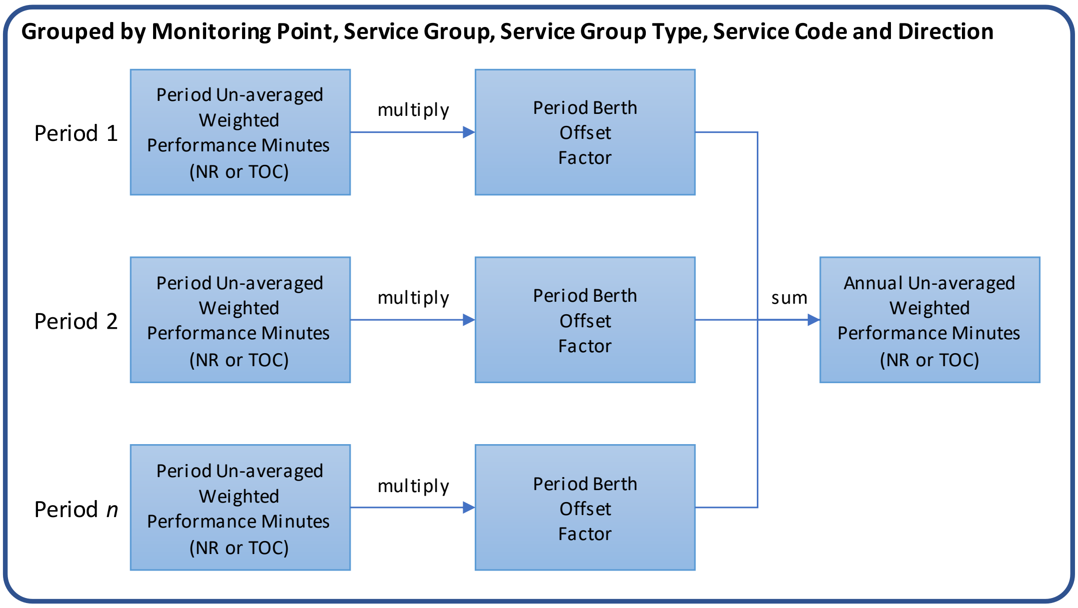
Figure A12.1: Updated Monitoring Point Weightings – Calculation of Un-Averaged Weighted PMs



Appendix 13 Calculation for Signal Berth Offsets

A.41 A list of factors was prepared for each combination of service group and service group type for every reporting period in the recalibration period. In order to apply these factors to the data, the insertion of an intermediate stage in the calculation of the annual average performance minutes was necessary. Instead of directly summing the daily un-averaged weighted performance minutes over an annual or biennial time period (as shown above), the values were summed by reporting period. These values were then multiplied by the period berth offset factors calculated and then the period figures were summed over an annual or biennial time period to give an annual un-averaged weighted performance minutes figure, as shown in Figure A13.1. The results were then applied to calculate the annual service group average weighted performance minutes.

Figure A13.1: Updated Signal Berth Offsets - Calculation of Annual un-averaged weighted performance minutes



Appendix 14 Remapping of ScotRail and East Coast

A.42 The movement of Service Codes between Service Groups is outlined in Table A14.1.

Table A14.1: ScotRail Service Code Remapping

Service Code(s)	Service Group Remapping
569, 571, 573	From HA06 to HA05
560, 563	From HA06 to HA08
577	From HA07 to HA03
565	From HA07 to HA05
564, 567, 568	From HA07 to HA06

A.43 In addition to the remapping outlined above, Service Group HA06 moved from being a Peak/Off-Peak Service Group Type in CP5 to an All Trains Service Group Type in CP6.

A.44 East Coast's remapping was at sub-Service Code level as outlined in A14.2.

Table A14.2: East Coast Service Remapping

Service	Service Code Remapping	Service Group Remapping
London – Glasgow/Sunderland	From 700 to 701	From HB01 to HB05
London – Harrogate/Bradford/Lincoln	From 703 to 702	From HB04 to HB02

A.45 The spreadsheet model contained CP6 MPW values that already took the ScotRail and East Coast remapping into account. However, to allow the impact of changing MPWs to be analysed without also taking into account remapping, the spreadsheet model was used to reverse the remapping and generate adjusted MPWs, the sum of which was normalised to 1 for the relevant ScotRail and East Coast Service Groups.

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Appendix 15: Step-by-step process for determining Peak Type

A.46 For the Enhanced Mileage File in the TOC Responsibility Matrix, we need to assign Peak Type to each service. In order to assign a peak type for each responsible and affected train, we implemented the following process each period:

1. Based on PEARS reference data, and the May 2015 timetable, we produced a Direction lookup table. This identifies a Direction for each TOC_Capri_Origin_Dest combination. The following is a short extract from the table:

Table A15.1 Cities, City Type, Peak Hours of Operation and Service Groups

Direction_Ref	Direction
EA_246_11720_31510	Reverse
EA_246_30120_7257	Forward
EA_246_31510_11720	Forward
EA_246_4303_31510	Reverse
EA_246_4303_32000	Reverse
EA_246_4303_32530	Reverse
EA_246_7257_31510	Reverse

TOC Capri Origin Stanox Dest Stanox

2. Add 'Direction' column into the period PSS Mileage file, such that each listed train has a Direction assigned.
3. Once each train has a Direction assigned, the peak type can be ascertained by checking the Origin/Destination/Intermediate station against the peak windows defined in the PEARS reference.

   i. Origin Station: Check whether the Origin Time is within either the AM or PM peak window, in the peak direction, for the appropriate station and Day Type (WD/SA/SU).
   ii. Destination Station: Check whether the Destination Time is within either the AM or PM peak window, in the peak direction, for the appropriate station and Day Type.
   iii. Intermediate Station: For each TOC_Capri_Origin_Dest combination, we have a pre-prepared list of all intermediate peak stations (i.e. peak stations that are neither the origin nor the destination), based on analysis of the May 2015 timetable. For each one of these, we have also calculated the average 'minutes from origin' per Day Type (based on the May 2015 timetable), so that we have a good estimate of the time at which the train will pass an Intermediate peak station. This is then checked against the PEARS peak windows in the same way as the Origin and Destination stations.

- For Service Groups defined as 'All Trains', we set the Peak Type to 'All Trains'. For all other SGs, if we cannot find any evidence that a train is Peak, the Peak Type simply defaults to 'Off Peak'. Freight, Charter and ECS trains are all given the peak type 'All Trains', as the peak type is trivial in these cases.
- For Scotrail, we have manually assigned all trains as 'All Trains', to reflect the removal of the Glasgow peak in CP6.
- For circular routes with a peak in only one direction, we assume that the AM Peak is the Destination, and the PM Peak is the Origin. This will provide a good estimate of the peak split.
- For circular routes that have peaks in both directions, we assume that the AM Peak could be either the Origin or Destination, and similarly the PM Peak could also be either the

Origin or Destination. These assumptions guide the way we check whether a train should be defined as Peak or not. Again, this will provide a good estimate of the peak split.

1. Add 'Peak Type' column into the period PSS Mileage file, such that each listed train has a Peak Type assigned. Output 'Enhanced Mileage File'. Essentially this is an enhanced version of the period PSS Mileage file whereby for each train we also have Peak Type and Direction specified
2. In the period PSS Delay data, assign Peak Type for each Responsible and Affected train, by cross-referencing the corresponding period Enhanced Mileage File. As shown in Figure A15.1, this merging is done by Train ID, Date and Service Group (VSG or PSG as appropriate), to ensure that the correct delayed train is matched to the correct train in the Enhanced Mileage File.

Appendix 16: Details of the Quality Assurance undertaken by Steer

Internal Quality Assurance of National Recalibration

A.47 Our approach to Quality Assurance is governed by the Steer Quality Management System (QMS), which is certified to ISO 9001: 2015 standards. Within this, the Peer Review role applies at various milestones of the project, with the methodology peer reviewed early on in the process to highlight any risks that could arise or improvements that could be made.

A.48 We undertook the following internal Quality Assurance reviews on the National Recalibration work:

- Review of methodology – The methodology was reviewed by the Steer Project Director and Project Manager.
- Review of data processing – A full review of the database processing, including every line of code and intermediary output. This review also checked for alignment of the processes against the agreed methodology.
- Review of NRPR, Benchmarks and TOC PR spreadsheet model – A cell-by-cell review of the spreadsheet inputs, calculations, outputs and text was undertaken. This review also checked for alignment of the processes against the agreed methodology.
- Review of source information – As part of the model review, a detailed review of all the source information was completed to ensure the inputs were correct.

A.49 In addition to this, we also run many sensitivities in the model to test a range of different inputs to verify the outputs of the model in various situations.

A.50 All technical (i.e. model and database) reviews were completed by people outside of the core project team, with experience modellers. The technical reviews were documented in Word documents, with any issue identified was given a rating of Low, Medium or High. This provided the modellers with a prioritised list of issues to resolve.

END

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