East Coast Main Line Enhancements Programme

Full Business Case: Economic Case

April 2018

Department for Transport

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Executive Summary

Background

Mott MacDonald has been commissioned to produce an economic appraisal of the elements of the East Coast Main Line Enhancements Programme (ECEP) intended to enable an increase in the frequency of Long Distance High Speed Passenger (LDHS) services and capacity, and an increase in rail freight capacity. These enhancements will be enabled by substantial recent DfT investment such as the IEP rolling stock procurement. The work assumes an infrastructure delivery date of May 2021. Our current work is in support of the ECEP Final Business Case (FBC), building on our work to support the Outline Business Case (OBC).

Do-minimum situation (Option 1)

In the absence of additional investment in infrastructure a Do-Minimum Train Service Specification (TSS) could operate with the following characteristics:

- The current quantum of LDHS services with some journey time improvements, enabled by IEP rolling stock.
- Some off-route extensions to LDHS services.
- Thameslink Key Output 2 services (an increase in frequency and destination choice versus currently).

The Do-Minimum TSS will deliver substantial improvements for passengers over the current situation. Focussing on LDHS services the following benefits are expected:

- A 17% increase in weekday East Coast Franchise seating capacity to/from London King's Cross.
- A circa 6 minute reduction in journey time between Edinburgh and London King's Cross.
- A circa 5 minute reduction in journey time between Leeds and London King's Cross.

Given the substantial previous and ongoing sunk cost of the investment required to achieve these benefits, the do-minimum scenario is referred to in this report as Option 1.

Do-something options (Options 2-4)

The do-something options have been refined from OBC stage based accounting for the following new assumptions:

- Further assessment of the track capacity delivered by potential enhancements between Northallerton and Newcastle and between Peterborough and Huntingdon.
- Updated and more realistic freight growth assumptions, resulting in a reduction in the amount of additional future freight capacity required.
- Additional rolling stock constraints, preventing the operation of IC225 rolling stock, and the services which would have been operated by this type of train.

Our timetable work suggests that a core package of infrastructure enhancements is required to deliver an increase the East Coast Franchise service frequency (between Newcastle/Edinburgh and London King's Cross) by 1 train per hour, also enabling a new planned First Group Open Access service to operate between London King's Cross and Edinburgh Waverley. The latter can be accommodated in a slow train path only, which occupies limited track capacity.

The key benefits of this are:

- An increase in the number of East Coast Franchise services between London King's Cross and the north of the ECML:
  - Newcastle – an increase from two to three trains per hour.
  - Edinburgh – an increase from 1.5 to two trains per hour.
  - A resultant capacity increase of over 10,000 seats per day both to and from London King's Cross. Table 1 below, shows the improvement in capacity at key locations.

- Reduction in East Coast Franchise journey times between London King's Cross and other key locations, enabled by moving intermediate station calls to some of the new services:
  - Edinburgh – up to 10 minutes (and up to 16 minutes versus 2017). A London – Edinburgh journey time of 4 hours 2 mins will be provided by some of the fastest services (approximately once every 2 hours).
  - Leeds – up to 8 minutes (and by up to 13 minutes versus 2017). London – Leeds journey times will be approximately two hours in most services.

- Fares competition resulting in a substantial transfer from domestic airline travel.

We have assessed the impact on the TSS of reductions in the scope of the infrastructure to improve the affordability to DfT. This assessment suggests that the same broad quantum and speed of services is likely to be deliverable whether or not the scope reductions occur, with the main dis-benefits being some marginal increases in journey time and reduced train punctuality.

Three Do-Something options were developed as follows.

	Option 2	**Option 3**	**Option 4**
Total incremental cost in the appraisal (cash prices)	£712m	£578m	£418m
LDHS service characteristics	Do Minimum plus: • Additional hourly King's Cross – Newcastle/Edinburgh (each way) • Open Access service King's Cross – Edinburgh (5 trains per day each way)	As per option 2 except: ○ 5 minute journey time penalty in hourly Northbound London – Newcastle stopping services	As per option 3 except ○ 3 minute total journey time extension spread across two TSGN Franchise services each hour in the southbound direction. ○ 1 minute total journey time extension in two southbound LDHS services in the AM peak ○ Reduced punctuality of train services

Appraisal results Options 2-4

Option 2 (full scope of infrastructure enhancements) is estimated to have a Benefit Cost Ratio (BCR) of 2.8. Our assessment therefore suggests that this is a high Value for Money (VfM) scheme based on the WebTAG categorisation, indicated by a BCR of between 2.0 and 3.99.

We estimate that the majority of the benefits and revenues would be a result of the substantial improvements to rail journey times generated by a combination of IEP rolling stock and more frequent services enabling a transfer of intermediate stations calls from some LDHS trains. Reduced rail fares and abstraction from the domestic air travel market also contribute significant benefits.

The flows (origin – destination pairs) with the largest benefits are London – Edinburgh and London – Leeds. Our forecasts imply a 22% and 10% increase, respectively, in franchise and open access revenue on these flows versus the do-minimum situation.

Option 3 (reduced scope of infrastructure to the north of the ECML) is estimated to have an increased Benefit Cost Ratio (BCR) of 3.2, which is still indicative of high VfM.

Versus Option 2, Option 3 has an incremental BCR of zero to one decimal place. The incremental infrastructure therefore represents poor VfM, indicated by a BCR of less than 1.0.

Option 4 (reduced scope of infrastructure to the north of the ECML, and without the Woodwalton Four Tracking scheme) is estimated to have an increased Benefit Cost Ratio (BCR) of 3.6, which is still indicative of high VfM.

Versus Option 3, therefore isolating the impact of the scheme at Woodwalton, the incremental BCR is 0.5. On that basis the incremental infrastructure represents poor VfM, indicated by a BCR of less than 1.0. This result is underpinned by a high-level assessment of the reduction in train punctuality from the absence of the scheme at Woodwalton.

Given the high-level nature of our performance analysis, we have also undertaken the same appraisal using an alternative (optimistic) assessment of punctuality benefit enabled by the scheme. On this basis the incremental BCR is 1.97. Here the incremental infrastructure represents medium VfM, albeit close to the boundary with high VfM.

We have adopted Option 3 as the **central Do-Something option**. Whilst Option 4 has a higher VfM, we acknowledge that our performance analysis is high-level and, we understand that DfT would like to consider further whether and how to progress with this scheme.

Sensitivity tests on Option 3

We have conducted a series of sensitivity tests to understand the robustness of our VfM assessment on the central Do-Something option. These tests vary key assumptions which may plausibly change, as well as variations in other factors specified by WebTAG.

In seven of the nine tests we conducted the VfM category remained at high. The exception was where we varied the underlying growth in rail passenger journeys by +/- 25% as specified by WebTAG. Here the BCR ranged between 5.0 and 1.9, which indicates very high – medium value VfM respectively.

Impact of HS2 Phase 2B

The introduction of HS2 Phase 2B would fundamentally change the pattern of services on the ECML, as several LDHS services would effectively transfer from the East Coast Franchise to become HS2 services. The bulk of LDHS passengers between London and locations such as Edinburgh, Newcastle and Leeds would transfer to these HS2 services.

HS2 services would use HS2 infrastructure as far north as Church Fenton (near York) and ECML infrastructure north thereof. This means that ECML track capacity would be released to the south of York, however the amount of capacity for non-HS2 ECML services north of York would be reduced.

To test the impact of HS2 Phase 2B we have developed new Do-Minimum and Do-Something Train Service Specifications assumed to operate following the opening of HS2 Phase 2B. Prior to then we retain the central do-minimum and option (Option 3) timetables.

The post HS2 ECML timetables have fewer fast long distance services to major regional cities which would be served by HS2, and instead increase the frequency of LDHS services to medium sized locations such as Lincoln, Hull and Peterborough. In the Do-Something option two additional East Coast Main Line Franchise services per hour are assumed to operate, enabled by the ECEP.

Assuming HS2 Phase 2B opens as planned in 2033, the BCR for the ECEP is estimated at 1.5 Indicative of medium VfM

Assuming HS2 Phase 2B opens in 2036, the BCR increases to 1.7, also representing a medium VfM classification.

1 Introduction

1.1 Background and purpose

The East Coast Main Line (ECML) is a strategically important GB rail corridor between London, Peterborough, York, Newcastle, and Edinburgh, with branches to locations such as Leeds, Lincoln and Northern Scotland, and interactions with numerous other long distance, commuter, and rail freight routes. The ECML carries large volumes of long distance passengers and rail freight, as well as substantial numbers of typically shorter distance commuter journeys. Five of the 20 busiest stations in Great Britain by passenger entries and exits are located on the ECML and its branches.

DfT has procured two major ongoing upgrades of the train services which operate on the ECML. They are the Thameslink Programme, and the Intercity Express Programme (IEP).

An integrated programme of work, termed the *East Coast Main Line Enhancements Programme* (ECEP), has been established to enable the delivery of the train service specifications for the Thameslink Programme and for IEP in addition to other outputs required by DfT. The other outputs are:

- an increase in the number of Long Distance High Speed (LDHS) passenger services to/from London and between key regional centres
- an associated increase in LDHS capacity
- an increase in the capacity for rail freight

Mott MacDonald has been commissioned to support the development of the Full Business Case (FBC) for the elements of the ECEP intended to deliver the increase in freight capacity and LDHS frequency and capacity described above. The funding source for this part of the programme has previously been referred to as the East Coast Main Line Connectivity Fund (ECCF).

Our principal role is to undertake an economic appraisal of the ECEP which will form the basis of the Economic Case for the investment. This is one of the Five Cases which comprise the FBC. The FBC is produced towards the end of the typical project development process, and substantial work has already been undertaken to upgrade the route:

- DfT has procured, through recent franchise competitions, additional and faster services between key locations on the ECML.
- The Office of Rail and Road (ORR) has granted additional Track Access Rights for both franchised and Open Access services.
- DfT and Network Rail have undertaken significant work to identify and specify infrastructure schemes and train service specifications to meet the objectives of the ECEP and ECCF. Mott MacDonald supported this at Outline Business Case (OBC) stage.

The FBC therefore builds on this work, updating the key assumptions made in the previous stages of the development process.

1.2 Document structure

The remainder of this document is structured as follows:

- Chapter 2 presents the Do-Minimum Train Service Specification
- Chapter 3 summarises the portfolio of potential infrastructure enhancements
- Chapter 4 presents the train service options which are likely to be deliverable, given alternative levels of infrastructure investment.
- Chapter 5 presents the economic appraisal of these service options.
- Chapter 6 presents the impact of HS2 phase 2 on the economic appraisal results.

- Appendix A provides further commentary on the operational assessment undertaken.
- Appendix B reviews capacity between Northallerton and Newcastle
- Appendix C sets out performance analysis undertaken to assess the Huntingdon-Woodwalton 4-tracking scheme
- Appendix D provides detailed commentary on the economic appraisal.
- Appendix E describes the Quality Assurance undertaken.

2 May 2021 Do-minimum Train Service Specification

2.1 Introduction

This chapter presents the do-minimum Train Service Specification (TSS) which could operate in the absence of further incremental investment enabled by the ECEP, assuming the delivery of all infrastructure items listed in **Chapter 3**.

2.2 Option 1- Do Minimum case (May 2021)

The Do Minimum TSS is an upgrade on the current situation, with the new IEP fleet and supporting infrastructure works enabling the following key benefits:

- Additional LDHS seating capacity.
- Journey time savings on LDHS routes. For example, a five minute saving between London King's Cross and Leeds and a six minute saving between London King's Cross and Edinburgh Waverley.
- An increase in the number and coverage of East Coast Franchise service extensions beyond the core ECML route, to locations such as Bradford Forster Square and Lincoln.

The do-minimum TSS is described below, split by operator. Figure 1 presents the same information in pictorial format. For the purpose of brevity local trains, such as those run by Northern, East Midlands Trains, and ScotRail are not shown in the text or the illustration.

The Do Minimum case is referred to in this report as Option 1.

2.2.1 Virgin Trains East Coast

Generally, 5 trains per hour (tph), with some variance in the peaks, comprising:

- 1 King's Cross – Edinburgh (and beyond) semi-fast (class 800/1)
- 1 King's Cross – Newcastle stopping, with extensions to/from Edinburgh at an interval slightly more frequent than one every two hours (800/1). Some Newcastle services would extend to/from Sunderland.
- 2 King's Cross – Leeds semi-fast (two hourly extensions to/from Bradford FS) (800/1)
- 1 King's Cross – Newark stopping service, with alternate 2-hourly extensions to/from Harrogate and Lincoln (800/1)

2.2.2 Govia Thameslink Railway

An 8 tph service all day, formed of:

- 2 Thameslink Core – Peterborough semi-fast (Class 700)
- 2 Thameslink Core – Cambridge semi-fast (Class 700)
- 2 Thameslink Core – Cambridge stopping (Class 700)
- 2 King's Cross – Ely / King's Lynn fast (Class 387)

This service is supplemented by an additional 4 tph (12 tph total) in the peaks:

- 2 King's Cross – Peterborough fast/semi-fast (Class 387)
- 2 King's Cross – Cambridge stopping (Class 387)

2.2.3 Grand Central and Hull Trains

1 train per hour in totality:

- Hull Trains, King's Cross – Hull (802)

- Grand Central, King's Cross – Sunderland, King's Cross – Bradford Interchange (180)

2.2.4 TransPennine Express

2 trains per hour:

- 1 (Huddersfield route) – York – Newcastle - Edinburgh (802)
- 1 (Huddersfield route) – York – Middlesbrough (802)

2.2.5 CrossCountry

2 trains per hour:

- 1 (Birmingham and beyond) – Leeds – York – Edinburgh (and beyond) (220)
- 1 (Birmingham and beyond) – Doncaster – Newcastle (220)

2.2.6 Freight

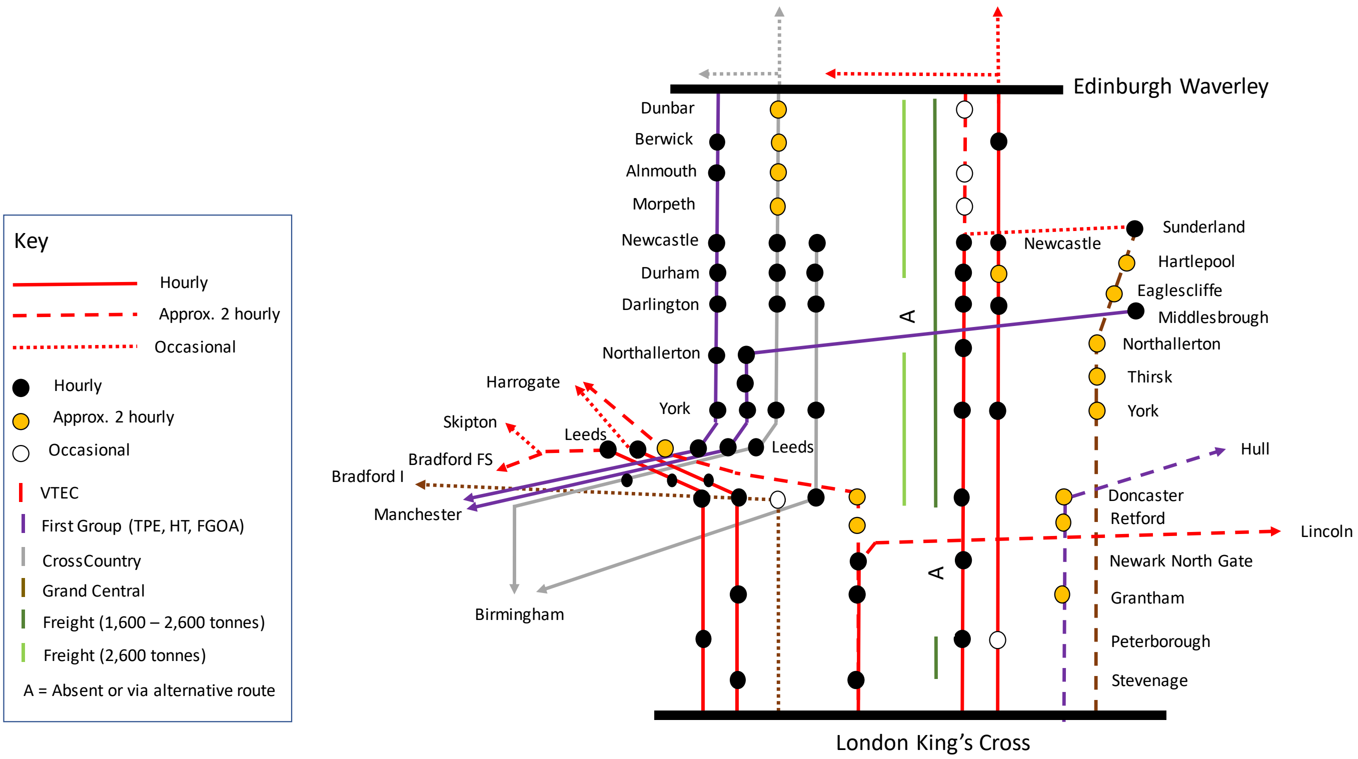
As follows:

- 1 train per hour in each direction south of Doncaster. Routeing is always via the GN/GE Joint Line
- 2 trains per hour north of Doncaster except for the section between Northallerton and Durham, where the frequency is one per hour, or the routeing of the second train is via Stillington. Appendix B provides a detailed description of freight assumptions between Northallerton and Newcastle.

Freight tonnages are set to the levels generally used for rail industry planning purposes. These typically exceed current levels, and therefore represent an increase in capacity.

The above is a reduced specification versus the OBC do-minimum, reflective of more realistic freight growth assumptions.

Figure 1: Option 1 - Do-Minimum Case (May 2021), Weekday Off-Peak Indicative Long Distance High Speed Train Service Specification



* Other operators are not shown, and some smaller station calls are not shown

3 Potential infrastructure investment

3.1 Introduction

A portfolio of potential infrastructure enhancements was identified during the early stages of development for the ECEP.

Previous development work undertaken by DfT and Network Rail suggests that delivery of the full set of infrastructure schemes by 2021 may not be affordable, and also that the schemes will may not provide sufficient capacity for all of the services in the Aspirational TSS. Previous analysis to support the OBC identified therefore incremental service enhancements which are potentially affordable to DfT. This work has been refined during the development of the FBC, and we have a clearer understanding of the incremental service upgrades which are likely to be enabled by the various infrastructure schemes.

3.2 Infrastructure investment

The following potential incremental infrastructure enhancements were considered at FBC stage:

- **London King's Cross Remodelling.** This is the enhancement element of a wider renewals scheme, intended to provide greater flexibility in the operation of London King's Cross, thereby increasing the resilience of the station to deal with timetable perturbation.
- **Huntingdon – Woodwalton four tracking.** This is a four-tracking scheme to allow an increased separation of traffic of different speed characteristics, thus enhancing the capacity and performance resilience of the route.
- **Peterborough Down Slow.** This is a journey time improvement scheme.
- **Werrington Grade Separation.** This is the grade separation junction scheme between the ECML and the GNGE Joint Line near Peterborough. This will reduce the number of conflicts between ECML trunk services and predominantly freight trains exiting the GNGE Joint Line, thereby improving the performance resilience.
- **York North Station Throat enhancement.** This involves track layout changes at the north end of York station, to enable greater flexibility and improve performance resilience.
- **Northallerton - Newcastle Freight Loops, southern section (Cowton).** This is the provision of additional track to enable greater separation of freight and passenger services. This will provide both additional capacity, and improved performance resilience.
- **Northallerton - Newcastle Freight Loops, central section (Bradbury).** This is the provision of additional track to enable greater separation of freight and passenger services. This will provide both additional capacity, and improved performance resilience.
- **Northallerton - Newcastle Freight Loops, northern section (Ouston).** This is the provision of additional track to enable greater separation of freight and passenger services. This will provide both additional capacity, and improved performance resilience.
- **IEP Enabling Works.** A small increment to this do minimum infrastructure enhancement
- **Power Supply upgrade:** A power supply upgrade is required on between Bawtry (south of Doncaster) and Edinburgh to accommodate the Aspirational TSS. This upgrade is referred to as PSU2.

The Anticipated Final Cost (AFC) of the above schemes is £745m (cash). This includes a sunk cost of £41m.

Other funded enhancements schemes are required to enable the Do-Minimum Case (Option 1).

Appendix D includes a detailed set of assumptions regarding Do-Minimum and Do-Something infrastructure costs.

4 Train Service Options

4.1 Introduction

This chapter presents a brief overview of the operational assessment undertaken to develop train service options, as well as the options themselves. A detailed set of assumptions and a description of the methodology is provided in **Appendix A.**

The operational assessment is largely the same as at OBC stage, except where there are known changes to the capability of the network following the infrastructure proposed upgrades, or where the Do-Minimum and/or Do-Something TSS has changed.

4.2 Operational planning approach

4.2.1 Geographical scope

The following route geography was considered.

- King's Cross – Edinburgh Waverley
- Doncaster – Leeds

As LDHS services on the ECML interact with a number of other routes and operators, it was not considered practical to attempt to timetable all of these interactions and the impact on off-route operator's services. It was therefore assumed that all services can be accommodated outside of the above geography, and that services not listed in **Chapter 2** can be accommodated. This approach is typical of the operational planning undertaken to support the development of enhancement projects.

To support future timetable development work, we have provided high-level advice in **Appendix A** on where the interaction between ECML services and local/off-route services may be problematic, highlighting key locations and key services.

4.2.2 Train punctuality

The potential impact of options on train punctuality (performance) has not generally been assessed in detail or quantified. This was agreed with DfT as a proportionate simplification at the current stage of scheme development. Advice is therefore limited to any performance risks that are apparent without detailed analysis such as simulation.

In addition, a high-level assessment of the potential benefits of Huntingdon – Woodwalton four tracking was undertaken, to provide DfT with some evidence to support its decision regarding the value of this infrastructure. The work undertaken is described in Appendix C.

4.2.3 Standard hour timetables

Timetables were developed for the following time periods and directions:

- Off-peak, Up direction (towards London King's Cross)
- Off-peak, Down direction
- AM peak, both directions to/from London King's Cross
- PM peak, both directions to/from London King's Cross

The timetables were intended to cover a standard hour of operation extended earlier and later to cover service patterns which repeat on a two-hourly basis. Service patterns at certain times of the day may differ slightly from these standard hours, e.g. during early mornings or late evening, but these differences are unlikely to result in a material difference in our assessment.

Timetables were developed using existing Train Planning Rules (TPRs), with the characteristics of new infrastructure, new rolling stock and proposed new services provided by either DfT or Network Rail. This approach is described in more detail in Appendix A.

We have assumed that freight services contained within the TSS must be accommodated, unless the purpose of the option is to test a reduced freight specification. The commentary below states when this is the case.

4.3 Core package of infrastructure enhancements

Our operational assessment during the OBC development work defined a package of enhancements that included all of the schemes listed in Chapter 3. These enable a substantial improvement in train services beyond the Do-Minimum. In the case of the PSU2 power supply upgrade however, we assume that half of the cost of this scheme would be required to enable improvements to the Do-Minimum TSS.

4.4 Do-Something Train Service Specification

The central do-something option for the OBC involved a TSS with a broadly 2 train per hour increase in LDHS service frequency over the do-minimum situation, with a series of other options testing trade-offs between the scope of the infrastructure upgrade and fewer passenger or freight services.

Further development work suggests that the core package of infrastructure enhancements is required to deliver an increase in the East Coast Franchise service frequency (to/from London King's Cross) by 1 train per hour, also enabling a new planned First Group Open Access service to operate between London King's Cross and Edinburgh Waverley. The latter can be accommodated in a slow train path only, which occupies limited track capacity.

It is unlikely that an increase in service frequency beyond the level described above can be accommodated within the existing available fleet.. Our TSS is therefore less ambitious than in the Central Do-Something option for the OBC, due to removal of the 2-hour Middlesbrough service, albeit it is still a substantial improvement on the Do-Minimum situation.

Our Do-Something TSS is identical to the Do-Minimum TSS except for the changes listed below:

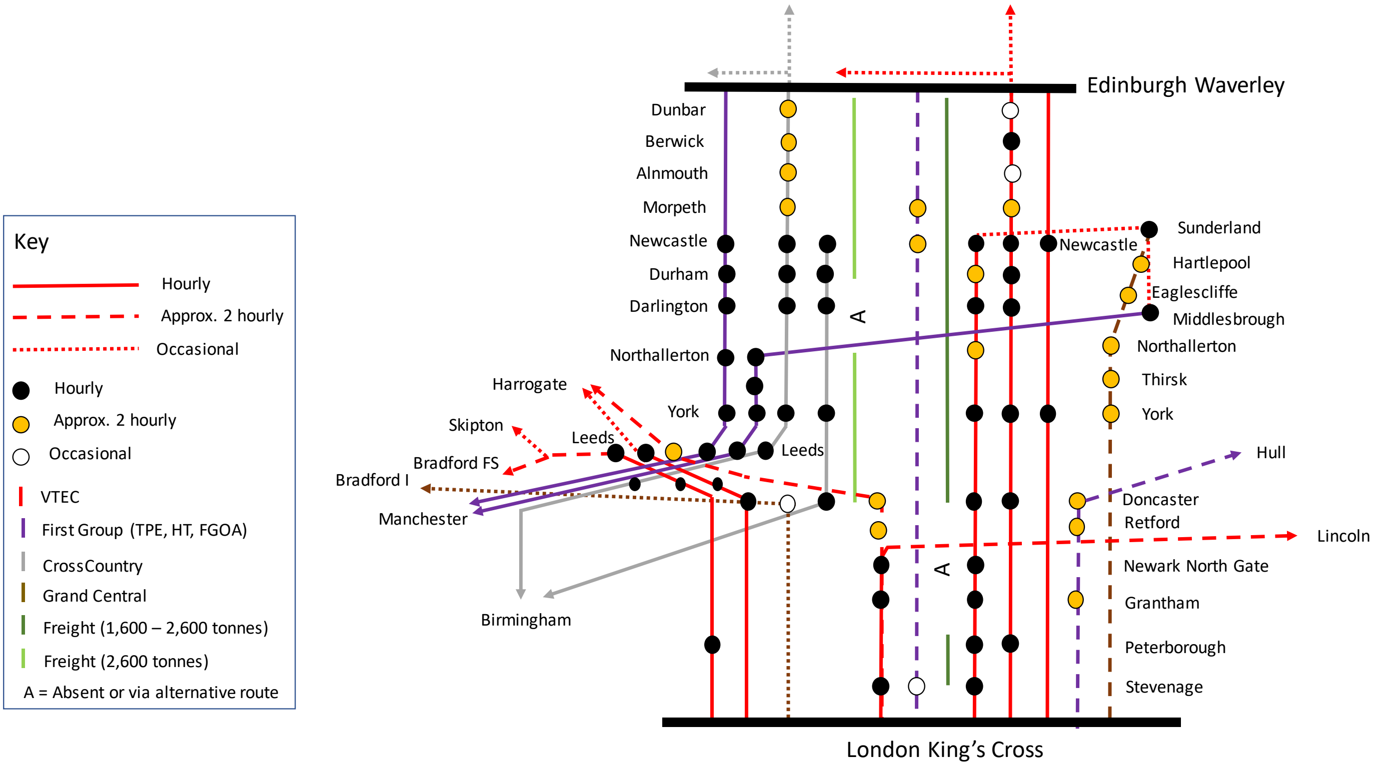
- An increase in the number of East Coast Franchise services between London King's Cross and other key locations:
  - Newcastle – an increase from two to three trains per hour.
  - Edinburgh – an increase from 1.5 to two trains per hour.
  - A resultant capacity increase of over 10,000 seats per day both to and from London King's Cross. Table 1 below, shows the improvement in capacity at key locations.

- Reduction in East Coast Franchise journey times between London King's Cross and other key locations, enabled by moving intermediate station calls to some of the new services:
  - Edinburgh – up to 10 minutes (and up to 16 minutes versus 2016). A London – Edinburgh journey time of 4 hours 2 mins will be provided by some of the fastest services (approximately once every hour).
  - Leeds – up to 8 minutes (and by up to 13 minutes versus 2016). London – Leeds journey times will be approximately two hours in most services.

- Introduction of a new low fares Open Access Service between London King's Cross and Edinburgh (five per trains per day in each direction). The proposed First Group Open Access services between London King's Cross and Edinburgh can be accommodated with around 25-35 minutes of pathing time between London King's Cross and Edinburgh. Whilst this journey time penalty would have a serious impact on the competitiveness of most operators' services, First Group's stated business model is a low fares operation where journey times are a secondary consideration. The best achievable journey times from our analysis are therefore only 2-12 minutes slower than the times submitted in support of its successful Track Access Application to ORR. We have therefore included the First Group Open Access services in this option, with the pathing time as described above.

Figure 2 below shows the Weekday Off-Peak TSS in pictorial format.

Figure 2: Do-Something (Options 2-4) May 2021, Weekday Off-Peak Indicative Long Distance High Speed Train Service Specification*



* Other operators are not shown, and some smaller station calls are not shown

Table 1. Indicative total number of seats provided (all classes of travel, Weekday)

Station	Current	Do-Minimum	Do-Something	Change: DM/Current	Change: DS/DM
London Kings Cross	39,450	46,246	58,889	17%	27%
Leeds	17,358	23,123	21,596	33%	-7%*
Newcastle	16,306	18,864	29,383	16%	56%
Edinburgh	12,098	13,996	19,647	16%	40%

* Fewer trains would operate to/from Leeds in maximum formation in the Do-Something TSS, however a reduction in the number of intermediate station calls enabled by an overall frequency increase, would reduce passenger numbers on these trains.

4.5 Options for a more affordable infrastructure investment package

We have considered options to reduce the scope and therefore the cost of the core package of infrastructure enhancements. Our analysis shows that likely impact of de-scoping this core package of infrastructure work is a reduction in journey time improvements and potentially reduced train punctuality, however the quantum and stopping pattern of services is unlikely to be affected.

Three options (2-4) were developed to test the overall Value for Money (VfM) of the core package of infrastructure and the resultant train services. This enables consideration of possible reduction to the scope of this core package andthese options are summarised in Table 2.

Table 2. Options 2-4 key differences

	Option 2	Option 3	Option 4
Infrastructure investment above Do-Minimum	Core Package: ○ KX Remodelling (enhancement) ○ Huntingdon – Woodwalton 4 tracking ○ Peterborough down slow ○ Werrington GSJ ○ Doncaster station enhancements ○ York North Station Throat Enhancements ○ Northallerton – Newcastle Freight Loops (x3) ○ IEP enabling works (small increment) ○ PSU2 (half of the scheme cost)	Reduced Package: ○ KX Remodelling (enhancement) ○ Huntingdon – Woodwalton 4 tracking ○ Peterborough down slow ○ Werrington GSJ ○ Doncaster station enhancements ○ PSU2 (half of the scheme cost) ○ IEP enabling works (small increment)	Reduced Package: ○ KX Remodelling (enhancement) ○ Peterborough down slow ○ Werrington GSJ ○ Doncaster station enhancements ○ PSU2 (half of the scheme cost) ○ IEP enabling works (small increment)
LDHS service characteristics	As per the TSS	As per option 2 except: ○ 5 minute journey time penalty in hourly Northbound London – Newcastle stopping services	As per option 3 except ○ 3 minute total journey time extension spread across two TSGN Franchise services each hour in the southbound direction. ○ 1 minute total journey time extension in two southbound LDHS services in the AM peak

5 Economic Appraisal

5.1 Introduction

This chapter summarises the economic appraisal of the options. The appraisal methodology is described briefly along with selected key appraisal assumptions, and the results are presented sequentially for each option. **Appendix D** presents the methodology and results in more detail.

All figures in this chapter are presented in 2010/11 prices and values unless stated and figures may not always sum correctly due to rounding.

5.1.1 Methodology – summary

5.1.1.1 Demand and revenue assessment

The ECML 2016/17 demand base was grown to the forecast years of 2021/22 and 2037/38, in line with DfT methodology.

The demand and revenue assessment of the passenger service changes was undertaken in the industry standard MOIRA software. The northern variant of MOIRA was used, which is the best version for assessing the impact of changes to ECML LDHS services, but produces approximate results for the impact of changes to London and South East trains (i.e. TSGN Franchise services).

Demand and revenue forecasting overlays were applied to the results from MOIRA to estimate the impact of serving new locations, abstraction from air travel, and fares competition between franchise and open access services. This was necessary as MOIRA cannot estimate these impacts.

Demand and revenue results were scaled to account for overcrowding on trains, using a crowding model developed for this purpose.

The above approach is consistent with both WebTAG and the relevant versions of the Passenger Demand Forecasting Handbook (PDFH).

5.1.1.2 Train Punctuality (Performance)

Consistent with most scheme appraisal of this type, we have not modelled or included the impacts of changes in train punctuality between the Do-Minimum and Do-Something options. However, we have included an increase in the Network Rail Capacity Charge as a proxy for the impact of a reduction in performance associated with the operation of a higher frequency of trains. This is noted below.

We have, however, conducted an assessment of the Huntingdon – Woodwalton Four-Tracking scheme, as it is considered that the performance impacts may be material to the Value for Money of this specific enhancement. This was a high-level analysis, intended to provide DfT with some evidence regarding the potential VfM of the scheme. This high-level analysis should not, by itself, form the basis upon which to form decisions regarding the detailed specification of infrastructure options (for example the length of the four tracking and the location of junctions). More detailed analysis such as simulation modelling would provide better evidence with this respect. Our performance assessment is detailed in Appendix C.

In producing this assessment we developed a core scenario with our central set of assumptions, and an alternative scenario with an optimistic set of assumptions.

In our core performance scenario we assume a delay minute saving of circa 2,600 minutes per year and a delay to lateness ratio of 1:2. In our alternative scenario we assume a delay minute saving of around 7,300 minutes and the same delay to lateness ratio of 1:2.

Our VfM assessment uses the performance analysis from the core scenario, however we also report the implications for the VfM of the Woodwalton scheme if the alternative scenario is used.

5.1.1.3 Operating Cost assessment

The incremental cost has been assessed for each option. This was undertaken by estimating the additional resource requirement and applying this to unit rates for the relevant cost components. Costs included in this assessment are listed below, inclusive of the data source:

- Train Crew. The source is:
  - ASLEF website for driver salaries.
  - Known uplift factors for driver pensions, overtime, etc.
  - Known salary differentials for other train crew.

- Rolling Stock procurement and maintenance. The source is:
  - Data provided by DfT.

- Mileage based costs (diesel fuel, EC4T, Variable Track Access Charges). The source is:
  - Network Rail CP5 Price lists
  - Known values such as diesel fuel prices

- Capacity Charge. The source is:
  - Network Rail CP5 Price lists

The Capacity Charge is designed to reflect the cost to the rail industry of a loss of passenger revenue caused by a performance degradation when additional services operate on the network. Although the main performance impact of the options has not been assessed in detail or quantified, including the Capacity Charge in the appraisal can be viewed as a proxy for this impact.

5.1.1.4 Infrastructure Cost assessment

Infrastructure costs are shown below in Table 3. The cost of work to date (COWD) is a sunk cost and is therefore excluded from the appraisal. Most schemes have a small sunk cost, and the enhancement at Doncaster Station has been delivered in its entirety.

The cost of work required to meet the Do-Minimum TSS is excluded from the appraisal.

We have also assumed that costs except for those which relate to civils are repeated in lieu of renewals after broadly 30 years. **Appendix D** explains the methodology in more detail.

Table 3. Infrastructure costs, cash prices (£million)

Infrastructure enhancement	AFC	COWD	Contingency	Optimism Bias	Total excluding contingency, including Optimism Bias		
					Option 2	Option 3	Option 4
Kings Cross Remodelling	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Huntingdon – Woodwalton four tracking	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Peterborough Down Slow	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
York North Throat	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Infrastructure enhancement	AFC	COWD	Contingency	Optimism Bias	Total excluding contingency, including Optimism Bias		
					Option 2	Option 3	Option 4
Werrington Grade Separation	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Northallerton - Newcastle Freight Loops	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Traction Power Supply Upgrade - PSU2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
IEP Enabling Works (share required for Do-Something TSS)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	**744.6**	**41.2**	**77.3**		**711.6**	**577.9**	**418.5**

5.1.1.5 Economic Appraisal

The outputs of the above assessments were monetarised in our standard WebTAG-compliant economic appraisal model which is used for all our DfT rail appraisal work.

Benefits and cost were assessed over a 60-year appraisal period, assuming an opening year of 2021.

5.2 Appraisal results, Options 2-4 (core options)

5.2.1 Key assumptions

In addition to the assumptions described above the following key assumptions support the Central Do-Something case, and other options unless stated:

- The procurement and maintenance costs for IEP rolling stock (operated by VTEC) are treated as a sunk cost. This is a function of the current contract for this rolling stock. Following contract expiry (assumed after 27.5 years) costs are included in the appraisal.
- All of the financial impacts on franchised operators are met by DfT.

All appraisal results are Present Value and 2010/11 values.

5.2.2 Option 2

5.2.2.1 Option description

This option assumes the complete delivery of the core package of infrastructure enhancements described in Chapter 3.

The TSS is the full Do-Something TSS, described in Chapter 4.

We have included the impact of a performance improvement in the Woodwalton area, consistent with our core assessment scenario. See Appendix C for a description.

5.2.2.2 Appraisal results

Appraisal results for Option 2 are shown below in Table 4. This option is estimated to deliver benefits of £3.0bn, comprising £2.1bn of User Benefits, £0.1bn of Non-User benefits and £0.8bn of profit to Open Access Operators

The net impact on Franchise Premium is -£0.4bn, as forecast growth in franchise revenue is outweighed by the combination of operating costs and revenue abstraction from Open Access operators.

The infrastructure cost is £0.7bn, which gives a net cost to DfT of £1.1bn. Overall the scheme is estimated to have a Benefit Cost Ratio (BCR) of 2.8. Our assessment therefore suggests that this is a high Value for Money (VfM) scheme based on the WebTAG categorisation, indicated by a BCR of between 2.0 and 3.99.

We estimate that the majority of the benefits and revenues would be a result of the substantial improvements to rail journey times generated by a combination of IEP rolling stock and more frequent services enabling a transfer of intermediate stations calls from some LDHS trains. Reduced rail fares and abstraction from the domestic air travel market also contribute significant benefits. The beneficial impact of an increase in the level of seating capacity is modest relative to the impact of journey time improvements, although still significant. The main explanation for this is that the forecast substantial increase in demand uses the bulk of the additional capacity provided.

Table 5, below, shows the split of revenue growth by contributing factor.

The flows (origin – destination pairs) with the largest benefits are London – Edinburgh and London – Leeds. Our forecasts imply a 22% and 10% increase, respectively, in franchise and open access revenue on these flows versus the do-minimum situation. This is a result of a number of factors in particular a significant improvement in LDHS journey times. Table 6 below shows the split of forecast revenue generation by flow.

Table 4. Option 2 economic appraisal summary results £M 2010 prices and values

Item	£M 2010
Transport User Benefits (1)	2,128
Non-User benefits (2)	137
OA Operator Benefits (3)	758
Total Benefits (4) = (1) + (2) + (3)	**3,024**
Franchised Revenue (5)	[redacted]
Franchised Opex (incl NR costs) (6)	[redacted]
Net impact on Premium (7) = (5) + (6)	**-397**
Total Infrastructure Costs (8)	**-671**
Total Cost to Govt (9) = (7) + (8)	**-1,068**
BCR (10) = (4) / -(9)	**2.8**

Table 5. Annual revenue generation (franchised + open access) by contributing factor Option 2 2038 (£000, 2016/17)

Contributing factor	Total Revenue Increase £ (16/17)	% of total option revenue
Direct MOIRA Impact	[redacted]	[redacted]
Exogenous Growth	[redacted]	[redacted]
Air Competition	[redacted]	[redacted]
Fares Overlay	[redacted]	[redacted]
New destination overlay	[redacted]	[redacted]
Crowding	[redacted]	[redacted]
Total	**80,480**	100%

Table 6. Annual revenue generation (franchised + open access) by key flow, Option 2 2038 (£000, 2016/17)

Rank	**Flow (2-way)**	**Total Revenue Increase £ (16/17)**	**% Revenue Increase vs. do-min**	**% of total option revenue**
1	Edinburgh - London	[redacted]	[redacted]	[redacted]
2	Leeds - London	[redacted]	[redacted]	[redacted]
3	Newcastle - London	[redacted]	[redacted]	[redacted]
4	York - London	[redacted]	[redacted]	[redacted]
5	Morpeth - London	[redacted]	[redacted]	[redacted]
6	Wakefield - London	[redacted]	[redacted]	[redacted]
7	Grantham - London	[redacted]	[redacted]	[redacted]
8	Durham - London	[redacted]	[redacted]	[redacted]
9	Doncaster - London	[redacted]	[redacted]	[redacted]
10	Newcastle - Stevenage	[redacted]	[redacted]	[redacted]
	Top 10 subtotal	[redacted]		
	Other	[redacted]		
	Total	**80,480**		

5.2.3 Option 3

5.2.3.1 Option description

As described in Chapter 4, in this option we have removed the following schemes from the core package of infrastructure enhancements:

- York North Station Throat Enhancements
- Northallerton – Newcastle Freight Loops (all three enhancements)

The purpose of this option is therefore to test the VfM of the above enhancements.

The TSS is identical to Option 2 except that the hourly northbound stopping service between London King's Cross and Newcastle incurs a five minute journey time penalty between Northallerton and Newcastle. Our initial expectation is that this would be a minor impact and the majority of long distance passengers, particularly those travelling between London and Edinburgh/Newcastle would use one of the two trains per hour which are substantially faster than the stopping service.

The potential impact of the reduced scope of infrastructure on train punctuality has not been assessed.

We have included the impact of a performance improvement in the Woodwalton area, consistent with our core assessment scenario. See Appendix C for a description.

5.2.3.2 Appraisal results

Appraisal results for Option 3 are shown below in Table 7, as well as a comparison between Options 2 and 3. As can be seen, the benefits, revenues and operating costs are very similar. This is unsurprising given the limited forecast impact on train services of the reduction in the scope of infrastructure.

The infrastructure cost of Option 3 is circa £150m lower than under Option 2, giving a reduced cost to DfT of approximately £0.5bn. Overall the scheme is estimated to have an increased Benefit Cost Ratio (BCR) of 3.2, which is still indicative of high VfM.

Comparing the two options, Option 3 has a reduced total benefit of circa £3m and a reduced cost to DfT of around £119m. The BCR is therefore zero to one decimal place. On that basis the incremental infrastructure represents poor VfM, indicated by a BCR of less than 1.0.

Table 7. Options 2 and 3 economic appraisal summary results £M 2010 prices and values

Item	Option 2	Option 3	Option 3 versus Option 2
Transport User Benefits (1)	2,128	2,113	-15
Non-User benefits (2)	137	136	-1
OA Operator Benefits (3)	758	771	13
Total Benefits (4) = (1) + (2) + (3)	**3,024**	**3,020**	**-3**
Franchised Revenue (5)	[redacted]	[redacted]	-30
Franchised Opex (incl NR costs) (6)	[redacted]	[redacted]	0
Net impact on Premium (7) = (5) + (6)	**-397**	**-427**	**-30**
Total Infrastructure Costs (8)	**-671**	**-521**	**149**
Total Cost to Govt (9) = (7) + (8)	**-1,068**	**-948**	**119**
BCR (10) = (4) / -(9)	**2.8**	**3.2**	**0.0**

5.2.4 Option 4

5.2.4.1 Option description

As described in Chapter 4, in this option we have removed the following schemes from the core package of infrastructure enhancements:

- York North Station Throat Enhancements
- Northallerton – Newcastle Freight Loops (all three enhancements)
- Huntingdon – Woodwalton Four Tracking

The first two of these schemes were also removed from Option 3, and the purpose of this option is therefore to test the VfM of Huntingdon – Woodwalton Scheme

The TSS is identical to Option 3 except that journey time penalties are applied to a few southbound services in the Woodwalton area. These penalties are as follows:

- A 3 minute journey time increase per hour, spread across two southbound TSGN Franchise services.
- A 1 minute journey time increase in two southbound AM peak LDHS trains.

We have also removed the punctuality improvement in the Woodwalton area, included in the other options.

5.2.4.2 Appraisal results – core Woodwalton performance scenario

Appraisal results for Option 4 are shown below in Table 8, as well as a comparison between Options 3 and 4.

Estimated Total Benefits for Option 4 remain at almost £3.0bn, comprising £2.0bn of User Benefits, £0.1bn of Non-User benefits and £0.8bn of profit to Open Access Operators. Total benefits have reduced by around £70m from Option 3.

The net impact on Franchise Premium is a reduction of around £40m, giving a total impact on Franchise Premium of -£0.5bn.

The infrastructure cost of Option 4 is circa £170m lower than under Option 3, giving a total cost to DfT of approximately £0.5bn. Overall the scheme is estimated to have an increased Benefit Cost Ratio (BCR) of 3.6, which is still indicative of high VfM.

Comparing the two options, Option 4 has a reduced total benefit of circa £67m and a reduced cost to DfT of around £134m. The incremental BCR is therefore 0.5. On that basis the incremental infrastructure represents poor VfM, indicated by a BCR of less than 1.0. However, given the high-level nature of our performance analysis, we have also produced a comparative appraisal on the basis of our alternative (optimistic) performance scenario. The results of this assessment are shown in the next section.

Table 8. Options 3 and 4 economic appraisal summary results £M 2010 prices and values, core Woodwalton performance scenario

Item	Option 3	Option 4	Option 4 versus Option 3
Transport User Benefits (1)	2,113	2,047	-66
Non-User benefits (2)	136	134	-2
OA Operator Benefits (3)	771	772	0
Total Benefits (4) = (1) + (2) + (3)	**3,020**	**2,953**	**-67**
Franchised Revenue (5)	[redacted]	[redacted]	-40
Franchised Opex (incl NR costs) (6)	[redacted]	[redacted]	0
Net impact on Premium (7) = (5) + (6)	**-427**	**-467**	**-40**
Total Infrastructure Costs (8)	**-521**	**-348**	**174**
Total Cost to Govt (9) = (7) + (8)	**-948**	**-815**	**134**
BCR (10) = (4) / -(9)	**3.2**	**3.6**	**0.5**

5.2.4.3 Appraisal results – alternative Woodwalton performance scenario

We have reproduced the comparative appraisal shown above on the basis of the alternative performance scenario. To do this we have included the benefit of this alternative scenario in Option 3 and compared the results with Option 4 where all performance benefits are excluded.

The results of this analysis are shown below in Table 9. As can be seen, the BCR of option 3 increases from 3.2 to 3.5 (driven by higher performance benefits)

Comparing the two options, Option 4 has a reduced total benefit of circa £154m and a reduced cost to DfT of around £78m. The incremental BCR is therefore 1.97, approaching the boundary between medium and high VfM.

Table 9. Options 3 and 4 economic appraisal summary results £M 2010 prices and values, alternative Woodwalton performance scenario

Item	Option 3	Option 4	Option 4 versus Option 3
Transport User Benefits (1)	2,196	2,047	-149
Non-User benefits (2)	139	134	-5
OA Operator Benefits (3)	771	772	0
Total Benefits (4) = (1) + (2) + (3)	**3,106**	**2,953**	**-154**
Franchised Revenue (5)	[redacted]	[redacted]	-96
Franchised Opex (incl NR costs) (6)	[redacted]	[redacted]	0
Net impact on Premium (7) = (5) + (6)	-371	**-467**	-96
Total Infrastructure Costs (8)	**-521**	**-348**	**174**
Total Cost to Govt (9) = (7) + (8)	**-892**	**-815**	**78**
BCR (10) = (4) / -(9)	**3.5**	**3.6**	**2.0***

***** 1.97 to decimal places

5.2.5 Summary of Options 2-4

Option 2, which includes the full core infrastructure enhancement package has the lowest BCR of the options considered.

Removal of the infrastructure enhancements at York and between Northallerton and Newcastle (Option 4) improves the VfM, and we assess the incremental VfM for these schemes as poor.

Removal of the Huntingdon-Woodwalton Four Tracking scheme, further improves the VfM, regardless of whether we use the core or alternative (optimistic) performance scenarios. Under the former the incremental VfM of this enhancement is poor. Under the latter the incremental VfM improves to medium /high.

Given these results, we have adopted Option 3 as the central do something option for the purpose of conducting further sensitivity test on the VfM of the East Coast Enhancements Programme. Whilst Option 4 has a higher VfM, we acknowledge that our performance analysis is high-level and, we understand that DfT would like to consider further whether and how to progress with this scheme.

5.3 Sensitivity tests

In this section we have conducted a series of sensitivity tests on the VfM of the central do-something option (currently Option 3). The tests are described briefly below, with the results shown in Table 10.

5.3.1 Reduced PM peak TSGN Franchise frequency

There is some uncertainty regarding the maximum capacity of the two-track section of the ECML over Welwyn Viaduct. This section is a capacity constraint which will not be addressed by the East Coast Enhancements Programme, however a pending change to Train Planning Rules may enable a capacity increase.

Our central do-something option assumes that a maximum of 8 LDHS and 12 TSGN Franchise services are operable. This includes an assumption that the change to Train Planning Rules is adopted. 20 trains per hour would only be reached in the PM peak direction when both sets of services are at their maximum frequency.

In this sensitivity test we have examined the impact of operating only 18 trains per hour in the PM peak, which is likely to be the maximum capacity based on the current Train Planning Rules.

The OBC work demonstrated that the reduction in VfM would be lower if 2 TSGN services per hour were removed, rather than 2 LDHS services. In this sensitivity test we have therefore removed 2 TSGN services per hour in the PM peak from the Option 3 timetable.

The impact of this is to reduce the BCR from 3.2 to 2.9. The VfM categorisation is therefore unchanged.

5.3.2 Sensitivity test – IEP rolling stock costs are not sunk

In this sensitivity test we assume that all of the IEP rolling stock procurement costs are incremental costs and therefore include them in the appraisal. This is for the fraction of the IEP fleet which is required to resource the additional services. We estimate that this is circa 6 x 9 car units.

Inclusion of these additional costs reduces the BCR to around 2.4. Therefore, despite the increase in cost, the Value for Money remains high.

5.3.3 WebTAG sensitivity tests

Several other sensitivity tests were undertaken to better understand the uncertainty of the option. These tests which involve adjusting parameters within the appraisal itself are generally required by WebTAG. All these tests are sensitivities to the core do-something Option (Option 3).

5.3.3.1 Demand cap sensitivity

The underlying growth in passenger journeys and the majority of other impacts are currently capped in the appraisal at 2036. This is consistent with the central approach stipulated in WebTAG. In this sensitivity tests we vary the cap by +/-10 years, so set the cap to 2026 and 2046.

Under the -10 scenario has a BCR of 2.5, while in the +10 scenario the BCR improves to 3.8. The VfM category is therefore unchanged under both tests.

5.3.3.2 Variable demand growth

In this test we vary the level of underlying growth in passenger journeys by +/- 25%. This figure represents our view of the potential range in demand growth given current uncertainty around UK economic prospects.

To calculate this each element of the appraisal (benefits, revenue passenger km etc) was scaled each year by 25%.

Under the low growth scenario has a BCR of 1.9, while in the high growth scenario the BCR improves to 5.0. Under the former test the VfM category reduces to medium (BCR of 1.5 – 1.99) whereas under the latter test the VfM category increases to very high (BCR greater than 4.0).

5.3.3.3 Value of Time growth sensitivity

In this test we vary the growth in the values of time used in the appraisal in line with recommendations in WebTAG. This means business and commuting values change by +/-25%, while other values change by +/-60%. This is consistent with a 95% confidence interval in the values of time used in the appraisal.

Under this low growth test the BCR reduces to 2.8 and under the high growth test the BCR increases to 3.6. The VfM categorisation is therefore unaffected by this test.

5.3.3.4 PDFH 6 exogenous growth

Our central do-something option (Option 3) uses the versions of PDFH referenced in the most recent version of WebTAG. To calculate exogenous rail demand growth we have used the approach and parameter values set out in PDFH5.1.

In this test we have used the new PDFH6 approach and values to calculate exogenous growth.

The impact of this test is to increase the BCR slightly from 3.2 to 3.3. The VfM categorisation is therefore unchanged.

Table 10. Sensitivity tests economic appraisal summary results £M 2010 prices and values

Item	Option 3 (central do-something)	Reduced PM peak TSGN	IEP not Sunk cost	2026 Cap Year	2046 Cap Year	Low Growth	High Growth	Low VOT	High VOT	PDFH 6.0
Transport User Benefits (1)	2,104	[redacted]	[redacted]	1,896	2,263	1,074	3,444	1,730	2,479	2,243
Non-User benefits (2)	136	[redacted]	[redacted]	121	147	123	149	136	136	144
OA Operator Benefits (3)	771	[redacted]	[redacted]	566	942	686	863	771	771	771
Total Benefits (4) = (1) + (2) + (3)	**3,011**	[redacted]	[redacted]	**2,583**	**3,351**	**1,884**	**4,456**	**2,636**	**3,386**	**3,159**
Franchised Revenue (5)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Franchised Opex (incl NR costs) (6)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Net impact on Premium (7) = (5) + (6)	**-433**	[redacted]	[redacted]	**-518**	**-361**	**-494**	**-364**	**-433**	**-433**	**-433**
Total Infrastructure Costs (8)	**-521**	**-521**	**-521**	**-521**	**-521**	**-521**	**-521**	**-521**	**-521**	**-521**
Total Cost to Govt (9) = (7) + (8)	**-954**	[redacted]	[redacted]	**-1,039**	**-882**	**-1,015**	**-885**	**-954**	**-954**	**-954**
BCR (10) = (4) / -(9)	**3.2**	**2.9**	**2.4**	**2.5**	**3.8**	**1.9**	**5.0**	**2.8**	**3.6**	**3.3**

6 Economic Appraisal – Impact of High Speed 2 Phase 2

6.1 Introduction

Option 3 has been tested to understand the impact that the proposed introduction of HS2 Phase 2B services would potentially have on the economic case for investment. This is treated as sensitivity tests as HS2 Phase 2B has not yet been fully approved by Parliament.

Two different scenarios were tested:

- Scenario 1: HS2 is introduced in 2033
- Scenario 2: HS2 is introduced with 3 years delay, in 2036

6.1.1 Methodology – summary

6.1.1.1 Released capacity TSS

Prior to HS2 Phase 2B opening we assume that the above Do-Minimum and Option 3 timetables would operate.

However, the introduction of HS2 Phase 2B would fundamentally change the pattern of services on the ECML, as several LDHS services would effectively transfer from the East Coast Franchise to become HS2 services. These HS2 services would use HS2 infrastructure as far north as Church Fenton (near York) and ECML infrastructure north thereof. This means that ECML track capacity would be released to the south of York, however the amount of capacity for non-HS2 ECML services north of York would be reduced.

To develop this sensitivity test we have developed a high-level weekday off peak hour TSS under two scenarios:

- Do-minimum infrastructure with HS2 Phase 2B. Here the maximum LDHS frequency to/from London King's Cross is 6 trains per hour. We have assumed that the following services would operate hourly:
  - **London King's Cross – Leeds (Skipton/Harrogate),** calling Peterborough, Doncaster, Wakefield.
  - **London King's Cross – Edinburgh**, calling Peterborough, Doncaster, York, Darlington, Durham, Newcastle, Alnmouth, Berwick.
  - **London King's Cross – Lincoln**, calling Stevenage, Grantham, Newark, Lincoln
  - **London King's Cross – Middlesbrough**, calling Peterborough, Grantham, Newark, Doncaster, York, Northallerton.
  - **London King's Cross – Hull**, calling Stevenage, Grantham, Newark, Retford, Doncaster.
  - **Open Access**, largely as now (so to/from Sunderland, Bradford Interchange, Hull).

- Central do-something (Option 3) infrastructure with HS2 Phase 2B. Here the maximum LDHS frequency to/from London King's Cross is 8 trains per hour, consistent with our assessment for Option 3. We have assumed that the following hourly services would operate in addition to the do minimum scenario with HS2 Phase 2B:
  - **London King's Cross – York**, calling Peterborough and Doncaster.

- **London King's Cross – Nottingham**, calling Peterborough and Grantham.

We assume that First Group Open Access services cease to operate in this scenario. This is on the basis that the train path is occupied by the services listed above, and is consistent with HS2's current business case modelling.

6.1.1.2 Loss of passengers to HS2

A simplified appraisal methodology has been used, whereby an overlay based on results from HS2 Ltd's PLANET Framework Model (PFM) has been applied to our demand and appraisal models. Due to differences in assumptions used between the two models, the result obtained should be treated as indicative.

The appraisal was undertaken by applying a pro-rata adjustment to the benefits assessment for the above options, in proportion to the expected transfer of passengers from the ECML to HS2. The pro-rata adjustment was applied from the assumed opening year of HS2 Phase 2B.

Mott MacDonald and our supply chain partner SYSTRA run PFM on behalf of HS2, and are therefore familiar with it. This adjustment was calculated using the model used to support latest published version of the business case for HS2, PFM v7.1.

As can be seen, there is a substantial forecast transfer of journeys from ECML services to HS2.This is unsurprising, given the journey time advantage of HS2 services, and also given the reduction in ECML services as described in the previous section.

Table 11. Assumed transfer of ECML rail journeys to HS2

Origin Station	Destination Station	Adjustment Factor		
		Business	Leisure	Commute
Edinburgh	London	2%	2%	2%
Leeds	London	0%	0%	0%
Total London	Wakefield BR	0%	0%	0%
Newcastle	London	5%	5%	6%
Harrogate	London	0%	0%	0%
Bradford Yks BR	London	0%	0%	0%
Total London	York	6%	6%	8%
Durham	London	31%	30%	34%
Northallerton	London	47%	43%	51%
Huddersfield	London	0%	0%	0%
Stirling	London	0%	0%	0%
Dundee	London	0%	0%	0%
Darlington	London	19%	18%	21%
Morpeth	London	0%	0%	0%
Hull	London	21%	20%	23%
Doncaster	London	49%	53%	54%
Newark N Gate	London	71%	63%	72%

6.1.1.3 Residual asset value

We understand that the PSU2 enhancement will also be required to enable HS2 services to operate. Given that this new infrastructure would only be 12 or 15 years old given HS2 Phase 2B opening in 2033 or 2036. Assuming an asset life of 60 years a residual asset value is included equivalent to 12/60 or 15/60 of the initial investment cost, respectively. The residual value is included in the appraisal in 2033 and 2036, respectively so the effective cost saving is heavily discounted back to 2010 prices and values.

6.2 Results

Appraisal results for HS2 sensitivity tests and for Option 3 are shown below in Table 12.

Under both sensitivity tests total benefits reduce by around two thirds, from circa £3bn to £1.1-£1.2bn.

The net reduction in franchise premium under Option 3 increases by roughly £140m in both sensitivity tests. This net increase in subsidy is because of lower East Coast franchise revenue due to abstraction by HS2 (offset partially by gains resulting from a switch from Open Access to franchised revenue). .

The total infrastructure cost reduces by around £160m in both sensitivity test, as result of the assumed residual asset value of the PSU2 enhancement.

With HS2 phase 2B opening in 2033 Option 3 has a BCR of 1.5, indicative of medium VfM. Assuming an opening year of 2036 increases the BCR to 1.7, also indicative of medium VfM.

Table 12. Option 3 and HS2 Phase 2B sensitivity tests, appraisal summary results £M 2010 prices and values

Item	Option 3	With HS2 Phase 2B opening in 2033	With HS2 Phase 2B opening in 2036
Transport User Benefits (1)	2,113	897	992
Non-User benefits (2)	136	52	58
OA Operator Benefits (3)	771	490	567
Total Benefits (4) = (1) + (2) + (3)	**3,020**	**1,440**	**1,617**
Franchised Revenue (5)	[redacted]	[redacted]	[redacted]
Franchised Opex (incl NR costs) (6)	[redacted]	[redacted]	[redacted]
Net impact on Premium (7) = (5) + (6)	**-427**	**-574**	**-558**
Total Infrastructure Costs (8)	**-521**	**-362**	**-369**
Total Cost to Govt (9) = (7) + (8)	**-948**	**-935**	**-926**
BCR (10) = (4) / -(9)	**3.2**	**1.5**	**1.7**

6.3 IEP fleet utilisation

We understand that under the current IEP contract a maximum of 54 units will be available, as follows:

- 36 x 9-car units
- 18 x 5-car units

Therefore, if all of the 5-car units operate in double (10-car) formation, there would be a maximum of 45 trains available.

We have assessed the size of the fleet required to operate the residual ECML services in the post HS2 Phase 2B do-minimum and do-something scenarios.

Under the post HS2 do-minimum scenario we estimate that approximately 35 trains would be required. This means that even if all 5-car units operated in 10-car formation, circa 10 units would not be required.

Under the post HS2 do-something scenario we estimate that approximately 45 trains would be required. Therefore, operation of all 5-car units in 10-car formation would completely utilise the IEP fleet.

A. Appendix: Operational Assessment – Assumptions and further commentary

A.1.1 Assumptions

A full set of assumptions has been included in the separate assumptions log. This has been shared previously with DfT and Network Rail. Other key assumptions requiring further description are listed below.

Running Times

Proposed running times have been supplied by Network Rail for Class 800/801 and Class 700 (Thameslink) trains. Class 802 rolling stock is assumed to have the same performance characteristics as Class 800/801.

Timetable Planning Rules (TPR)

Dwell times for Class 800/801/802 services are assumed to be per Class 91 services. For new infrastructure, standard assumptions have been applied as full detail is not yet known (e.g. 3 minute headways and junction margins).

Timetable allowances for VTEC services (particularly performance allowance) have been taken from the supplied VTEC bid timetable to avoid having an adverse impact on journey times. All other TPR values are taken from the 2018 TPR document published by Network Rail.

Interacting Services

Due to the requirement to undertake a high-level timetable assessment, certain interacting services not listed in the train service specification have been omitted. To a certain extent, these trains may need to be retimed around the core ECML paths as part of the overall timetable recast. It has therefore been assumed that there is capacity to operate these services alongside the sample timetables presented here.

Key sections which would need to be analysed in more detail are discussed below

Newark Flat Crossing.

Passenger and freight services running between Nottingham and Lincoln cross the ECML at Newark Flat Crossing. There are long-standing stakeholder aspirations to increase the number of services on this route. These crossing moves require a gap in train service on the ECML in both directions. The timings of these trains therefore dictate the structure of the ECML timetable. Previous analysis by Network Rail has shown that there is capacity to accommodate these crossing moves within an 8 tph LDHS timetable, but further analysis would be needed to identify crossing opportunities within the final timetable structure.

Doncaster

There are a significant number of local and inter-regional flows which either terminate at or pass through Doncaster station (including crossing the ECML layout for services running from Sheffield towards Goole or Scunthorpe). Some ECML Connectivity schemes already being progressed (including Platform 0 and the east-side bi-directional signalling) aim to reduce the impact of some of these moves, but a significant issue will remain. The timings of these local services will need to be optimised around the ECML timetable, which will therefore need to be considered in more detail. However, there is an opportunity to provide a journey time improvement on some flows if current excess pathing or dwell time can be removed as a result of the wider timetable recast.

York

In the York area there are a number of flows which use the station area either to terminate or pass through which are outside the scope of this work (such as stopping trains from Leeds, Hull/Selby or Harrogate and the inter-regional trains to Scarborough). Although platform capacity is not expected to be a significant issue and the proposed York North throat upgrade would give more flexibility in timetabling, further work would be needed to assess the impact on these services.

Newcastle

Platform capacity at Newcastle station has been highlighted previously due to more terminating trains (such as the London – Newcastle stopping service) and also longer trains which are too long for the current bay platforms. Alternative service options to improve platform capacity may need to be explored (such as shunting trains out of the station or running around the High Level Bridge loop). Interactions with local services which pass through and terminate at York (particularly the MetroCentre – Morpeth service and peak trains terminating at Chathill which interact with the ECML for a long distance) will also need to be analysed in more detail.

Edinburgh

Platform capacity at Edinburgh will need to be examined in more detail for the London services to assess the impact of a consistent 2 tph terminating throughout the day. The approaches to Edinburgh (from Dunbar, Drem/North Berwick and the Borders line) will also need to be examined in the context of the changed ECML timings. Furthermore, extensions beyond Edinburgh (such as Inverness, Aberdeen and Glasgow) will also need to be revised as the timings will have been changed from today (and new rolling stock is being used).

A.1.2 Option 2 Timetable Development

The Option 2 timetable forms the basis of all the other option timetables. The bulk of this assessment was undertaken at OBC stage. Timetable development started from the VTEC bid timetable and the Thameslink Development Timetable being produced by Network Rail. At the time of this work, the Thameslink timetable was still a work in progress and may therefore not be fully representative of the final output produced. Our timetables for this option have been supplied to DfT in separate file.

The Thameslink timetable development work is based around a 2018 timetable year (before the increase in LDHS services unlocked in 2021) and therefore only contains a 6 tph LDHS service for most of the day. There are therefore fundamental differences between the Thameslink and VTEC timetables that mean they cannot simply be overlaid onto each other.

As an example, to provide sufficient time for the different fast / semi-fast / stopping LDHS patterns to operate south of Doncaster, flighting of trains leaving King's Cross is required (as occurs today). The Thameslink timetable assumes 2 flights of 2 LDHS trains are required, with the Thameslink trains following behind. To operate an 8tph timetable, 2 flights of 3 LDHS trains are required and therefore the third path will clash directly with a Thameslink path. To deliver the 8 tph timetable, additional dwell time is therefore required at Finsbury Park to enable the train to follow the LDHS flight.

At certain times of the day, the level of do-something service over Welwyn Viaduct exceeds the available capacity. The available capacity is normally taken to be 18 tph (with calls at Welwyn North). In the peaks, the aspirational level of service exceeds this (e.g. in the PM peak 12 tph TSGN and 8 tph LDHS). Following discussions with the DfT, the 20tph has been assumed in the PM peak on the understanding that changes in the TPRs may enable an additional 2tph.

North of York, one fundamental issue with the specification is that a fast London – Edinburgh train with a four-hour journey time (departing at xx.00 from King's Cross) needs to pass the northbound South West – Scotland CrossCountry north of Newcastle. There is no infrastructure to enable this. However, there are likely to be a number of changes to this path before 2021 due to franchise changes, CrossCountry's desire to improve journey times and infrastructure works on the train's route off of the ECML. Therefore, this path has been moved from today's timings (this also applies in all other options).

The First Group Open Access can be included over this section due to a significant amount of pathing time added to fit amongst other services.

A.1.3 Option 3 Timetable Development

Under Option 3 we assume that the infrastructure enhancements at York and between Northallerton and Newcastle are not delivered.

Option 3 is identical to Option 2, except that the hourly northbound London King's Cross – Newcastle service incurs a five minute journey time penalty between Northallerton and Newcastle.

Appendix B presents our capacity analysis which supports these assumptions. The text presented is a repeat of a previous technical note issued to DfT.

A.1.4 Option 4 Timetable Development

Under Option 4 we assume that the four-tracking scheme in the Woodwalton area is not delivered.

Option 4 is identical to Option 3, except for the following journey time penalties:

- 3 minutes per hour in the up direction spread across 2 TSGN Franchise services
- 1 minute in two AM peak LDHS services

These penalties were estimated by calculating how much earlier the affected services would need to depart to avoid being caught by a following service. This earlier departure time is then treated as pathing time, maintaining the planned arrival time at destination.

The impact of reduced train punctuality has also been estimated and is shown in Appendix C.

B. Northallerton – Newcastle capacity

B.1.1 Introduction

In 2017, Mott MacDonald prepared the Economic Case for the East Coast Main Line (ECML) Enhancements Programme Outline Business Case on behalf of the DfT. One of the scenarios within this study was the provision of freight loops between Northallerton and Newcastle (at Cowton, Ferryhill and Ouston) to enable an increase in the number of Long Distance High Speed (LDHS) paths operating north of York; there was a financially positive business case for doing so.

This analysis was based on the assumptions used in the ECML Enhancements Programme that two freight paths would be provided on most of the ECML (notionally one Class 4 and one Class 6 path per hour). More recent data from the Freight Market Study in 2013 shows that forecast freight traffic is likely to be lower and could be contained within one hourly path between Northallerton and Newcastle. This would reduce the business case for constructing the loops, and the Mott MacDonald operational analysis showed that they may not be required with a lower level of freight.

The purpose of this analysis is to expand on the previous analysis and see if it is feasible to operate one freight path alongside the passenger service (6 LDHS every hour and a five trains per day Open Access service) without any infrastructure enhancement between Northallerton and York.

B.1.2 Current Freight Services

The remit for this additional work specified freight paths operating at 1800 tonnes (Class 4 intermodal) and 715/2600 tonnes (Class 6 bulk freight). This is not fully representative of paths that operate today, as coal/biomass services operate as loaded Class 6 southbound and empty Class 4 northbound.

Analysis was therefore undertaken to examine current freight paths in the May 2017 Working Timetable (WTT); this covers trains which are booked to run in the permanent timetable plan but not any Short Term Plan (STP) paths arranged at shorter notice. Not all of the paths will be used on any given day. At Birtley Junction (south of Newcastle), between 0700 and 2000 (the time when the most intensive passenger service operates) the following WTT freight paths operate.

Table B1: Current northbound WTT paths between 0700-2000 at Birtley Jn

Class	Type	Tonnage	Route	Quantity
4	Empty coal/biomass	600	Darlington	10
4	Intermodal	1000	Stillington	1
6	Empty bulk	600	Darlington	2
6	Loaded bulk	1600-2200	Darlington	4
TOTAL				17

Table B2: Current southbound WTT paths between 0700-2000 at Birtley Jn

Class	Type	Tonnage	Route	Quantity
4	Intermodal	1200	Darlington	1
6	Empty Bulk	600	Darlington	1
6	Empty Bulk	600-1000	Stillington	3
6	Loaded Bulk	1600-2200	Darlington	5
TOTAL				10

The conclusion of this analysis is that northbound, an hourly path operates *via* Darlington which is a mixture of empty biomass/coal, empty bulk and loaded bulk traffic. Southbound, less than an hourly path operates *via* Darlington which is mostly loaded bulk, with some empty and intermodal traffic.

Combined with the remit assumptions, the following scenarios have been analysed in this Technical Note:

Northbound:

- Class 4 715t (empty biomass/coal). These are timed as 800 tonnes in this analysis as the best matching Timing Load.
- Class 4 1800t (intermodal)
- Class 6 2600t (bulk)

Southbound:

- Class 4 1800t (intermodal)
- Class 6 715t (empty bulk). These are timed as 800 tonnes in this analysis as the best matching Timing Load.
- Class 6 2600t (loaded bulk)

If paths can be found matching these requirements, current traffic will be able to be accommodated on the route and also allow for growth in trailing load across all categories.

B.2 Baseline Timetable

The timetable used in Mott MacDonald's original analysis has been used as the base for this work. This analysis only considers York – Newcastle, but basing it on the previous work means that the findings are more realistic as they are consistent with a whole route timetable. It should be noted that no combined ECML timetable current exists for 2020 onwards and thus the actual timetable may differ, but the conclusions from this work will demonstrate whether or not a timetable could be designed to deliver the outputs.

Some amendments to the previous timetable were made to bring it in line with the remit due to differences in specification from the original work. The key differences can be summarised as:

- Northbound, 1 minute of pathing time was added in to the northbound fast King's Cross – Edinburgh train. This still delivers a 4-hour journey time, but means the Reading – Newcastle CrossCountry service is not overtaken at Durham which provides extra capacity for freight.
- Following clarification about services north of Newcastle, the northbound CrossCountry (Scotland) and TransPennine paths in the original work were swapped. This has minimal impact on the findings here and is only to align the timetable more closely to the remit.
- Southbound, minor amendments were made to the southbound CrossCountry (Scotland) path to bring it in line with the current stopping patterns of this service.

It should be noted that the northbound CrossCountry Scotland path operates earlier than its current path (whereas all other CrossCountry paths are approximately in the current location). This could be enabled by reducing the current extended dwell at Leeds (a significant timetable change is happening at Leeds in 2019) and potential alterations due to other schemes such as Derby remodeling. This issue was also noted in the Mott MacDonald report and arises because any London – Edinburgh service departing at xx.00 with an approximate 4-hour journey time will clash with the current CrossCountry path on the north end of the route. This will need to be resolved in the future timetable and will occur independent of the impact of any findings in this analysis.

6.4 Viability of freight paths

6.4.1 Northbound

There is only one suitable gap within the northbound timetable to operate a freight path: following the TPE service from Northallerton. Running within this path, a Class 4 empty coal/biomass path can operate all the way to Birtley Junction without impact on any other service and without looping. No amendments are required to accommodate this.

For heavier trains, they are caught by the following London - Newcastle service. Previously, these paths were looped at the new Ferryhill Down Loop, but must now be looped on the Up side on the existing Slow Lines. This involves two new crossing moves to access the new loop which does increase performance risk, however the risk is minimised as these moves occur in a natural gap in Up traffic. Looping at other locations would have a bigger impact on passenger services and may also restrict the length of intermodal trains, so the looping on the Up side has been deemed the best solution.

As there is only a single viable freight gap in the timetable, looped trains need to wait until the same path in the following hour (albeit at the start of the window between passenger trains, which involves a dwell of approximately 45 minutes).

Intermodal paths are looped at Ferryhill/Tursdale Junction. They require a 3-minute journey time extension in the London – Newcastle service to give a compliant margin at Ferryhill South Junction.

Loaded bulk paths are looped at both Darlington and Ferryhill/Tursdale Junction. They require a 5-minute journey time extension in the London – Newcastle service. Lighter timing loads than 2600t would reduce this penalty.

Complications arise because if, for example, an intermodal train operates in one hour, an empty coal/biomass path could not operate in the next hour as the intermodal train is looped and requires the next path. However, this is mitigated by setting it in the context of the current timetable:

- The majority of northbound paths today are empty coal/biomass traffic which would be able to operate non-stop.
- The only intermodal path operating today during the hours of 0700-2000 is 1000 tonnes (rather than the 1800 tonnes tested here) which would be able to operate non-stop per the empty coal/biomass traffic. Today, this path comes from Teesside and is routed *via* Stillington and would therefore only need a single path. Traffic from Teesside could increase to 1800 tonnes and still operate in a single path. It is only traffic *via* Darlington which is heavier that would cause a problem.
- Bulk traffic is the most problematic as it needs to be looped twice. However, there are relatively few paths today and none today operate above 2200 tonnes (2600 tonnes is tested here). Although outside the scope of this remit, increased use of the route *via* Stillington would enable these trains to operate in a single path.

6.4.2 Southbound

Southbound, the only viable freight path is between the Newcastle – Kings Cross service and the Edinburgh – Kings Cross Open Access train. This path cannot cross from the Goods/Slow Lines at Birtley Junction and must therefore be routed from Newcastle station or Greensfield Junction. This is only an issue if it is a heavy path (above 800 tonnes) which requires to run from Tyne Yard; amendment would be required to the Up Newcastle – Kings Cross train (approximate 2 minute journey time extension). However, this would only be required for one path between 0700 – 2000 today.

The empty bulk path can be accommodated with looping at Ferryhill South Junction. Redistribution of pathing time is required in the Open Access service (if it operates in this hour) but no journey time extension results.

The gradient between Birtley Junction and Durham extends journey times for heavy freight considerably. For the weights being tested, any path 1800 tonnes or above cannot operate in the hours when the following Open Access service operates.

The intermodal path therefore cannot run between Birtley Junction and Tursdale Junction in the hours when the Open Access path operates. It is looped at Ferryhill South Junction, but can operate south thereof without further impact (including if the Open Access path operates in the following hour).

It is not possible to operate a 2600 tonne Class 6 path between Birtley Junction and Tursdale Junction without both the Open Access and one other passenger service (likely to be a CrossCountry train) operating. However, a 2200 tonne path can operate with just the Open Access service not operating. This weight would accommodate all current bulk traffic on the route. The path is looped at Durham. Two options then exist; if the Open Access train also does not run in the following hour, the path can run through with no impact on other services. If the Open Access train does operate, additional looping is required at Ferryhill South Junction.

In the context of today’s paths:

- The majority of the southbound paths are loaded bulk paths (mostly coal/biomass). These paths can operate at today’s weight in the hours when the Open Access path does not operate, being looped either once or twice. The relatively low number of paths and the five trains-per-day Open Access service means both could be accommodated by careful selection of the hours in which each operates.
- Empty bulk trains can operate being looped at Ferryhill South without significant impact on other services.
- Intermodal paths can operate being looped at Ferryhill South provided the Open Access path does not run in the same hour between Birtley and Tursdale Junctions. There are very few intermodal paths today.

B.2.1 Interaction with local services

The main interaction with local services on the route is with the services which cross the route at Darlington, which operate between Saltburn and Darlington, and Saltburn and Bishop Auckland.

The original analysis assumed that these services would be adjusted to fit amongst the LDHS services, and thus a number of conflicts exist irrespective of the nature of the freight paths. To resolve these, today's Saltburn – Bishop Auckland (and return) services would both need to be moved around 5 minutes later. This does conflict with the southbound heavy bulk freight path (in one of the two options presented here) but this could be resolved if the path is looped twice.

The Saltburn – Darlington service would also have to be moved later by a similar amount, although this is due to conflicts with LDHS services rather than freight paths. Therefore, there would be limited impact on service interval, and the journey time impact would depend on whether the revised paths could be accommodated outside the scope of this study.

However, this scenario is unlikely to actually occur. The Saltburn – Darlington – Bishop Auckland route is one which will see significant change in the new Northern franchise. It is highly unlikely the paths will operate with today's timings as there are wholesale changes to the Teesside area in the new franchise. These revised paths will need to be reviewed against the new ECML LDHS timetable in any case, and there is no reason why the provision of the freight path would make this more difficult. In fact, the reduction from two assumed paths to one path will free up capacity for crossing moves in the Darlington area.

Today, some Northern services run between Darlington and Newcastle *via* the ECML. However, this is typically at the start and end of the day when there are fewer LDHS paths, and the freight infrastructure is unlikely to make a significant different to these paths as they are typically lower speed (75mph) paths.

Arriva's service proposal for the new franchise included an option to run Middlesbrough – Carlisle Northern Connect service *via* Stillington and the ECML. These services are optional services that do not have access rights and the issue of whether they can operate on the ECML irrespective of freight has not been resolved. However, it should be noted that the reduced freight infrastructure would likely make it more difficult to operate these trains.

C. Performance Analysis – Huntingdon to Woodwalton 4-tracking scheme

C.1 Introduction

We undertook an assessment of the performance impact of introducing additional capacity to the route between Huntingdon and Woodwalton, through the reinstatement of a fourth track.

This was a high-level analysis, intended to provide DfT with some evidence regarding the potential Value for Money (VfM) of the four-tracking scheme, as part of the overall work we are undertaking to support the Final Business Case (FBC) for the East Coast Main Line Enhancements Programme. A high-level analysis of this nature should not, by itself, form the basis upon which to form decisions regarding the detailed specification of infrastructure options (for example the length of the four tracking and the location of junctions). More detailed analysis such as simulation modelling would provide better evidence with this respect.

This scheme will allow faster trains to overtake slower ones in the Up direction and releases the potential to improve journey times and also to reduce the impact of a delay.

In order to carry out this analysis, data was requested from Network Rail (NR) on the amount of delay and lateness that has occurred on the route for the last 13 periods, then a judgement was made on the level of these minutes that could be saved by having the section of 4-tracking.

This saving in delay minutes was then converted to a lateness saving, so this could be used to assess both the passenger demand response and the transport user (time saving) benefits

This document discusses the data received from NR, the editing and analysis that was carried out, the assumptions that have had to be made and the resultant conclusions regarding delay minutes potentially avoidable as a result of the scheme.

The assumptions made in this note provide a plausible basis for the impact of the scheme on delay, but no simulation modelling has been completed, nor assessment of future timetable changes or operating characteristics. As such the output should be considered as indicative, and not relied upon to assess the relative benefits of different variants of the Huntingdon to Woodwalton 4-tracking scheme.

C.2 Data

We requested several data sets from Network Rail in order to carry out the analysis required to evaluate the impact of the increase in track capacity.

Delay and lateness data for the route between Doncaster and Kings Cross was requested, in the Up direction only, for trains that pass through the Huntingdon to Woodwalton study area.

Four sets of files were received, together comprising 13 periods of data to the end of Period 11, 2017/18, each set containing two main files of data (broken down due to their size), and in addition a set of files containing lookup data for various codes used in the main sets.

The main files were as follows:

- Attributions data (incidents, cause, location of delay or cancellation, etc.); and
- Timings data: timing events at specific locations.

The former of these data sets was found to contain all passenger and freight services that had experienced a delay somewhere between Doncaster and Kings Cross, but in both directions and also on services that were not booked to run through the study area. The timing data showed lateness that occurred between Doncaster and Kings Cross but only for services that travelled through the study area in the Up direction.

As stated above, the files also included lookup data to describe various codes used in the main data sets, so these too also had to be incorporated to enable analysis to be carried out.

The data sets therefore required considerable editing which will be described in the Methodology section below.

C.3 Methodology

This section describes how the data was edited and the analysis that was carried out in order to generate results on current performance levels and the amount of savings that could be assumed from implementing the scheme.

C.3.1 Data editing

As described in section 1 above, some editing of the delay data was required before the analysis was commenced. This was as follows:

- Use of the lookup tables to insert:
  - Identification of stanoxes for origin and destination of the victim and perpetrator trains, as well as the delay and incident locations;
  - Description of the two digit TRUST reason codes; and
  - Description of the two digit Operator codes.
- Deletion of all freight services that experienced a delay on the route (as delay to freight operators in not normally included in a WebTAG appraisal);
- Deletion of all services that did not travel through the study area (Huntingdon to Woodwalton); and
- Deletion of all services that did travel through the service area but in the Down direction.

This then left the services required to be investigated and the analysis could be commenced.

C.3.2 Analysis – core assumptions

Attributed delay

In order to capture the delays that occur currently in the study area, the delay locations were studied and due to the way in which these are identified within TRUST, “Peterborough to Huntingdon” was found to be the narrowest delay section that could be selected. This section encompasses the Huntingdon to Woodwalton study area and is the smallest section that can be selected within TRUST in this area. Delays were then summarised by period, reason code and by operator for the Peterborough to Huntingdon section.

Once these delays had been isolated, a view was taken on which incidents could be avoided by introducing the 4th track. It was assumed that no primary[1] delays could be saved, only reactionary[2] delays and specifically those that occurred as follows:

- All reactionary delay experienced by class 2 trains that are delayed as a result of following class 1 trains. Here we assume that the class 2 train would be on the slow line and therefore would not be delayed by the class1 train.
- All reactionary delays experienced by class 1 trains that are delayed following GTR trains coded as class 1. Here we assume that class 1 GTR services would now be on the slow line.
- All reactionary delays experienced by class 1 trains that are delayed following any class of train apart from a class 1 (excluding the afore mentioned GTR services). Here we assume that all trains other than class 1 services would now be on the slow line.

The above assumptions are, in our opinion, optimistic as the four-tracking would not extend the full length of the route between Peterborough and Huntingdon. Therefore, some of the delays described above may still occur following the four-tracking scheme.

Sub-threshold delay

The above assumptions relate to above threshold attributed delay. Our core assumption is that no sub-threshold delay would be avoided by the four-tracking as there is no evidence in the data to suggest this is the case (as by definition the delay has not been attributed). This is likely to be a pessimistic assumption, but on balance we believe this is reasonable given the optimistic assumption relating to above threshold delay.

Lateness at destination/Schedule 8 monitoring point

We expect a general worsening of delay, and hence lateness as a train heads south from the study area. This is a view which we understand is supported by operators on the route. We have therefore selected a delay-lateness ratio of 1:2. I.e. a train which is delayed by one minute between Peterborough and Huntingdon will be two minutes late at subsequent destinations/Schedule 8 monitoring points. A delay-lateness ratio of this level is within the range that we have seen on other busy mixed-use railways, and we believe that to be a prudent assumption given limited opportunity for recovery towards London, and that GTR trains will interact with the Thameslink core from later this year.

C.3.3 Analysis – alternative assumptions

In recognition that the above analysis is high-level, we have developed some alternative assumptions to support an optimistic case assessment of the four-tracking. An alternative scenario existed previously but had not been reported in previous version of this note.

Here our approach to attributed delay is as described above, however we have also included some sub-threshold delay savings.

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[1] A primary delay is a delay to a train that results from an Incident that directly delays the train concerned, irrespective of whether the train concerned was running to its schedule (schedule includes booked platform or line) at the time the incident occurred, i.e. the delay is not the result of another delay to the same or other train.

[2] A reactionary Delay is a delay to a train that results from an incident that indirectly delays the train concerned, i.e. the delay is the result of a prior delay to the same or any other train.

We estimated the level of sub-threshold delay minutes using Network Rail lateness data. Here we took the lateness at Huntingdon and at Peterborough for all the class 1 and 2 trains that pass through these points in the up direction, then subtracted the latter from the former to work out how much extra delay was accrued in the section. We then disregarded any results that were 0 or less (as these were for trains that had gained back time in the section), then also disregarded any results 3 minutes and above (making the assumption that these would be above threshold delays and therefore would already have been accounted for in our previous analysis and totals).

Due to time constraints our analysis considered four periods P1712-P1802, rather than a full year as above. Over this period the split of sub-threshold/attributed delays was broadly 60/40.

The following assumptions were used to include sub-threshold delays:

- Sub-threshold delay follows same proportion of secondary and primary delay as attributed delay threshold delay.
- The proportion of sub-threshold reactionary delay saved is as per attributed delay
- Zero sub-threshold primary delay is saved to avoid double-counting, as primary delay can result in attributed delay elsewhere on the network

Again, we consider the above to be an optimistic scenario as sub-threshold delays are not attributed.

C.4 Results

This section details the results obtained from the analysis described above

C.4.1 Peterborough to Huntingdon delays by period

Table C1: Peterborough to Huntingdon Reactionary and Primary delays - P1712-P1811 (minutes)

Description	1712	1713	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	Total
Lost path - regulated for train running less late	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Lost path - regulated for another later running train	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Lost path - following train running less late	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Lost path - following another later running train	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Regulated in accordance with Regulation Policy	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]				[redacted]		[redacted]		[redacted]
Late arrival of booked inward stock		[redacted]												[redacted]
Special stop orders within the contingency plan or agreed by NR/TOC							[redacted]		[redacted]					[redacted]
Waiting platform/station congestion/platform change		[redacted]												[redacted]
Delays due to diversions from booked route or line		[redacted]		[redacted]	[redacted]		[redacted]		[redacted]	[redacted]	[redacted]	[redacted]		[redacted]
Service Recovery-booked rolling stock, not available									[redacted]					[redacted]
Reactionary	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Primary	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Grand Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Source: NR and Mott MacDonald

The table above shows the delays that occurred between Peterborough and Huntingdon to trains travelling in the Up direction between P1712 and P1811. Reactionary delays have been broken down by cause and primary delays have just been shown as a total.

The following table shows the same group of delays, but this time broken down by the TOCs that experienced them:

Table C2: Peterborough to Huntingdon delays by TOC – P1712-P1811 (minutes)

TOC	1712	1713	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	Grand Total
Caledonian Sleeper			[redacted]											[redacted]
Grand Central	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
GTR	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Hull Trains	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Virgin Trains East Coast	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Grand Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Source: NR and Mott MacDonald

C.4.2 "Avoidable delays"

It was decided that when looking at the Peterborough to Huntingdon delays that by the introduction of a 4th track, a proportion of these could be avoided. As discussed in section C.3.2 of this note, the delays which are thought to be avoidable are:

- All reactionary delay experienced by class 2 trains that are delayed as a result of following class 1 trains; and
- All reactionary delays experienced by class 1 trains that are delayed following any class of train apart from any class 1s not operated by GTR.

Again, looking at this by period, the results are as follows:

Table C3: Peterborough to Huntingdon Avoidable delays - P1712-P1811

Description	1712	1713	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	Total
Lost path - regulated for train running less late	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]						[redacted]	[redacted]		[redacted]
Lost path - regulated for another later running train	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Lost path - following train running less late	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Lost path - following another later running train	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Regulated in accordance with Regulation Policy	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]				[redacted]				[redacted]
Waiting platform/station congestion/platform change		[redacted]												[redacted]
Delays due to diversions from booked route or line		[redacted]		[redacted]	[redacted]		[redacted]			[redacted]	[redacted]	[redacted]		[redacted]
Grand Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Source: NR and Mott MacDonald

Table C4: Peterborough to Huntingdon avoidable delays by TOC – P1712-P1811

TOC	1712	1713	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	Grand Total
Grand Central	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
GTR	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Hull Trains	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Virgin Trains East Coast	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Grand Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Source: NR and Mott MacDonald

Table C5: Annual Delay minutes saved, both scenarios

Annual delay minutes	Core scenario		Alternative scenario	
	Total	Avoided	Total	Avoided
Attributed delay mins reactionary	6,501	2,563	6,501	2,563
Attributed delay mins primary	4,916	-	4,916	757
Sub threshold delay mins reactionary	10,117	-	10,117	3,989
Sub threshold delay mins primary	7,650	-	7,650	-
Delay mins total	**29,185**	**2,563**	**29,185**	**7,309**

C.5 Conclusions

Following on from the high-level analysis described in this document, we are able to conclude the following:

- 6,502 delay minutes in the year P1712 to P1811 between Peterborough and Huntingdon were caused by reactionary causes, compared to 4,916 which were caused by primary causes;
- VTEC experience the most delay between Peterborough and Huntingdon ([redacted]), followed by GTR ([redacted])
- Using the definition of “avoidable” delay to define those that could be saved from the introduction of a 4th track, a total of 2,563 minutes meet the criteria, 39% of all reactionary delay.
- In an alternative, optimistic, scenario this increases to 7,309 minutes

In this analysis an assumption has been made that no primary delay will be saved through the introduction of the proposed new infrastructure; this is due to the fact that the scheme will mostly benefit the management of incidents once they have occurred and therefore saving reactionary delays only. It could be argued that a small percentage of these delays could also be avoided as services would be timetabled over the 4th track and therefore have a chance of avoiding the initial impact of an incident. However, this should only be considered to be a conservative amount, perhaps 10% (492 minutes) as it is likely that new primary delays will be encountered on the additional track too. However, if the utilisation of the infrastructure becomes lighter due to the extra capacity, this assumption could perhaps be made and added into the calculation of benefits. Further benefits could also be derived by expanding the study area and claiming a small reduction in delays for these areas to reflect the resultant “ripple effect” of making an improvement in this area.

As discussed above, we have allowed for knock-on impacts further south through a delay-lateness ratio of 1:2

D. Technical Appendix – Economic Case Modelling

D.1 Introduction

A suite of models has been developed to assess the economic case of the three core options (Options 2-4) for investment in the East Coast Main Line.

The suite comprises a demand and revenue model that captures inputs from MOIRA and functions alongside a stand-alone Crowding and Fares Overlay model. Together these models assess the demand, revenue and passenger benefits (time and fares savings) of the following elements:

- An improved timetable, representing faster journey times, increased frequency and new direct journey opportunities (standard impacts modelling in MOIRA)
- Additional capacity, notably to and from London on East Coast franchise services, reducing crowding and releasing supressed demand
- Reduced off-peak fares stimulated by a new open access operator serving the London to Newcastle and Edinburgh Market.
- New directly served markets, e.g. London to/from Morpeth

The figure below illustrates the structure of the model suite.

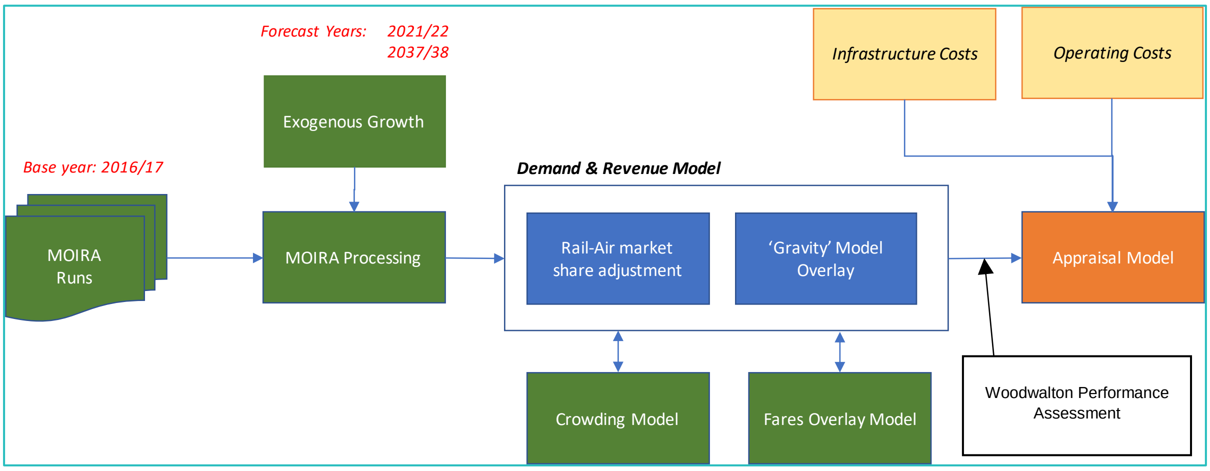


Figure D1: Structure of Model Suite

Each version of the model suite for a single option, captures from the Demand & Revenue Model, output for two forecast years: 2020/21 and 2037/38. The model has a base year of 2016/17. Output to the Appraisal Model represents the difference between a do-minimum (DM) and do-something (DS, or option) position.

In addition to three core do-something options (Options 2-4) the FBC economic case includes a range of sensitivity tests. Depending on the nature of the sensitivity tests, different elements of the model suite are used and assumptions are documented in the final section of this appendix.

At a summary level:

- MOIRA1 is used to assess the impact of the timetable change between the DM and option scenario. MOIRA1 estimates the demand and revenue impact due to changes in service provision and journey times. Results data is extracted for various segments and is processed and used to populate the Demand and Revenue Model (DRM).

- Exogenous demand growth from macro-economic and modal competition drivers is forecast using guidance from within the Passenger Demand Forecasting Handbook (PDFH) and Webtag to produce rail demand for the 2020/21 and 2037/38 future years.
- The DRM and also via an interface with the Fares Overlay, undertakes the following further forecasting elements:
  - Air-Rail competition due to journey time: PDFH methodology on air-rail competition due to journey times has been deployed to better model the rail market share for London to Newcastle and London to Edinburgh when journey times are reduced in DM and DS timetables.
  - Fares competition due to First Group Open Access (FGOA) services: MOIRA1 does not model the impact of fares changes at all, therefore is required to calculate adjustments to forecast demand and revenue to take this into account of both FGOA fares and a competitive response from the East Coast franchise operator. These calculations are undertaken within the Fares Overlay Model.
  - New destinations modelling: A series of stations on the ECML network are proposed to receive improvements in service provision that provide much more frequent and direct connectivity with London. In these instances, a gravity modelling approach has been used to estimate the demand generation – and abstraction – brought about by these changes.
- A crowding model has been developed, follow a PDFH methodology and utilising inputs from MOIRA1 and demand growth from the DRM. This constrains demand growth in both the DM and DS scenarios, and as such determines the incremental impact of crowding on the option being tested. In addition to a demand and revenue impact, the Crowding Model also assesses a change in crowding minutes for consideration within the Appraisal Model.
- High level analysis of performance impacts is undertaken following an assessment of delay minutes avoidable as a result of the Huntingdon-Woodwalton 4-tracking scheme. This analysis determines a demand and revenue impact (utilising PDFH parameters) and also captures a value of time impact.
- Operating costs based on incremental mileage and train vehicles between DM and DS option are calculated within the Operating Cost model.
- Capital (infrastructure scheme) costs are input the Appraisal after application of optimism bias.

The further sections of this appendix document the assumptions and methodology in relation to each of the following components:

- MOIRA model runs & timetable scenarios
- Exogenous / background growth forecast & MOIRA processing
- Crowding Model
- Fares Overlay Model
- Demand & Revenue Model
- Operating Cost Model
- Infrastructure (capex) costs
- Performance Impacts
- Appraisal Model

Results from each component of the model suite are also summarised within these sections.

The final section of this appendix documents the sensitivity tests.

D.2 MOIRA model runs & timetable scenarios

MOIRA1 provides estimates of station to station demand and revenue according to the level of service provided by the input timetables. MOIRA1 calculates these estimates by pivoting off a base year timetable held within the program – for this study we have used the May 2016 timetable; and used demand and revenue values for the financial year to end September 2017. The demand and revenue estimates are generated within MOIRA1 through the application of the PDFH v5.1 Generalised Journey Time (GJT) mathematical framework.

The timetables developed for the study were weekday only, therefore these are the only timetables that have been modelled within MOIRA1, however when data was extracted weekday and weekend days were selected to estimate the full year impact of the effect of the timetable change.

Consistent with the timetable scenarios developed at OBC stage, the Northern (OR23) version of MOIRA is used.

The timetable scenarios that have been created for the three core options (options 2-4) are shown within the table below. Further details on the development of these timetables are described and referenced within the main FBC economic appraisal report.

Table D1: Summary of timetable scenarios

Scenario	Impacted TOCS (compared to May16 timetable base)
Do-minimum (option1)	East Coast, TSGN, Grand Central, Hull Trains, TPE
Option2	East Coast, TSGN, Grand Central, Hull Trains, TPE, FGOA
Option3	East Coast, TSGN, Grand Central, Hull Trains, TPE, FGOA
Option4	East Coast, TSGN, Grand Central, Hull Trains, TPE, FGOA

Outputs from MOIRA are produced for each option representing:

- Base (May 16) vs DM
- Base (May 16) vs DS

Outputs of demand and revenue by flow are produced both by TOC and separately by ticket type (Full, Reduced and Seasons).

D.3 MOIRA processing sub-model

Outputs from MOIRA1 model runs are input to a 'MOIRA processing' sub-model. This sub-model is produced for each of two forecast years and has the following purposes:

1. It extracts from the long-list of flows produced by the MOIRA model a common set of 709 station to station flows
2. It combines 8 demand revenue output files from MOIRA and creates data that is a cross tabulation of both TOC (for 7 selected TOCS) and ticket type.
3. Passenger miles is calculated based on a distance for each OD flow (distances are also sources from MOIRA but not updated for each scenario).
4. GJT values for each of the station to station pairs are populated, and an average yield for each ticket type and TOC was also calculated for each of the May 16, DM and option timetable.

5. It applies exogenous /background demand and revenue growth from the Exogenous Growth Model, based on 24 defined flow groups.

The 7 TOCS captured within the model are listed below:

- Virgin East Coast (VTEC)
- Grand Central (GC)
- Hull Trains (HT)
- TransPennine Express (TPE)
- Cross-Country (XC)
- Govia Thameslink (GTR)
- First Group Open Access (OA)

In order to capture demand and revenue split by TOC and ticket type an assumption is made that MOIRA's allocation between Full, Reduced and Season Tickets applies equally to all TOCs.

The flow groups used in the model are listed in the table below.

Table D2. Model Flow Groups

ID	Description	ID	Description
1	London <> Edinburgh	13	within Northeast
2	London <> North East	14	Northeast <> East of England
3	London <> Other Scotland	15	Within London & SE
4	London <> North Yorkshire	16	Yorks <> Scotland
5	London <> West Yorkshire	17	Northeast <> Scotland
6	London <> East Yorkshire	18	Within Scotland
7	London <> East of England	19	Other to Scotland
8	London <> Retford, Grantham, E Mids	20	Other within England and Wales
9	East of England <> Yorks & East Mids	21	London <> Middlesbrough
10	East of England <> Scotland	22	London <> Morpeth
11	Within Yorkshire	23	Between Newcastle and Edinburgh
12	Northeast <> Yorkshire & E Mids	24	Morpeth <> Edinburgh and Beyond

D.4 Exogenous Growth sub-model

The exogenous growth is held constant for all scenario testing, the scenarios have been tested for growth to 2020/21 and to 2037/38. The DfT's EDGE (Exogenous Demand Generation Estimation) Demand Driver Generators (DDGs) have been used to calculate an appropriate level of growth due to the external environment and modal competition as well as regulated train fare increases.

The source of data for the exogenous drivers was the December 2017 DDGs. Car availability, Population, Employment and GDP drivers are processed to sectors of interest and then aggregated by model flow. Whilst LU Fares, Bus Headway, Bus Cost, Bus Time, Car Time, Car Cost were matched to PDFH5.1 flow type.

The following formula gives the change between the base and new for each component and applies an elasticity to calculate a combined uplift. The elasticities were calculated by flow type, as recommended from the guidance in PDFH.

[redacted]

In addition to the growth drivers listed above, the exogenous growth forecast also explicitly includes the impact of Government regulated fares policy, i.e. RPI+0 to 2020 and RPI+1 thereafter. The assumption made is that all fares increase together at this rate (the impact of individual fares strategies by operator or segment are treated separately in the Fares Overlay Model). In line with Webtag guidance, PDFH 4 fares elasticities are used to assess the impact on demand.

The output from the sub-model is a growth factor, by flow group, for full, reduced and season ticket types. These factors are applied to the model flows of revenue and demand from Moira. The uplifts can if required be calculated and applied for any year from 2017 through to 2050. In the scenarios tested, years 2021 and 2038 were used, the uplifts by flow and ticket type are shown in the tables below.

Table D3: Exogenous demand and revenue growth (2016/17 to 2020/21)

		Demand				Revenue		
		Full	Reduced	Seasons		Full	Reduced	Seasons
1	London <> Edinburgh	4%	4%	3%		4%	4%	3%
2	London <> North East	5%	5%	3%		5%	5%	3%
3	London <> Other Scotland	4%	4%	2%		5%	5%	3%
4	London <> North Yorkshire	5%	5%	3%		5%	5%	3%
5	London <> West Yorkshire	5%	5%	3%		5%	5%	3%
6	London <> East Yorkshire	5%	5%	3%		5%	5%	3%
7	London <> East of England	5%	5%	3%		5%	5%	3%
8	London <> Retford, Grantham, E Mids	5%	5%	2%		5%	5%	3%
9	East of England <> Yorks & East Mids	4%	4%	5%		4%	4%	5%
10	East of England <> Scotland	4%	4%	5%		4%	4%	5%
11	Within Yorkshire	2%	2%	3%		3%	3%	3%
12	Northeast <> Yorkshire & E Mids	3%	3%	4%		3%	3%	4%
13	within Northeast	2%	2%	3%		3%	3%	3%
14	Northeast <> East of England	4%	4%	5%		4%	4%	6%
15	Within London & SE	-1%	-1%	-2%		0%	0%	-1%
16	Yorks <> Scotland	4%	4%	3%		4%	4%	3%
17	Northeast <> Scotland	2%	2%	3%		3%	3%	3%
18	Within Scotland	2%	2%	3%		3%	3%	3%
19	Other to Scotland	3%	3%	5%		3%	3%	5%
20	Other within England and Wales	3%	3%	5%		3%	3%	5%
21	London <> Middlesbrough	3%	3%	9%		3%	3%	9%
22	London <> Morpeth	4%	4%	9%		4%	4%	9%
23	Between Newcastle and Edinburgh	1%	1%	0%		2%	2%	1%
24	Morpeth <> Edinburgh and Beyond	1%	1%	1%		1%	1%	1%

Table D4: Exogenous demand and revenue growth (2016/17 to 2037/38)

		Demand				Revenue		
		Full	Reduced	Seasons		Full	Reduced	Seasons
1	London <> Edinburgh	24%	24%	7%		47%	47%	27%
2	London <> North East	26%	26%	6%		49%	49%	26%
3	London <> Other Scotland	24%	24%	5%		47%	47%	25%
4	London <> North Yorkshire	26%	26%	7%		50%	50%	27%
5	London <> West Yorkshire	25%	25%	7%		49%	49%	27%
6	London <> East Yorkshire	26%	26%	7%		49%	49%	27%
7	London <> East of England	31%	31%	7%		55%	55%	27%
8	London <> Retford, Grantham, E Mids	26%	26%	6%		50%	50%	26%
9	East of England <> Yorks & East Mids	26%	26%	15%		50%	50%	36%
10	East of England <> Scotland	26%	26%	11%		49%	49%	32%
11	Within Yorkshire	15%	15%	10%		37%	37%	30%
12	Northeast <> Yorkshire & E Mids	20%	20%	10%		42%	42%	31%
13	within Northeast	18%	18%	4%		40%	40%	24%
14	Northeast <> East of England	29%	29%	15%		53%	53%	37%
15	Within London & SE	-10%	-10%	-10%		6%	6%	7%
16	Yorks <> Scotland	28%	28%	5%		52%	52%	25%
17	Northeast <> Scotland	17%	17%	3%		39%	39%	22%
18	Within Scotland	16%	16%	2%		38%	38%	21%
19	Other to Scotland	22%	22%	14%		45%	45%	35%
20	Other within England and Wales	22%	22%	15%		45%	45%	36%
21	London <> Middlesbrough	23%	23%	21%		46%	46%	44%
22	London <> Morpeth	27%	27%	21%		50%	50%	44%
23	Between Newcastle and Edinburgh	23%	23%	10%		46%	46%	31%
24	Morpeth <> Edinburgh and Beyond	13%	13%	7%		34%	34%	27%

A sensitivity test has been undertaken, documented separately, that assesses use of a PDFH v6 rather than PDFH5.1 methodology.

D.5 Demand & Revenue Model

D.5.1 Overview

The demand and revenue model utilises inputs from MOIRA and the exogenous / background growth forecast. The purpose of the model is to calculate revenue, demand and time saving benefits representing the increment between do-minimum and do-something and for input into the Appraisal model.

The model has a 2016/17 base year and represents revenue in 2016/17 prices. Beyond the output from MOIRA and impact of exogenous growth, it captures the following demand forecasting elements:

- Air competition overlay
- New destinations overlay ('gravity' overlay)
- Fares Overlay impacts (calculated within separate Fares Overlay Model)
- Crowding suppression (impact calculated within a separate crowding model)

The sections below document the assumptions and methodology associated each of these elements, before the combined results are also summarised for the two forecast years.

D.5.2 Assumptions and Methodology

Air Competition

Section B2.8 of PDFHv5.1 recommends that specific circumstances be considered for flows where air competition is prevalent – this should be considered over and above any consideration of air competition with the exogenous forecasting framework. This is certainly the case for the ECML where there is significant competition with air competition for movements between London and Edinburgh; and also, although to a lesser extent Newcastle.

PDFHv5.1 recommends the use of a mode share S-curve to evaluate the impact to the rail and air market shares when changes are made to rail GJT.

This methodology was adopted by the Office of Rail and Road (ORR) within their study to assess track access applications for the ECML in 2016. The work that was undertaken has been summarised and published on their website[3]. Within this documentation is an assessment of the air and rail market shares for May 2014 and we have rounded these numbers to provide an estimate of today's rail and air market shares as presented in the table below.

Table D5. Air & Rail Base Market Shares for Newcastle and Edinburgh (May 2014)

	London – Edinburgh			London - Newcastle		
	Rail	Air	Total	Rail	Air	Total
Market Share	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Market Share (%)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

The first step in the air-rail competition overlay is to compare these market shares in the table above with the market shares the PDFHv5.1 implies using the S-curve and the current rail journey times to between London and Newcastle and Edinburgh. Then the journey times in each of the DM and option scenario are also considered using the PDFHv5.1 S-curve to ascertain the market share within each of these scenarios. These market shares are compared back to the base market shares to calculate a market uplift to apply to the in-scope station to station pairs within the overlay.

Table D6. Journey Time Assumptions (mins)

	London – Edinburgh	London - Newcastle
May 16	258	170
DM	252	163
DS (options 2-4)	243	157

The market share uplift is calculated as described in the example in the table below.

Table D7. London to Edinburgh DM Example (mins)

	Journey Time	Rail Market	Air Market	Total Market
May 16	[redacted]	[redacted] (a)	[redacted]	[redacted]

[3] http://orr.gov.uk/rail/access-to-the-network/track-access/east-coast-main-line

Adjusted Base Shares		[redacted] (b)	[redacted]	[redacted]
DM	[redacted]	[redacted] (c)	[redacted]	[redacted]
Adjusted DM Market Share		[redacted] (d)	[redacted]	[redacted]
PDFH Journeys Adjusted		[redacted] (e)	[redacted]	[redacted] –
% Rail Market Uplift		[redacted] (f)		

Where:

- Adjusted DM Market Share allows for total market increase due to improved service, and is calculated as:

$$b * c * ((1-a)/a + \left(\frac{256}{262}\right)^{IVT\ Elasticity}$$

  And, PDFH Journeys Adjusted is the incremental journey time change between d and b added on to the original rail market share assumption
- The rail market uplift is calculated from the change between e and the original base market share.

The market share uplifts are applied to all flows in-scope for air competition. Rail stations in the London and South East area were identified as in-scope to the London airports; as well as stations in both the North East and Scotland defined as in-scope catchments for Newcastle and Edinburgh airports.

New Destinations Overlay

The new destinations overlay uses a gravity model to assess the demand generated as a result of providing more frequent and direct connectivity with London. This is proposed within both the DM and DS option timetables at the following locations.

Table D8. Location of New Destinations on the ECML with Improved Connectivity

Scenario	Destination	Number of Direct Services to London per Weekday			TOC Service Provider
		May 2016	DM	DS	
DM	Shipley	1	6	6	VTEC
DM	Bradford	1	6	6	VTEC
DM	Harrogate	1	6	6	VTEC
DM	Lincoln	1	6	6	VTEC
DM	Horsforth	0	5	5	VTEC
DS	Morpeth	0	0	5	FGOA

The gravity model applied at these locations was developed within the ORR's track access application assessment, and it has the following form:

$$Journeys = \ Origin\ Population^{\alpha} Origin\ Wage_{LA}^{\gamma} GJT_{OD}^{\delta}$$

Where:

- Journeys is the annual trips made between the destination and London
- Origin Population is defined as the catchment population of the destination station
- Origin Wage is the average wage in the local authority area where the station is located.
- GJT is the generalised journey time between London and the destination.

The elasticity values for each of the parameters described above are presented in the table below.

Table D9. Gravity Model Elasticity Values

Elasticity	Description	Value
α	Elasticity with respect to population	0.4525
γ	Elasticity with respect to mean local authority wage of origin station	1.8168
δ	Elasticity with respect to GJT between origin and London	-2.3487

More information of the form of this model, including the derivation of the parameter values can be found within the published ORR documentation.

The origin population and wage assumptions for each of the new destinations is presented in the table below. These have been extracted from the ORR analysis and we note that they likely represent an earlier position than our 2015/16 base position, however the impact of this in the modelling results will be minimal. These parameters have been used within the gravity model equation to calculate the uplifts to passenger demand between London and the designated new destination, these uplifts are also presented in the table below.

Table D10. Gravity Model Parameter Assumptions & Resulting Uplifts

Destination	Population	Wage	GJT Base	GJT Test	Uplift Factor
Middlesbrough	773,711	19,631	289	211	2.356
Morpeth	886,202	24,685	287	242	2.439
Shipley	427,218	22,822	231	186	1.661
Bradford	394,145	22,822	232	207	1.297
Harrogate	935,022	27,639	241	214	1.603
Lincoln	147,177	22,823	195	150	1.859
Horsforth	21,332	25,274	240	197	1.585

The passenger demand uplifts derived by the gravity model are applied within the DRM to any flows between Greater London stations and the specific destination. The uplifts are assumed to represent an upper bound to the level of demand growth for that destination, and therefore the incremental demand impact is calculated and only added on where this incremental demand has not been exceeded by the MOIRA1 modelling and any of the previous overlays. Applying the uplift in this way also ensures that no double counting has taken place in growth for FGOA destinations on the ECML due to the derivation of the fares competition uplifts factors. All uplifts indicated as having an impact to DM demand are also applied within the DS along with the incremental impact of any DS uplifts.

The gravity analysis within the ORR track access study also indicated where significant proportions of the generated passenger demand would be abstracted from other nearby stations. This is the case at Morpeth where it is estimated that 10% of the demand generated would be extracted from Newcastle.

Where the gravity overlay identifies incremental positive demand to add on to the new destinations this is added to the TOC that provides the level of service increment, whereas when the gravity overlay calculations identify a reduction in demand at stations where abstraction occurs, this is applied pro-rated to the TOCs that contribute passenger demand and revenue.

Fares Competition

The proposed First Group open access (FGOA) services are predicated on the assumption that they provide a low cost service between the North East (generally non-stop) and Edinburgh offering cheap fares bought in advance of travel, that will compete primarily with the air and coach markets, but also with the other TOCs in operation on the ECML.

A stand-alone Fares Overlay model has been developed to assess the demand and revenue impact of new off-peak low fares introduced by the FGOA operation and an assumed competitive response from the East Coast franchise operator.

The details of this model are documented in the relevant section below.

Crowding

Demand growth generated from MOIRA and from the exogenous growth drivers produces an unconstrained demand forecast. A crowding model has been developed to generate demand suppression factors based on timetable and capacity scenarios.

The Crowding Model itself is documented separately in the relevant section of this appendix below.

The Crowding Model has a two-way interface with the Demand and Revenue Model, receiving unconstrained growth for a given scenario and then passing back suppression factors. These suppression factors are forecast consistently for both do-minimum and do-something scenarios. Suppression factors added to the DRM are relative to the level of existing crowding in the base year. This means that the factor may be below 1 (indicating demand lost due to crowding) or above 1 (indicating the release of supressed demand in the base).

Given the nature of options 2-4, where timetable differences only relate to minor variation in journey time and capacity supply is unchanged, the crowding model has only been run once (separately for each of the two forecast years) and suppression factors are used equally for options 2, 3 and 4.

In order to avoid double counting the impact of allocation between operators, the train loading output from MOIRA used as an input to the crowding model is derived from a MOIRA run with Fixed Market Share. Instead, changes in market share between operator are derived within the unconstrained growth forecast.

D.5.3 Demand & Revenue Model Results

The tables below summarise the output from the Demand and Revenue Model, showing disaggregation by forecast element, output for each forecast year, and for both do-something option 2 and 3. Option 4 results are not shown, as variation from option 3 is only minor (the predominant differences between these options is cost and performance impacts, and these are captured directly within the Appraisal Model).

D.6 Crowding Model

D.6.1 Introduction

The Crowding Model developed for the ECML FBC forecasts the demand suppression levels to constrain demand to the capacity levels provided by the timetable and its rolling stock allocation for each Revenue Model flow group and TOC for the two forecast years (2020/21 and 2037/38).

The model operates at station level, using demand growth from the Revenue Model flows to forecast loads on each station to station section. The train loads at station level, both unconstrained and constrained, are then aggregated back to Revenue Model flows to calculate the forecasted suppression on the Revenue Model flows.

The level of demand suppression is impacted by changes in:

- Generalised Journey Time (GJT) through timetable changes
- Capacity (rolling stock allocation)
- Demand

D.6.2 Crowding Model Scope

The model calculates suppression factors for weekday standard class demand only; it is assumed that first class and weekend standard class crowding is insignificant.

The model simply calculates the level of demand suppression on a given train. The model does not have the functionality to re-allocate suppressed demand on to adjacent, less crowded services.

Whist the Crowding Model can handle any number of TOCs, it has only been actively used within options 2-4 to model crowding on Virgin Trains East Coast (VTEC) as this TOC is where crowding is heaviest and where there is a material difference in service pattern and capacity in the Do-Minimum (DM) and the Do-Something (DS). The other TOCs using the ECML were excluded on the following grounds:

- **Grand Central** – no change in capacity between DM and DS (although DS has faster journey times). Additionally, this TOC is heavily yield-managed and serves predominantly the discretionary long-distance market.
- **Hull Trains** – no change in capacity or service pattern between DM and DS
- **TransPennine Express** – no change in capacity or service pattern between DM and DS
- **Cross Country** – no significant change to train service between DM and DS; train capacity is identical
- **First Group Open Access –** heavily yield-managed and serves predominantly the discretionary long-distance market.
- **Thameslink, Southern and Great Northern (TSGN) -** no change in capacity or service pattern between DM and DS

D.6.3 Crowding Model Methodology

The model methodology is summarised as follows:

1. Base year (2016/17) loadings are taken from MOIRA1 (Northern version) which provides loadings on each station to station link for every train operated by a given TOC according a given timetable in the base year.
2. The base year loadings are capacity-constrained and therefore it is necessary to undertake a de-constraining calculation to ascertain the level of suppression in the base year and hence the level of unconstrained demand. This essentially involves running the constraining process (see below) in reverse.

3. Growth factors between the base year and forecast year are calculated from the Revenue Model demand input and are applied to the unconstrained base year loadings to produce future year unconstrained loadings.
4. The crowding impact is applied as follows:
    a. Seating and standing penalties are calculated according to PDFH methodology based on the load on the link and seating capacity and standing space of the rolling stock used on the train service. Penalties are derived from Table B6.2 in PDFH v5.1.
    b. A crowding factor is calculated as a demand-weighted average of the seated and standing crowding penalties for the level of crowding on the link as per PDFH guidance:

[redacted]

    c. A standard elasticity approach is then applied to the ratio of the two GJTs to calculate a demand suppression factor, and hence a constrained train loading, as per PDFH guidance:

[redacted]

    d. The process then iterates by feeding the crowded GJT back into same process as above in place of the uncrowded GJT and repeating this process successively until convergence is achieved. In total 10 iterations were performed (this number was determined after testing which showed convergence is achieved within this limit).
    e. The crowded minutes are also calculated for each station link as follows:
        i. *Crowded seated minutes = (demand-weighted average seating penalty – 1) * seated demand * IVT*
        ii. *Crowded standing minutes = (demand-weighted average standing penalty – 1) * standing demand * IVT*
        iii. *Total crowded minutes = Crowded seated minutes + Crowded standing minutes*
5. The above process produces suppression factors and crowded minutes at the individual station link level for each train. These are then aggregated across all links and trains and mapped to provide a % suppression factor and crowded minutes for each Revenue Model flow. A annualization factor of 300 is applied to the crowded minutes to give the annual crowded minutes.

The methodology above is represented diagrammatically in the figure below.

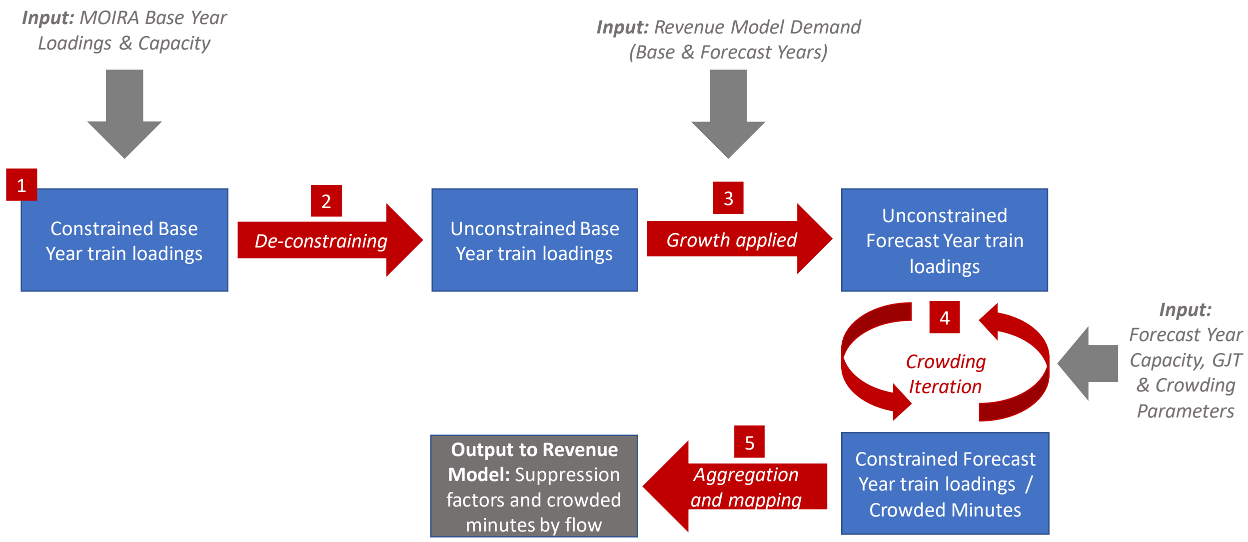


Figure D2: Crowding Model Methodology (numbers correspond to numbering in methodology description above)

D.6.4 Model Inputs and Assumptions

The key inputs and associated assumptions used in the Crowding Model:

- Timetable inputs
- Semi-constrained demand forecasts
- GJT inputs

These are discussed in more detail below:

Timetable inputs

1. The 'Loads by TOC' report is extracted from the MOIRA Timetable Manager which gives loadings data and IVT for each station-to-station pair for all weekday trains for a specific timetable.
2. According to the rolling stock type, the seating capacity and standing area are appended to the data.
3. This data is pasted into the Crowding Model via a macro.

The rolling stock assumptions applied in the model for the different timetable scenarios are shown in below.

Table D13. Rolling Stock and Capacity Assumptions

TOC	Scenario	Stock Type	Standard Class Seating	Standard Class Standing Space (m^2)	Number of trains	Total Standard Class Seats
VTEC	Base	ELH125	398	120	156	**62,088**
	DM	9/10-car IEP	513	123	158	**81,054**
	DS – Option 2	9/10-car IEP	513	123	170	87,210
		5-car IEP	258	64	22	5,676
					Total	**92,886**

	DS – Option 3	9/10-car IEP	513	123	170	87,210
		5-car IEP	258	64	22	5,676
					Total	**92,886**

Semi-constrained demand forecasts

1. Base (2016/17) and forecast year (2020/21 and 2037/38) demand disaggregated by Revenue Model flow, ticket type (Full, Reduced and Seasons) and TOC are provided from the Revenue Model
2. First Class demand is removed according to the proportions of first class demand by ticket type and flow
3. Total all-week standard class demand by Revenue Model flow and TOC is determined by aggregating the three ticket types.
4. Total weekday only standard class demand is calculated by applying a weekday factor of 0.85 (from MOIRA).
5. This demand in the base and the two forecast years is pasted into the Crowding Model via a macro.

GJT inputs

1. The crowding penalty is applied only to the IVT element of the GJT i.e. excluding the wait time element. However, the demand suppression calculation (see 4c above) uses the total GJT. The difference i.e. GJT – IVT therefore needs to be calculated and applied in the model.
2. Using the Data Inspector report in MOIRA1, GJT and IVT by station-to-station pair and ticket type are extracted for a given timetable.
3. The demand-weighted average GJT and IVT are aggregated to Revenue Model flow and the ‘GJT addition’ calculated as Avg(GJT) – Avg(IVT) and then pasted into the Crowding Model via a macro.

D.6.5 Model Outputs

The following outputs are generated from the Crowding Model for each scenario tested and for the two forecast years (2020/21 and 2037/38):

- **Demand suppression factors** by Revenue Model flow which are fed into the Revenue Model
- **Annual crowded minutes** by Revenue Model flow and by distance band (0-50km/50-100km/100-200km/200+km) which are fed into the Appraisal Model

Summary of Crowding Levels

Base

In the base in 2016/17, the number of daily boarders is [redacted], resulting in an average all-day average load of [redacted]). The figure below shows the proportion of trains according to their maximum load factor. 37% of trains have a maximum load factor of under 60% (the point at which crowding penalties begin to apply) whilst 23% have a maximum load factor of 100% or more.

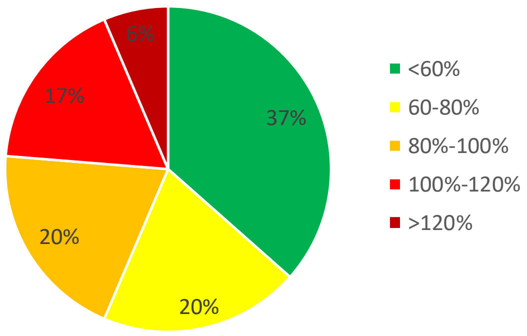


Figure *D3*: Proportion of Trains by Maximum Load Factor – Base (2016/17)

DM

In the DM in 2037/38, the number of daily boarders is [redacted] (based on constrained demand), resulting in an average all-day average load of [redacted]). The figure below shows the proportion of trains according to their maximum load factor. 36% of trains have a maximum load factor of under 60% (the point at which crowding penalties begin to apply) whilst 27% have a maximum load factor of 100% or more.

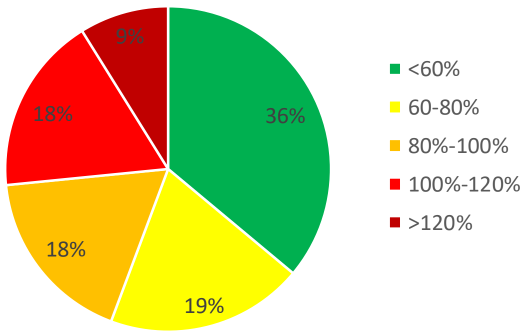


Figure D*4*: Proportion of Trains by Maximum Load Factor – DM (2037/38)

DS – Options 2-4

In the DS Option 2 in 2037/38, the number of daily boarders is [redacted](based on constrained demand), resulting in an average all-day average load of [redacted]). Figure shows the proportion of trains according to their maximum load factor. 46% of trains have a maximum load factor of under 60% (the point at which crowding penalties begin to apply) whilst 17% have a maximum load factor of 100% or more.

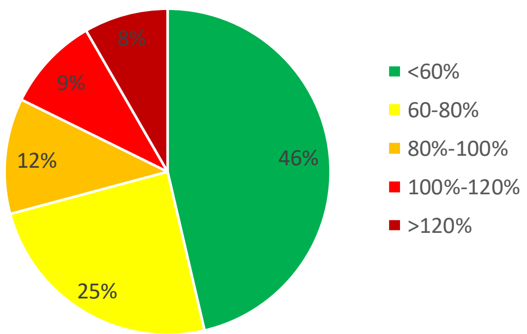


Figure D*5*: Proportion of Trains by Maximum Load Factor – DS Option 2-4 (2037/38)

Summary of Results

[redacted]

Table D14. Suppression Factors by Scenario, 2037/8

[redacted]

[redacted]

Table D15. Annual Crowded Minutes by Scenario, 2037/38

[redacted]

D.7 Fares Overlay Model

D.7.1 Background

The three core modelled options involve the introduction of a new Open Access (OA) operator, namely the First Group offering which provides a low-cost alternative between selected conurbations along the ECML as far as Edinburgh in the north, and London in the south.

Within the wider modelling suite, neither the demand and revenue model (DRM) nor MOIRA has the capability to robustly derive the impact of a fare differential between competing operators.

Therefore a bespoke fares overlay model was designed to answer two questions:

1. To understand the abstractive demand and revenue impact of a fares[4] differential between a new OA service and existing train operators.
2. To understand the demand and revenue impact on the rail market of the introduction of a new OA service when in competition with the air market.

This section discusses the inputs to the model, the methodology employed, and the outputs to the wider modelling suite.

D.7.2 Inputs

This section presents the details and the source of the inputs to the model, categorised as:

- Flow groups
- Demand and revenue inputs
- Fares
- Values of time, journey purposes and elasticities

[4] Only advance fares are considered for the differential.

- Air market

Flow groups

The demand response to a fares differential is clearly not homogenous, and therefore the rail market needs to be segmented at an appropriate level to reflect the nuanced decisions passengers are likely to make.

Flow groups utilised in the DRM were transferred into the fares model. However, the DRM had a wider remit than the fares model, and as such separate filters were applied to the flow groups to capture:

- Flows for which the First Group Open Access (FGOA) service would compete with existing operators on advance fares; and
- Flows for which the rail market would compete with the air market.

It is worth noting that the FGOA service is assumed to call at: London King's Cross, Stevenage (selected trains only), Newcastle, Morpeth and Edinburgh.

For air competition, flights between Edinburgh/Newcastle, and all London airports were considered.

Demand and revenue inputs

Demand and revenue inputs were taken directly from the DRM for rail.

Demand data for air was sourced from data publicly available on the Civil Aviation Authority (CAA) website. Data for 2016/17 was used.

Fares

Initial fares for each option are derived from the DRM inputs, dividing revenue by demand to obtain an average yield.

The following adjustment is applied to Reduced fare tickets to reflect the impact of expected pricing policy

Open Access services (First Group)	[redacted]
East Coast franchise competitive response	[redacted]

Air fares were sourced from airline websites.

Values of time, journey purposes and elasticities

Values of time

Values of time are taken directly from WebTAG. These are show in the table below.

Table D17 – Values of Time

Journey Purpose	0-50km	50-100km	100-200kr	200km+
Business	£10.28	£16.61	£28.94	£41.74
Commuting	£12.14	£12.14	£12.14	£12.14
Other	£5.54	£5.54	£5.54	£5.54

Journey purpose splits

Journey purpose splits are taken from PDFH 5.1, shown below.

Table 16 – Journey Purpose Splits

[redacted]

Elasticities and spread parameters

Fare elasticities were taken from PDFH, shown below.

Table D18 – Fare Elasticities

[redacted]

A logit spread parameter of 0.04 was used for the rail competition. A calibration exercise for the air/rail market was inconclusive, and so a spread parameter of 0.04 was used here also.

Air market

Demand and fares data are discussed above. To complete the rest of the generalised cost information, the following inputs were sourced/assumed.

Table 19 - Air market inputs

Input	Source
Flight time	Sourced from airline websites
Headway	Derived from CAA data – number of flights/day to/from London
Wait time	60 minute wait time assumed
Access/egress	45 minutes assumed at non-London end; 75 minutes assumed at London end
Car parking	Sourced from airport websites

No weightings were applied to the inputs above.

D.7.3 Methodology

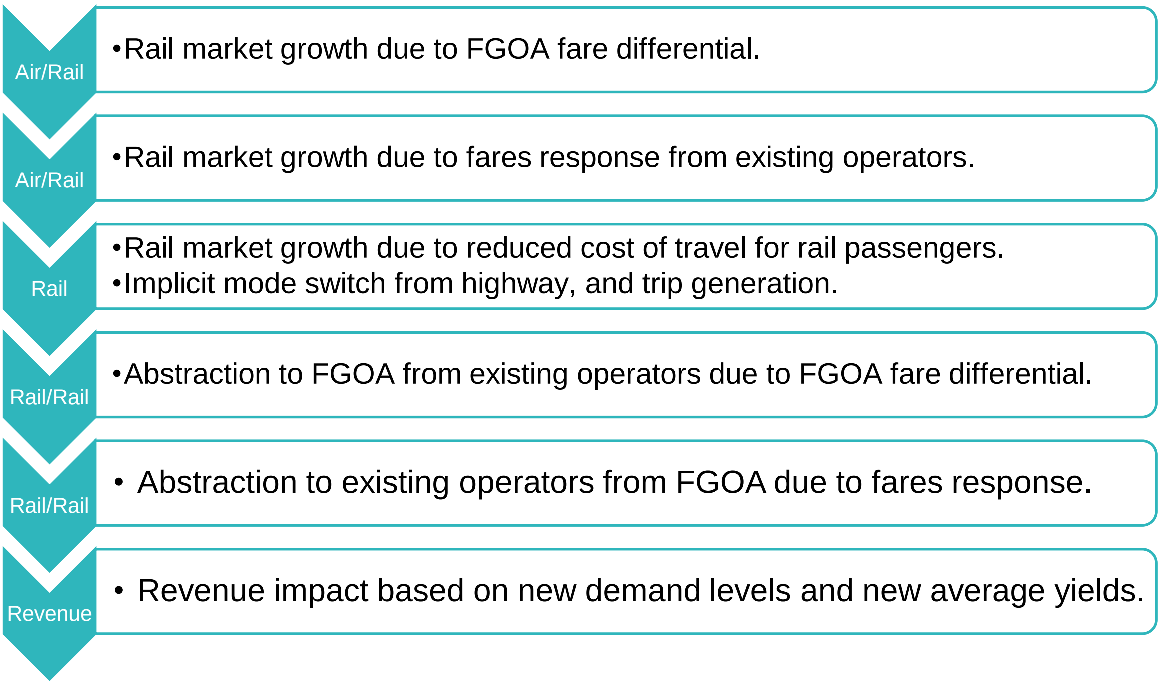
The fares overlay model utilises a double pivot approach:

- The first pivot considers the fare differential between the new average FGOA fare, and the average fare on existing TOCs.
- The second pivot considers the fare differential between an adjusted fare (fares response) on existing TOCs, and the original fare on existing TOCs.

In practice, these two events would occur (almost) simultaneously. However, for the purposes of this exercise, we separated them to enable interrogation of distinct demand/revenue responses.

The two pivots described above are also separately applied to the air competition model.

The process is linear and can be summarised by the diagram below.



Air/rail competition

As rail travel becomes cheaper, it is reasonable to assume that some abstraction from the air market will occur. Rail movements in competition with Edinburgh/Newcastle to/from London airports were identified and an uplift was derived. This uplift was derived based upon the change in generalised cost before/after a fares change is implemented.

The inputs from the DRM attribute passengers to FGOA and existing operators due to choices made purely based upon generalised journey time (i.e., excluding fares). The uplift due to the FGOA fares differential is only applied to FGOA demand, and the uplift due to the fares response is only applied to demand for existing operators.

A logit function is applied as shown below.

$$MS_{nr} = \frac{MS_{or}.e^{-\lambda(GC_{nr}-GC_{or})}}{MS_{or}.e^{-\lambda(GC_{nr}-GC_{or})} + MS_{oa}.e^{-\lambda(GC_{na}-GC_{oa})}}$$

Where:

MS_{nr} = New rail mode share

MS_{or} = Original rail mode share

MS_{oa} = Original air mode share

CG_{nr} = New rail generalised cost

CG_{or} = Original rail generalised cost

CG_{na} = New air generalised cost

CG_{oa} = Original air generalised cost

λ = Logit spread parameter

Rail market growth

As rail travel becomes cheaper, it is assumed that demand will increase. There is an implicit mix of trip generation – people who would not previously have travelled by any mode – and abstraction from other modes. Note that abstraction from air is expected to be significant in this case, and it was therefore deemed reasonable to consider a distinct demand response to reflect this.

Rail market growth is calculated using an elasticity with respect to the proportional change in rail fares, as shown below.

$$D_n = D_o . \left(\frac{F_n}{F_0}\right)^{\beta}$$

Where:

D_n = New demand

D_o = Original demand

F_n = New fare

F_o = Original fare

β = Fare elasticity

Rail abstraction

Abstraction to the FGOA service is calculated using the formula below. The terms in the formula can be reversed to calculate the abstraction back to existing operators. The formulation takes the relevant parts of a standard logit equation.

$$MS_{OAn} = \frac{1}{1 + e^{-\lambda(\Delta GC_{OA} - CG_{EO})} . \left(\frac{1}{MS_{OAo}} - 1\right)}$$

Where:

MS_{OAn} = New Open Access market share

MS_{OAo} = Original Open Access market share

GC_{OA} = Open Access generalised cost

GC_{OA} = Existing operators (average) generalised cost

λ = Logit spread parameter

The demand response in totality is calculated by applying the three steps above multiplicatively. Note that the model contains the functionality to switch various parts on and off to isolate each of these steps.

Revenue

The new revenue is calculated by multiplying the new demand by a new average yield.

D.7.4 Outputs

Outputs are presented as uplift factors to be multiplied to input demand, such that output demand may be passed back into the wider modelling suite.

The impact of the Fares Overlay Model on demand and revenue for each of the option is shown within the summary results in section A.5.3 of this Appendix.

D.8 Infrastructure (capex) costs

Assumptions were provided by the Department for the total anticipated cost of the infrastructure projects required to deliver each option considered by the Appraisal. See Appraisal Model, section A.11 below and the main report for full details including treatment of contingency, optimism bias and renewals.

D.9 Performance Impacts

The impact of the business case options on train performance has been assessed on an emerging basis as details of the schemes and requirements for the business case have been developed. As such a Performance Model has not been developed per se, but rather bespoke analysis has been completed where necessary.

The only scheme judged to have a material impact on performance is the Huntingdon-Woodwalton 4-tracking scheme that distinguishes option 4 from options 2 and 3.

The basis for assessing the performance benefit (i.e. reduction in average minutes lateness) is documented in a separate Appendix of this report.

Two variant scenarios have been determined, giving a central and high case forecast of reduced average minutes lateness associated with the scheme.

A PDFH v5.1 methodology has been followed to convert the following AML savings into a demand and revenue impact for both GTR and East Coast franchise services traveling to London via Huntingdon:

- Central case: 4.3 seconds
- High case: 12.4 seconds

This performance benefit is only associated with up direct train services (to London only).

A simple model using the following further assumptions and a demand and revenue base segmented by journey purpose and distance band is used to convert this performance impact into incremental revenue, demand and time savings that are then passed directly to the Appraisal model.

- Lateness multiplier: 3 (business and leisure) and 2.5 (commuter)
- A GJT elasticity of -1.35 (50-200+km flows) and -1.25 (0-50km flows)
- An impacted demand base representing 29-34m annual journeys and £509m – £712m annual revenue
- Average GJTs (sourced from MOIRA) as per the table below.

Table D20: Average GJT by distance band and journey purpose for market impacted by performance benefit

	Business	Commuter	Leisure
200+km	293.7	282.0	288.0
100-200km	89.9	91.3	87.8
50-100km	72.3	72.5	71.5
0-50km	43.8	43.4	43.7

Output from this analysis determines an annual time saving, demand and revenue impact for each of two forecast years (see results shown in the table below).

Table D21: Impact of the Woodwalton Scheme

	Central		High	
	2020/21	**2037/38**	**2020/21**	**2037/38**
Revenue	[redacted]	[redacted]	[redacted]	[redacted]
Demand	[redacted]	[redacted]	[redacted]	[redacted]

Annual demand (journeys) and revenue (£, 2016-17 prices) benefit from performance improvement associated with Huntingdon-Woodwalton 4-tracking scheme

D.10 Operating Costs

The incremental cost has been assessed for each option. This was undertaken by estimating the additional resource requirement and applying this to unit rates for the relevant cost components. Costs included in this assessment are listed below, inclusive of the data source:

- Train Crew. The source is:
  - ASLEF website for driver salaries.
  - Known uplift factors for driver pensions, overtime, etc.
  - Known salary differentials for other train crew.
- Rolling Stock procurement and maintenance. The source is:
  - Data provided by DfT. VTEC class 800 (IEP) costs are currently based on data for Trans Pennine Franchise class 800 stock. This is because the IEP cost information was provided too late to be included in the assessment. We have briefly reviewed the IEP data and believe the costs per vehicle are comparable, [redacted]
- Mileage based costs (diesel fuel, EC4T, Variable Track Access Charges). The source is:
  - Network Rail CP5 Price lists
  - Known values such as diesel fuel prices
- Capacity Charge. The source is:
  - Network Rail CP5 Price lists

The Capacity Charge is designed to reflect the cost to the rail industry of a loss of passenger revenue caused by a performance degradation when additional services operate on the network. Although the performance impact of the options has not been assessed in detail or quantified, including the Capacity Charge in the appraisal can be viewed as a proxy for this impact.

The table below shows our incremental resource estimates for Options 2-4

Table D22. Option 2-4 annual resource estimates

Operator	Rolling Stock	Trains	Train Miles (Daily)	Diesel Miles	Electric Miles	Drivers	Conductors
FGOA	Class 800 5-car	5	[redacted]	0%	100%	[redacted]	[redacted]
VTEC	Class 800 9 or 10-car	6*	[redacted]	0%	100%	[redacted]	[redacted]

* IEP procurement costs are treated as a sunk cost in this option for appraisal purposes

D.11 Appraisal Model

Calculating Transport Benefits and Revenues

Transport benefits and revenues for the appraisal options have been estimated using a demand and revenue model suite incorporating use of MOIRA1.

Forecasts of changes in travel costs (GJT) and demand with the introduction of the scheme are used to calculate Rule of a Half benefits at an Origin-Destination level within the model. These are aggregated to give total benefits (in terms of minutes saved) for four distance bands (0-50km, 50-100km, 100-200km and 200km+). MOIRA1 does not provide a disaggregation of benefits by component of GJT, so a single GJT saving (in minutes) is therefore used and applies MOIRA1 model weights for the different components of this GJT. This is supplemented by an assessment of crowded minutes, which are used to identify crowding impacts in the appraisal.

For select movements there is a change in fares available between DM and DS. The introduction of an Open Access operator provides a new choice for passengers between London and the North East and Scotland to trade off journey time against fares. For these movements a fare saving has been calculated using the rule of a half.

The appraisal model takes the outputs from the demand model and calculates a profile of benefits over time by:

- Applying WebTAG values of time to the minutes saved. Business values of time are applied using the four distance bands;
- Applying growth in values of time in line with WebTAG;
- Using change in rail passenger km to estimate the reduction in highway km. A diversion factor of 26% is applied[5];
- Marginal External Costs of Car travel from WebTAG are then used to convert the reduction in highway trips into benefits for road congestion and environmental impacts. Given the spread of impacts across the country, MECCs for the Great Britain are used;
- All of these benefits are extrapolated over time based on the growth in benefits between modelled year (based on a linear extrapolation);
- Demand growth is capped at 2037 in line with WebTAG.

These benefits are then discounted to give Present Value benefits and revenues over a 60-year appraisal period.

Revenue data is also provided by the demand model, split into six TOCs (VTEC, Open Access, TPE, TSGN, Cross County and other TOCs). Underlying fares are assumed to grow in nominal terms at RPI+0% per year until 2022/3, after which they are assumed to increase by RPI+1% until the cap year in 2036. It is assumed that all changes in revenue (other than those of open access operators) ultimately accrue to Government in the form of changes in subsidy/premium payments.

Calculating Costs

The appraisal model estimates the costs of the scheme over the 60 year appraisal period using inputs from a bespoke operating cost model and infrastructure cost estimates. Annual operating costs are provided, which are then:

- Converted into a consistent 2010/11 price base and values;
- Have inflation assumptions applied based on guidance in WebTAG A5-3, specifically:
  - Staff costs are assumed to grow in nominal terms by Average Weekly Earnings throughout the 60 year appraisal period;

[5] More detailed diversion factors (broken down by PDFH flow type) are available, but have not applied as there are multiple positive and negative impacts on different flow categories.

- Rolling Stock lease costs are assumed to be fixed in nominal terms (falling in real terms) for the life of the rolling stock. When rolling stock is renewed the assumed cost increases in line with RPI (to the cap year) and then the GDP deflator;
- Other costs are assumed to grow in nominal terms by RPI until the cap year, at which point they grow by the GDP Deflator.

- The costs are then deflated by the GDP deflator to give 2010/11 prices.

For the core options it is assumed that IEP rolling stock represent a sunk cost given the stage of procurement. For these options it is assumed that there is no cost for this rolling stock until it is renewed (assumed to be in 2056). At this point an estimate of the full cost of the IEP rolling stock is included in the appraisal. This cost is represented as an on-going lease cost.

Optimism bias is added to these cost estimates. The values selected depend on the certainty of operating costs, and the quality of underlying data used to estimate them. The table below sets out the assumptions used.

Table D23: Optimism Bias Assumptions in Operating Costs

Cost Category	OB Assumption	Justification
Staff Costs	2%	Robust cost data available, with a clear understanding of the staffing requirements for the scheme. An assumption of GRIP 2 is applied
Rolling Stock lease costs	1%	Rolling stock is well understood and is assumed to be equivalent to GRIP 3
Rolling stock maintenance and stabling	1%	See rolling stock lease costs
VTAC	1%	VTAC rates and ranges are clear. Assumed to be equivalent to GRIP 3
Capacity Charge	1%	Capacity charges are well set out. Assumed to be equivalent to GRIP 3
Electricity Costs	1%	Fuel consumption rates relatively well understood. Assumed to be equivalent to GRIP 3
Diesel Costs	1%	Fuel consumption rates relatively well understood. Assumed to be equivalent to GRIP 3

Cost estimates are again broken down by TOC, with VTEC and Open Access operators being relevant for these tests. In line with the revenue assumptions, it is assumed all costs (except for the open access operators) feed through to Government through increases in subsidy/premium payments.

Data on the operational mileage and fuel consumption of the additional services is used to calculate change in rail fuel consumption, and the consequent impacts on indirect tax and Greenhouse Gas emissions in the appraisal.

Infrastructure costs for the projects involved in the ECML Enhancements have been provided by DfT. These have been applied in the appraisal by:

- Removing cost of works to date (treated as a sunk cost);
- Assuming costs are incurred over a two or three year construction period (depending on opening date and size of scheme). It has been assumed that the opening year for each project remain as with the OBC, with the distribution of costs adjusted to reflect this;
- Applying optimism bias in line with the GRIP stage;

Renewal costs are added for some schemes, depending on the nature of the investment. Where a scheme largely constitutes civils assets and/or or permanent structures we have assumed that the asset life will be at least as long as the appraisal period and have applied zero renewals costs. Where a scheme largely constitutes track and/or signalling assets we have assumed that a renewal equivalent to the full cost of the scheme will be required in the period between 2047/8 and 2050/1, inclusive. This approach is a simplification in the absence of a cost breakdown by asset type. This simplification is unlikely to affect the economic case and costs applied over 30 years into the future are heavily discounted in the appraisal.

Table D24: Infrastructure Cost Assumptions

Package	Infrastructure enhancement	Incremental Do-Something cost (£m)	Optimism Bias	Construction Period and Opening Year	Renewal Cost
Southern	London King's Cross Remodelling.	[redacted]	4%	2017/18-2019/20	Full cost after 30 years
	Huntingdon – Woodwalton four tracking.	[redacted]	18%	Mid 2017/18-Mid 2020/21	Full cost after 30 years
	Peterborough Down Slow.	[redacted]	4%	2017/18-2018/19	Full cost after 30 years
	Werrington Grade Separation.	[redacted]	4%	Mid 2017/18-Mid 2020/21	No renewal cost assumed
	Doncaster Station Enhancements.	[redacted]	0%		No renewal cost assumed
Northern	York North Station Throat enhancement.	[redacted]	64%	Mid 2017/18-Mid 2019/20	Full cost after 30 years
	Northallerton - Newcastle Freight Loops.	[redacted]	18%	2017/18-2018/19	Full cost after 30 years
Whole route	IEP Enabling Works	[redacted]	6%	2018/19	Full cost after 30 years
	Power Supply Upgrade 2 (PSU2)	[redacted]	18%	2018/19-2020/21	No renewal cost assumed

D.12 Sensitivity Tests

The following sensitivity tests have been undertaken, results of which are presented in the main report. All sensitivity tests pivot from option 3.

D.12.1 Alternative 2026 demand cap year

In line with WebTAG, as sensitivity test has been undertaken where the cap in demand growth is adjusted to reflect a lower bound of 10 years' growth in rail demand.

D.12.2 Alternative 2046 demand cap year

In line with WebTAG, as sensitivity test has been undertaken where the cap in demand growth is adjusted to reflect an upper bound of 30 years' growth in rail demand.

D.12.3 Alternative demand growth (high)

In line with WebTAG, a test was conducted which assumes the underlying growth in revenue and benefits is + 25% to reflect uncertainty in demand growth in the future.

D.12.4 Alternative demand growth (low)

In line with WebTAG, a test was conducted which assumes the underlying growth in revenue and benefits is - 25% to reflect uncertainty in demand growth in the future.

D.12.5 Alternative value of time assumption (high)

In line with WebTAG, a sensitivity test has been applied to the value of time used in the appraisal. The value used is +25% for business and commuting values of time and +60% for other values of time.

D.12.6 Alternative value of time assumption (low)

In line with WebTAG, a sensitivity test has been applied to the value of time used in the appraisal. The value used is -25% for business and commuting values of time and -60% for other values of time.

D.12.7 Background growth based on PDFH v6

PDFH v6 rather than PDFH v5.1 parameters are used to forecast background (exogenous) demand growth.

D.12.8 Alternative IEP rolling stock cost treatment (no sunk costs)

This test assumes that the costs of the new IEP fleet (which are assumed to be sunk costs and therefore excluded in the Central Do-Something) are included in the appraisal cost inputs.

D.12.9 With HS2 phase 2b in 2033

Operation of HS2 phase 2b from 2033 will have a significant impact on travel patterns and timetabled train services on the East Coast mainline. This will have a material impact on costs and benefits in the business case, albeit part-way through the appraisal and therefore subject to significant discounting.

The interaction of East Coast services with HS2 cannot be modelled in MOIRA and therefore an alternative methodology is required to assess this sensitivity test.

In summary the following two impacts have been captured within the Demand and Revenue model:

- An output from HS2 Ltd’s PLANET Framework Model (PFM) has been used to scale demand on East Coast franchise flows.
- Based on specification of a ‘released capacity’ timetable with assumed additional East Coast franchise train services, additional demand and revenue benefits of utilising spare capacity following operation of HS2 have been modelled.

It is assumed that the First Group Open Access service ceases to operate upon commencement of HS2 phase 2b in 2033.

PLANET Overlay

The PLANET overlay reduces passenger demand and revenue on the ECML in line with expectations of demand abstraction due to the introduction of HS2 services. This overlay has been derived from HS2 Ltd’s PLANET Framework Model (PFM v7.1) – the primary tool used by HS2 Ltd to assess the impact of ridership on the proposed HS2 services.

Data extraction from the PLANET Long Distance (PLD) model was carried out within its DM – without HS2 – and Phase 2b – with HS2 Y-network – scenarios to evaluate the level of ridership on the ECML in these two scenarios for the 2037/38 year. Comparison of these estimates was carried out to produce a factor for certain station to station pairs, in order to reduce future year demand on the ECML in 2037/38. These factors are presented in the table below.

Table D25. PLANET Derived Forecast Adjustments for 2037/38 ECML Passenger Demand & Revenue

Origin Station	Destination Station	Adjustment Factor		
		Business	Leisure	Commute
Edinburgh	Total London	2%	2%	2%
Leeds	Total London	0%	0%	0%
Total London	Wakefield BR	0%	0%	0%
Newcastle	Total London	5%	5%	6%
Harrogate	Total London	0%	0%	0%
Bradford Yks BR	Total London	0%	0%	0%
Total London	York	6%	6%	8%
Durham	Total London	31%	30%	34%
Northallerton	Total London	47%	43%	51%
Huddersfield	Total London	0%	0%	0%
Stirling	Total London	0%	0%	0%
Dundee	Total London	0%	0%	0%
Darlington	Total London	19%	18%	21%
Morpeth	Total London	0%	0%	0%
Hull	Total London	21%	20%	23%
Doncaster	Total London	49%	53%	54%
Newark N Gate	Total London	71%	63%	72%

The factors represent the reduction in demand due both the introduction of the competing HS2 services, and the reduction in the level of service assumed on the ECML to accommodate the HS2 service paths.

Benefits from Released Capacity

The adjustment to demand and revenue from the PLANET model assumes a standard 'do-minimum' timetable for ECML services post-HS2 phase 2b. This is understood to utilise the 6 LDHS paths as follows:

- Leeds (or Skipton/Harrogate); via Peterborough, Doncaster, Wakefield
- Edinburgh; via Peterborough, Doncaster, York, Darlington, Durham, Newcastle, Berwick
- Lincoln, via Stevenage, Grantham, Newark
- Middlesbrough; via Peterborough, Grantham, Newark, Doncaster, York, Northallerton
- Hull; via Stevenage, Grantham, Newark, Retford, Doncaster
- Open Access; broadly as today

Assumptions have been developed for how the two additional paths available with the ECML enhancement programme could be operated. This has been determined as:

- York, via Peterborough and Doncaster
- Nottingham, via Grantham and Nottingham

The benefit of this released capacity has been assessed in MOIRA, by testing this additional 2tph incrementally against the pre-HS2 option timetable. This simplification is required, as neither HS2 nor the post-HS2 do-minimum timetable are available coded in MOIRA.

Demand and Revenue Results (2037/38 with HS2 scenario)

The two impacts (PLANET overlay and benefits from released capacity) are combined in a version of the Demand and Revenue model for 2037/38.

A summary of the business case 2037/38 future year revenue, bridging between Option 2 and the with-HS2 sensitivity test is shown in the table below.

Table D26. Annual revenue £m 2016/17 prices following HS2 Phase 2B introduction

[redacted]

Impact of HS2 sensitivity test on 2037/38 business case revenue (£k, 2016-17 prices); step 1 captures the PFM Model overlay and step 2 the benefit from released capacity

Cost Inputs to the Appraisal (HS2 sensitivity test)

In addition to the amended demand and revenue outputs, the appraisal of the with-HS2 sensitivity test includes adjusted cost inputs.

FGOA operating costs were removed, whilst VTEC mileage based operating costs were increased by 5% to represent the higher mileage of the incremental services to Nottingham and York (with HS2), compared to a single Newcastle service and 2-hourly extension to Edinburgh (without HS2).

The PSU2 power upgrade is required by HS2 in 2033. An adjustment to this infrastructure cost input is therefore made such that the ECML enhancements business case only bears the costs of this scheme for the 12 years prior to operation of HS2 phase 2b.

D.12.10 With HS2 phase 2b in 2036 (3-year delay)

This scenario assumes that HS2 phase 2b commences operation in 2036 rather than 2033.

D.12.11 Reduction in PM peak GTR services via Welwyn Viaduct

Two PM peak services per hour are removed from the option timetable, with consequential impact on outputs from MOIRA.

E. Appendix: Quality Assurance

E.1.1 Overview

Mott MacDonald understands the importance of a robust Quality Assurance (QA) process. Our in-house process has been developed over a number of years, principally through our long term role producing the demand forecasts and economic appraisal for HS2 Ltd. This QA process is common to the bulk of our supply chain, with whom we have collaborated to support HS2 for several years.

The work to develop the ECEP Economic Case has been subject to our QA process.

The core principle of this process is that analysis, models and written deliverables are reviewed by a qualified individual other than the author of the work. Reviewers consider the following categories of issues:

- **Assumptions**. Whether the key assumptions made are plausible and well-evidenced.
- **Methodology.** Whether the methodology undertaken is consistent with WebTAG.
- **Calculations.** Whether there are errors or simplifications in the calculations made; and of the materiality of these issues.
- **Model inputs.** Whether inputs are consistent across models, and whether the model inputs are representative of the intention for the options tested.
- **Reporting.** Whether the reporting is clear, unambiguous and an accurate reflection of the model outputs.

Our Quality Assurance is embedded in the work with reviews undertaken as the models have been developed