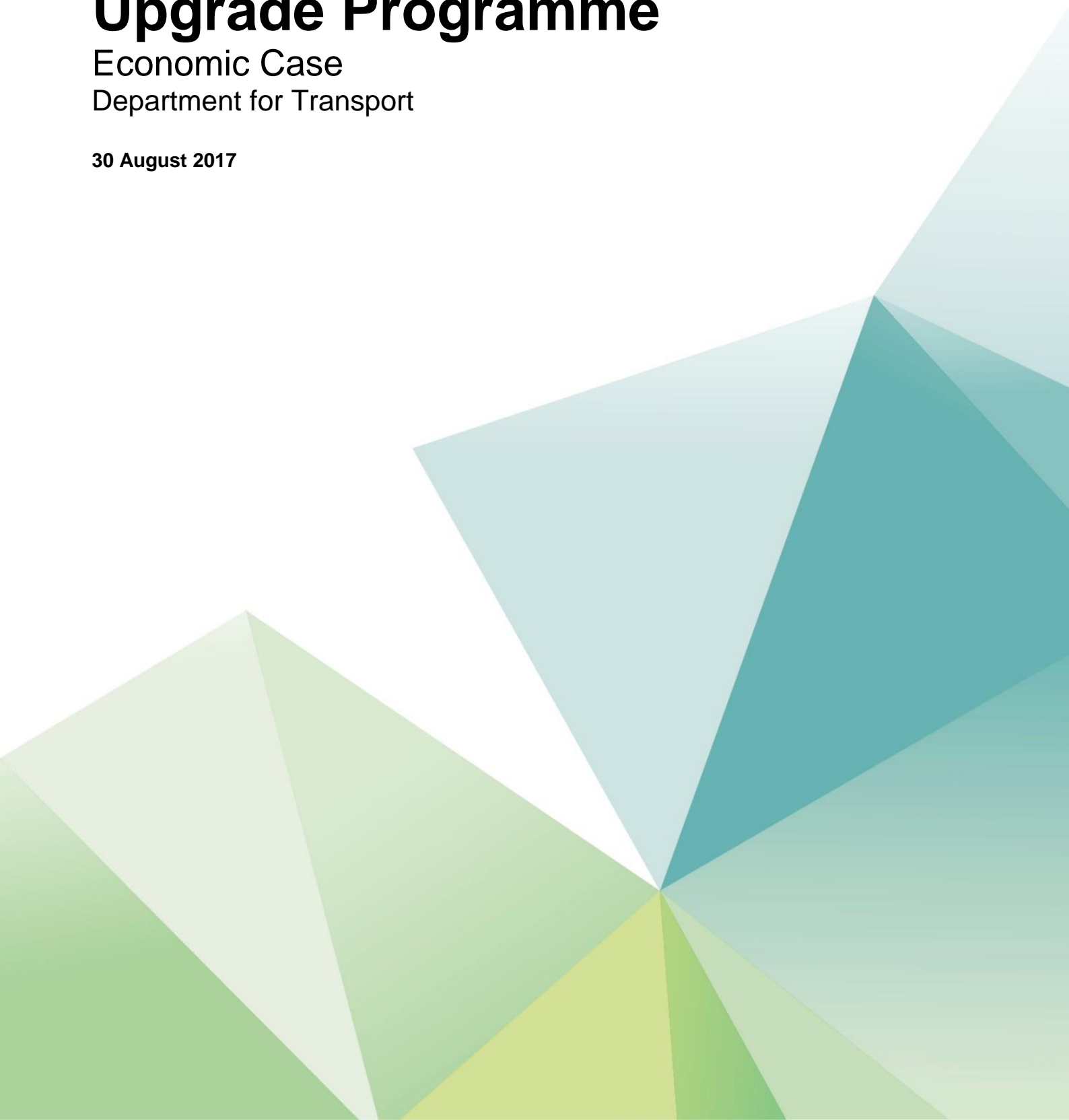


# Midland Main Line Upgrade Programme

Economic Case  
Department for Transport

30 August 2017



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This document has 108 pages including the cover.

## Document history

Job number: 5159267			Document ref: v4.0			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	Interim draft for client comment	██████████	██	-	██	18/08/2017
Rev 2.0	Revised draft for client comment	██████████ ██	██	██	██	18/08/2017
Rev 3.0	Revised draft addressing client comment	██████████	██	-	██	22/08/2017
Rev 4.0	Final	██████████	██	██	██	30/08/2017

## Client signoff

Client	Department for Transport
Project	Midland Main Line Upgrade Programme
Document title	Midland Main Line Upgrade Programme: KO1 Final Business Case
Job no.	5159267
Copy no.	
Document reference	

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# Executive Summary

This document presents the analysis undertaken by Atkins on behalf of the Department for Transport on the business case for Key Output 1 (KO1) of the Midland Main Line (MML) Programme. Key Output 1 will enable two commuter trains per hour from Corby to be operated with higher density electric trains. The second hourly commuter service allows several calls at outer commuter stations on the longer distance services to be removed, providing a significant proportion of the total crowding and journey time benefits of the full programme (i.e. Key Outputs 1 & 2). Key outputs include:

- Reduced journey times into St Pancras;
- Increased passenger capacity into St Pancras and to regional stations through the addition of a 6th path;
- Increased freight capacity (additional 2 paths per hour for 16 hours per day)

## Scope of Economic Case

The economic case is presented assuming that the route capacity enhancements will allow an enhanced service frequency, enabling local stations between London and Corby to be served by dedicated services. In turn, this facilitates a reduction in journey times on the longer distance services from Nottingham and Sheffield to London through a corresponding reduction in stops south of Kettering. This also enables crowding on long distance services to be reduced by transferring London high peak commuter demand from stations at the southern end of the route onto the Corby services; this reduction in crowding on services to Sheffield and Nottingham will provide scope to grow the long distance market.

In both the Do Minimum and Do Something scenarios the assumption is that the Class 222s and High Speed Trains (HSTs) continue to operate over the next franchise term and would be replaced in 2030/31 (at the time of scoping in June 2017 this was consistent with current 'Do Minimum' assumption in the East Midlands Rail Franchise (EMRF) comparator model). Onwards replacement of rolling stock reflects the strategy which would be available with investment held at KO1 and is shown in the table below. Note that this represents a significant change in assumptions compared to the OBC in which the 'do-minimum' scenario assumed HST timings for one train per hour throughout the appraisal period.

Timeline	Do Minimum	Do Something
December 2019	A PRM compliant HST fleet required in service to operate the 5tph Dec-18 MML timetable. Fleet size is assumed to be the same as that required to resource the current timetable. This assumes no dispensation is allowed regardless requirements for the future timetable	
December 2020	-	Cascaded 4 car 100 mph EMUs <sup>1</sup> procured for Corby services.
2030/31	Assumed replacement of the existing fleet with 125DMU capable of Class 222 sectional running times	Assumed replacement of Class 222 and HSTs with new-build 5-car 125DMU capable of Class 222 sectional running times
2045/46	-	Replacement of 100 mph EMUs
2060/61	Identical replacement of 125DMUs	
2080/81	End of 60-year appraisal period	

<sup>1</sup> Electric-capable trains that will operate at least at 100 mph. Timetable development use 100mph SRTs for the Corby Class 375s reflecting the current infrastructure limitation of maximum speed of 100mph for electric traction between London St Pancras and Bedford, and broadening options for cascaded EMUs. On the cost side, EMUs have been considered as 100 mph cascaded EMUs initially for consistency.

The following table summarises the fleet assumptions under for the Do Minimum and Do Something positions:

	4-car 125mph DMU	5-car 125mph DMU	7-car 125mph DMU	HST (2+8 cars)	4-car 100mph EMU
5tph Timetable	■	■	■	■	■
KO1 6tph: Pre 2030/31 (with strengthening)	■	■	■	■	■
KO1 6tph: Post 2030/31 (with strengthening)	■	■	■	■	■

■ complete HST sets, plus some spares, i.e. ■ powercars and ■ coaches

Costs for the infrastructure upgrades were based on information supplied by Network Rail, and were not reviewed, checked or verified as part of this work.

Standard DfT demand forecasting and appraisal assumptions were used to calculate the economic appraisal figures presented in this report.

## Timetable Development

Timetable development builds on a sample 'core specification' which was developed for the Strategic Outline Business Case (SOBC) (December 2016). The timetables developed by Atkins were checked by Network Rail and shared with the relevant train operators including East Midlands Trains and Govia Thameslink Railway (GTR). The sample timetable was reviewed and agreed by a group of DfT and other stakeholders as providing a reasonable representation of a possible service pattern that could be enabled by the improved infrastructure. South of Wigston North Junction, all trains were timetabled in full. To the North of Wigston North Junction, only Midland Main Line long distance services were timetabled, with the assumption that other services could be altered to suit.

For this appraisal, additional timetable development has been undertaken evolving of the work above. This is based on the 2016 (Iteration 1) cut of the Thameslink timetable. Significantly, in terms of progress from the SOBC, this timetables trains for their full journey on the MML, as far as Nottingham and Sheffield, alongside expected changes to the Cross Country timetable according to their aspirations to accelerate the Southampton to Newcastle service and discontinue interworking at Nottingham between Cardiff – Nottingham and Birmingham – Nottingham diagrams. Revised timetables also account for TRIP<sup>2</sup>, which recommends increasing Sectional Running Times (SRTs) between St Pancras and Bedford by up to 3 minutes. The best possible paths were sought to minimise journey times, but, inevitably, both the inclusion of TRIP and the creation of a de-conflicted standard hour on the whole MML increase journey times within the core specification when compared to the SOBC timetable. Journey times are also increased using 100mph rather than 110mph EMUs on Corby services and assuming existing Class 375 SRTs where they exist.

At the same time, despite TRIP, some Do Minimum journey times are less than today's. This is because the timetable development indicates that there may be opportunities to remove pathing time from some services. This is particularly noticeable on the slower St Pancras to Sheffield services, which currently have an extended dwell at Derby and pathing time between Derby and Ambergate Junction. This contrasts to East Midlands Train's (EMT's) operator bid for the May 2018 timetable which is markedly more pessimistic than the Do Minimum timetable developed above; notably removing peak stops at Bedford, Luton and Luton Airport to protect existing journey times. An alternative Do Minimum timetable was derived from this EMT timetable, estimating how it might look if these stops were reinstated, which was assessed as the Do Minimum timetable of the Timetable 2 Scenario described below.

Currently, uncertainty surrounds both the December 2018 timetable and the potential impact this has on the business case. Therefore, future timetables have been treated in three scenarios.

- **Timetable Scenario 1** presents results using the timetables developed during the FBC.

<sup>2</sup> TRIP throughout this document refers to the Timetable Planning Rules Investment Programme in readiness for operating up to 24 Thameslink trains per hour through London and has concluded that SRTs on the MML be revised, generally leading to a net increase in journey time for EMT services.

- **Timetable Scenario 2** presents results using the KO1 6tph timetable as developed above. However, in this instance a modified version of EMTs earlier bid timetable replaces the baseline timetable, presenting a more pessimistic view of the Do Minimum scenario.
- **Timetable Scenario 3.** Presents results using timetables developed in the SOBC reflecting a scenario whereby conflicts north of Wigston Junction can be resolved by retiming other operators' services with little net detriment (Corby times in the Do Something case are modified as reported above)

## Results of Business Case Analysis

The table below summarises the key results for the options tested around the core specification timetable.

Timetable Scenario	Scenario 1	Scenario 2	Scenario 3
<b>Present Value Benefits (£m PV)</b>	<b>673</b>	<b>1,066</b>	<b>1,113</b>
Infrastructure costs (£m PV)	771	771	771
Operating costs change (£m PV)	■	■	■
Revenue increase (£m PV)	■	■	■
<b>Present Value Costs (£m PV)</b>	<b>399</b>	<b>155</b>	<b>21</b>
<b>Net present value (£m PV)</b>	<b>274</b>	<b>911</b>	<b>1,092</b>
<b>BCR</b>	<b>1.69</b>	<b>6.87</b>	<b>52.87</b>

Based on the results presented in the table above, Key Output 1 of the Midlands Main Line Upgrade package represents:

- Very High VfM assuming conflicts in the Do Something timetable north of Wigston Junction can be resolved by retiming other operators' services with little net detriment (as per the SOBC)
- Very High VfM assuming the Do Something timetable is as developed during this business case and the Do Minimum timetable reflects the EMT version of the timetable provided in July 2017 (including reinstated EMT stops at Bedford, Luton and Luton Airport Parkway during peak hours that had been removed as part of the TRIP Programme<sup>3</sup>).
- Medium VfM using FBC development undertaken on the December 2016 (Iteration 1) cut of the Thameslink timetable. In this timetable the end to end journey time savings to Nottingham and Sheffield are reduced, lowering the net benefits of the timetable change, whilst the Do Minimum timetable runs relatively unaffected by the wider changes to the GTR2018 timetable changes.

**At the time of preparation of this business case no definitive version of the baseline May/December 2018 timetable exists. This introduces considerable uncertainty around both the Do Minimum 5 tph timetable and also the Do Something 6tph timetable. This position will become clearer towards the end of 2017 and will need to be kept under review.**

## Sensitivity Testing

A number of sensitivity tests have been examined to monetise the scale of potential benefits which are not included in the central case above. These tests include:

- **Freight Benefits.** Estimates the monetised benefits from increased freight provision on the route. This is based on the Department's set of HGV specific Marginal External Costs.
- **Cross Country timetable aspirations.** Cross Country aspire to achieve journey time savings following Derby remodelling, concentrating on the Birmingham – Newcastle (via Doncaster) service. Proposals save up to 28 minutes on the Birmingham– Newcastle (via Doncaster) service with minimal changes to other operators' services.
- **NOx emissions.** A sensitivity test using higher damage costs for (March 2017).

<sup>3</sup> A modified version of the timetable where Bedford, Luton and Luton Airport Parkway stop had been removed was supplied on 11th August 2017 reinstating peak hour stops at Luton Airport Parkway.

The results of these sensitivity tests are presented below (Net Present Value expressed in 2010 Discounted Market Prices):

Timetable Scenario	Timetable 1		Timetable 2		Timetable 3	
	£m NPV	BCR	£m NPV	BCR	£m NPV	BCR
<b>Central Case</b>	<b>274</b>	<b>1.69</b>	<b>911</b>	<b>6.87</b>	<b>1,092</b>	<b>52.87</b>
Freight Benefits	632	2.78	1,269	12.53	1,450	Fin+
XC Timetable Aspirations <sup>4</sup>	■	■	■	■	■	■
Higher Air Quality Benefits	331	1.83	968	7.25	1,149	55.7

The table above shows that the potential benefits additional to the central case are of significant value to the appraisal with an increment of ■ PV associated with increased provision for freight and Cross Country's timetable aspirations following Derby Remodelling. The impact on the BCR is dependent on the net benefits and costs of each scenario. The addition of freight benefits would uplift the BCR in the most pessimistic timetable scenario from 1.7 to 2.8 (High VfM) the additional consideration of Cross Country's timetable aspirations would further uplift this to ■

## High Speed 2

Further sensitivity testing examined the impact of HS2 on the economic case of the programme. This found that the introduction of HS2 Phase 2 (2033) would have a material impact on the value for money of the MML Upgrade Programme, reducing the BCR from 52.9 to 0.9. The upgrade programme can therefore be categorised as providing 'poor' value for money with HS2 Phase 2. In this instance, abstraction of the long distance market to Sheffield, Derby and, to a lesser extent, Nottingham reduces the future revenue and user benefits delivered by the 6<sup>th</sup> path.

This sensitivity test is sensitive to the introduction data of HS2, a delayed implementation date to 2036 would raise the BCR back to the vicinity of 1.2. The BCR of this sensitivity test is also sensitive to growth rates; a high growth scenario consistent with TAG Unit M4 Forecasting and Uncertainty Section 4.2, which allows for a relatively limited 2.5% additional growth over 20 years, would take the BCR from 0.9 to 1.1.

## Caveats and Limitations on Analysis

It is important to note the limitations on the analysis undertaken in certain areas:

- At the time of preparation of this business case no definitive version of the baseline May/December 2018 timetable exists. This introduces considerable uncertainty around both the Do Minimum 5 tph timetable and also the Do Something 6tph timetable. While this uncertainty primarily revolves around assumed journey times and timings around the clock (i.e. shifting the departure or arrival times at certain locations), it may also influence rolling stock requirements. Atkins' understanding of the latest May-18 timetable position is that EMT have been instructed to lease an additional ■ HST sets in order to maintain capacity on MML services in the May-18 timetable. This change is not currently reflected in the modelled Do Minimum scenario or the Do Something. While this assumes the incremental fleet requirements do not differ from the previous MML SOBC, the changes to rolling stock requirements as a result of the Thameslink timetable could result in additional efficiency savings from the Do Something 6tph timetable obtained through reprogramming the new required rolling stock fleet. This position will become clearer towards the end of 2017 and will need to be kept under review
- The GTR 2018 timetable is still undergoing development. The timetables for this study were developed using the latest version of the GTR 2018 timetable made available to this study (December 2016,

<sup>4</sup> CrossCountry benefits are realised post Derby remodelling, which is treated as a sunk cost. Therefore the benefits included in this sensitivity should be regarded as well as sunk benefits.

Iteration 1). Atkins have been made aware that there have been significant changes to the GTR 2018 timetable since this time.

- The estimated fleet sizes presented in this report are provided for business case comparison purposes only. These numbers should in no way be viewed as recommendations for the optimum fleet size on the upgraded route, which should be the subject of further detailed analysis.
- Changes to the Department's exogenous growth forecasts (known as DDG) between January 2016 and July 2017 reduce real revenue growth projections on the East Midlands Rail Franchise (EMRF) over the next 20 years from [REDACTED] and demand growth is reduced from [REDACTED]. This substantially reduces the NPV of the Key Output 1 investment proposals. Atkins are aware that the PDFH 6.0 (Passenger Demand Forecasting Handbook) update proves is considering changes to the exogenous growth framework. Any revisions to growth rates could have a significant impact on the appraisal results.
- Revenue transfer from crowding relief is subject to the methodological application of the PDFH approach. If longer distance journeys are subject to a lower level of constraint (for example through a high use of advance purchase with seat reservations) then this approach may overstate revenue transfer from crowding relief.
- On 20<sup>th</sup> July 2017 it was announced that the next operator of the EMRF will be required to deliver modern, fast and efficient intercity and commuter trains, including a new set of bi-mode intercity trains from 2022. For bi-mode trains to operate in electric mode south of Kettering additional overhead line infrastructure (and associated investment) would be required. This investment is needed to deliver 125 mph line speeds south of Bedford in electric mode and capability for a 6 train per hour electric service south of Kettering. This additional investment and rolling stock strategy is not reflected in the core appraisal undertaken within this document; although an option for this further investment in the MML infrastructure and rolling stock is considered as a sensitivity test.

# 1. Introduction

## 1.1. Background

The High Level Output Specification (HLOS) 2012 key outcomes for the MML Programme were as follows:

- Deliver shorter journey times into St Pancras;
- Increase passenger capacity into St Pancras and to regional stations through the addition of a 6th path;
- Improve performance and passenger experience through the procurement of electric rolling stock;
- Reduce operating costs through electrification of the line to Corby, Nottingham, Derby and Sheffield; and
- Increase freight capacity (additional 2 paths per hour for 16 hours per day)

The revised Network Rail Enhancement Delivery Plan (March 2016) that resulted from the Hendy Review set out two MML Key Outputs, Key Output 1 and Key Output 2. A summary of each Key Output is provided below

### Key Output 1 December 2019

- provision of 25 kV electrification from the existing limits at Bedford to Kettering and Corby;
- enabling improved journey times through the delivery of key infrastructure schemes;
- provision of additional capacity for a 6th Long Distance High Speed service between St Pancras and Kettering;
- enabling additional freight paths;
- enhanced capability at key stations south of Leicester through extension of platforms and other operational measures; and
- new stabling facilities at Kettering.

### Key Output 2 December 2023

- provision of 25 kV electrification from Kettering to Nottingham and to Sheffield via Derby;
- enabling improved journey times through the delivery of key infrastructure schemes;
- completion of adjustments to existing Fast Line OLE south of Bedford, increasing the permissible speed for electric trains; and
- enhancing the capability at key stations north of Leicester through extension of platforms and other operational measures and completion of gauge enhancement works to provide W12 clearance.

The MML SOBC (December 2016) recommended to proceed with KO1, incorporating all elements of the capacity works and electrification between Bedford and Kettering/Corby. Whilst the full programme offered very high value for money it was not recommended given the affordability constraints in CP5 and CP6. KO1 will enable two commuter trains per hour from Corby to be operated with higher-density electric trains, with the Sheffield and Nottingham services initially deploying the existing Class 222 and HST fleet. The second hourly 'commuter' service allows several calls at outer commuter stations on the longer distance services to be removed, providing a significant proportion of the total crowding and journey time benefits of the full programme. KO1 also delivers the increased freight capacity identified within the full programme.

In June 2017, the Department for Transport commissioned Atkins to prepare an updated business case for the KO1 programme of works detailed above. The remainder of this document develops and presents the results of this updated business case.

On 20<sup>th</sup> July 2017 it was announced that the next operator of the EMRF will be required to deliver modern, fast and efficient intercity and commuter trains, including a new set of bi-mode intercity trains from 2022. For bi-mode trains to operate to Kettering additional overhead line infrastructure (and associated investment) would be required for overhead line equipment to deliver 125 mph line speeds south of Bedford in electric mode, and capability for a 6 train per hour electric service south of Kettering. This investment, and rolling

stock strategy is not reflected in the core appraisal undertaken within this document; although an option for this further investment/rolling stock strategy is considered as a sensitivity test.

## 1.2. Report Structure

Following this introduction, the remainder of this report is structured as follows:

- Chapter 2 provides an overview of the scope of the appraisal;
- Chapter 3 describes the development of a notional timetable for business case testing purposes and discusses ongoing development of industry timetables;
- Chapter 4 outlines the demand and revenue forecasting methodology and presents the results of this process;
- Chapter 5 sets out the approach to the estimation of the size of rolling stock fleet required to operate the services in the new timetable;
- Chapter 6 sets out the approach to the estimation of operating costs for each modelled option;
- Chapter 7 details the scheme costs for the upgrade programme;
- Chapter 8 presents the results of the economic appraisal;
- The impact of HS2 on the value for money of the MML upgrade programme is considered in Chapter 9; and
- Chapter 10 presents conclusions to the study.

## 2. Scope of the Appraisal

### 2.1. Introduction

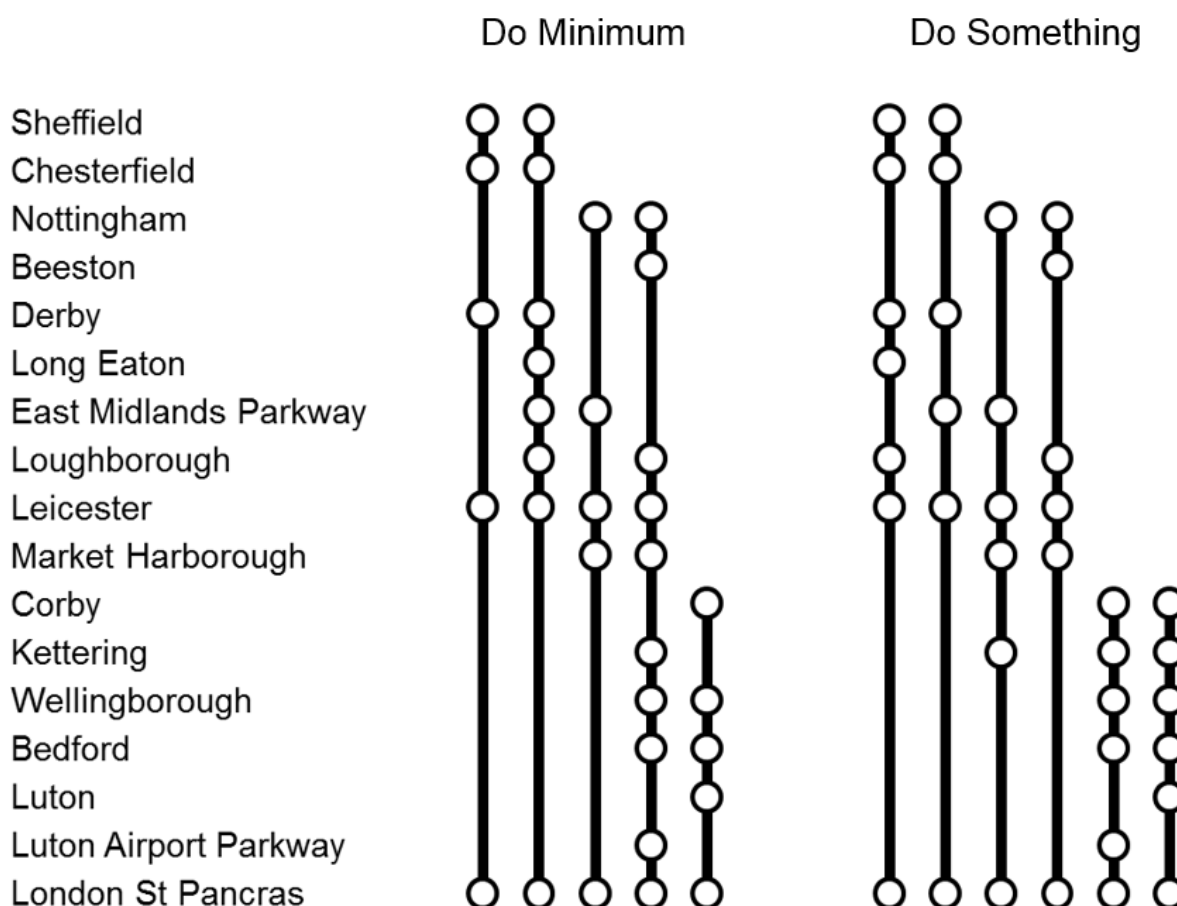
The section presents the scope of the appraisal. This includes an outline of the baseline position and option tested alongside a broad description of the modelling approach.

### 2.2. Scenario Development

The assessment considers the Midland Main Line Upgrade Programme Key Output 1 against a Do Minimum baseline scenario.

- The 'Do Minimum' is based on East Midlands Trains' current long distance service specification on the Midland Main Line integrated onto 5 of the 6 paths in GTR's proposed 2018 Thameslink timetable.
- The 'Do Something' retains the 6 train per hour service pattern from the SOBC which is also consistent with that used for comparator forecasting for the East Midlands Rail Franchise. The figure below presents the notional standard off-peak service pattern for the Baseline and the Central Case timetable.

**Figure 2-1 Notional Off-Peak Service Pattern**



The Do Something service pattern assumes a standardised stopping pattern across the whole day. In contrast, the Do Minimum timetable requires additional peak calls at Kettering and Wellingborough to cater for high peak demand, particularly in the AM peak where high flows into London are concentrated into a relatively short period, as shown in the table below.

**Table 2-1 Do Minimum Timetable: Southern MML Stations Calling Pattern – Trains per Hour (East Midlands Trains Services Only)**

Station	Do Minimum			Do Something (all day pattern)
	Off-Peak	AM High Peak Hour (0700-0800)	PM High Peak Hour (1700-1800)	
Kettering	2	5	3	3
Wellingborough	2	5	3	2
Bedford	2	2	2	2
Luton	1	2	1	1
Luton Airport Parkway	1	2	1	1

The Do Something service specification is presented in Table 2-2 below:

**Table 2-2 Do Something Service Specification**

From	To	Service Group	Peak/Off Peak Variations	Assumed Stock Type	Calling Pattern	Peak Pattern
Sheffield (fast)	St Pancras	MML long distance	All day	125mph EMU	Chesterfield, Derby, Long Eaton, Loughborough, Leicester	30 min interval
Sheffield (fast)	St Pancras	MML long distance	All day	125mph EMU	Chesterfield, Derby, East Midlands Parkway, Leicester	
Nottingham (fast)	St Pancras	MML long distance	All day	125mph EMU	East Mids Parkway, Leicester, Market Harborough, Kettering	30 min interval
Nottingham (fast)	St Pancras	MML long distance	All day	125mph EMU	Beeston, Loughborough, Leicester, Market Harborough	
Corby (semi-fast)	St Pancras	MML outer	All day	100mph EMU	Kettering, Wellingborough, Bedford and Luton	30 min interval
Corby (semi-fast)	St Pancras	MML outer	All day	100mph EMU	Kettering, Wellingborough, Bedford and Luton Airport Parkway	

### 2.2.1. Modelled Rolling Stock Options

The appraisal period begins with the opening of the scheme and covers a 60-year period. At scheme opening it is assumed that:

- The Do Minimum timetable would be operated by EMT's current fleet, a mixture of 4, 5 and 7 car Class 222 (Meridian) Diesel Multiple Units (DMUs) and 8-car HST sets.
- In the Do Something the Corby services would be operated by 100mph EMUs<sup>5</sup> with the existing class 222 and HST fleets deployed on the Sheffield and Nottingham services. One of the hourly Nottingham

<sup>5</sup> Electric-capable trains that will operate at least at 100 mph. Timetable development has used 100mph SRTs for the Corby Class 375s reflecting the current infrastructure limitation of maximum speed of 100mph for electric traction between London St Pancras and Bedford, and broadening options for cascaded EMUs.

services is timed for operation by HSTs, with sectional running times requiring an additional 8-minutes relative to Class 222 operation.

Onwards assumptions regarding the replacement of rolling stock during the appraisal period have been based on guidance in TAG Unit A5.3. This advises that new DMUs should be assumed to have a minimum lifespan of 30 years, and new Electric Multiple Units (EMUs) and electric locomotives should be assumed to have a minimum lifespan of 35 years. The table below shows the assumptions relating to rolling stock replacement over the appraisal period. In both the Do Minimum and Do Something scenarios the assumption is that the Class 222s and HSTs continue to operate over the next franchise term and would be replaced in 2030/31 (At the time of scoping in June 2017 this was consistent with current Do Minimum assumption in the EMRF comparator model). The assumptions for rolling stock replacement reflect the strategy which would be available with investment held at KO1. In the Do Minimum scenario the existing Class222/HST fleet is replaced with an identical fleet. In the Do Something scenario the existing Class222/HST fleet is replaced by a fleet of 5-car 125mph DMU. In both Do Minimum and Do Something scenarios the replacement fleet is assumed to be capable of matching existing Class222 sectional running times.

**Table 2-3 Rolling Stock Replacement**

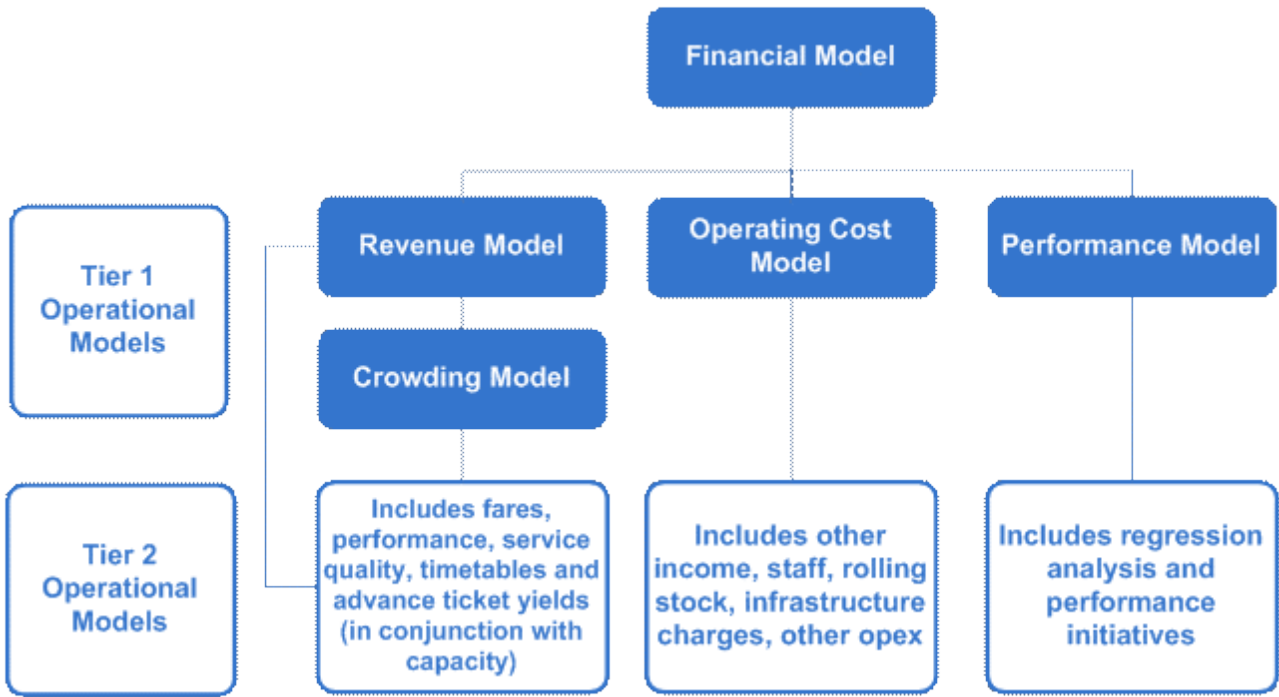
Timeline	Do Minimum	Do Something
December 2019	A PRM compliant HST fleet required in service to operate the 5tph Dec-18 MML timetable. Fleet size is assumed to be the same as that required to resource the current timetable. This assumes no dispensation is allowed regardless of requirements for the future timetable	
December 2020	-	Cascaded 4-car 100 mph EMUs <sup>6</sup> procured for Corby services.
2030/31	Assumed replacement of the existing fleet with 125 DMU capable of Class 222 sectional running times	Assumed replacement of Class 222 and HSTs with new-build 5-car 125 DMU capable of Class 222 sectional running times
2045/46	-	Replacement of 100 mph EMUs
2060/61	Identical replacement of 125 DMUs	
2080/81	End of 60 year appraisal period	

## 2.2.2. Modelling Approach

Consistently with the SOBC presented in 2016 the appraisal has continued to be based on the Comparator Model Suite developed for the East Midlands Franchise competition. This model suite has been kept up to date with recent socio-economic forecast and has accounted for outturn demand and revenue for the 2016/17 financial year. For this study uses exogenous forecasts provided by the DfT in the format of the July 2017 Demand Driver Generators. This model suite is based upon the models that are being used on the East Midlands Rail Franchise competition which were subject to external assurance in early 2017. The figure below provides an overview of the East Midlands Franchise Comparator Suite.

<sup>6</sup> Electric-capable trains that will operate at least at 100 mph. Timetable development will use previous 100mph SRTs for the Corby Class 375s reflecting the current infrastructure limitation of maximum speed of 100mph for electric traction between London St Pancras and Bedford, and broadening options for cascaded EMUs. On the cost side, EMUs have been considered as 100 mph cascaded EMUs initially for consistency.

**Figure 2-2    East Midlands Franchise Comparator Model Suite**



### 3. Timetable Development

#### 3.1. Overview

This section discusses the timetabling development, assumptions and outputs, starting with the SOBC work.

##### 3.1.1. Strategic Outline Business Case

Timetable development for the MML Outline Business Case (OBC) was undertaken using the Version 3.2 of the GTR2018 timetable, which was the latest version available at the time (July 2016). A small number of conflicts were identified by Atkins. Some of these could be easily resolved, but others required reworking by GTR. The most serious occurred in the PM peak between Up Midland Main Line services and Down Thameslink trains making crossing moves at Carlton Road and Harpenden (note that rail terminology defines ‘Up’ services as those running towards London and ‘Down’ services as those running away from London). Resolving these would inevitably impact on GTR services through the Thameslink Core (i.e. through Central London) and, therefore, fell outside the scope of this work. GTR were already aware of these issues and are working to resolve them. Owing to GTR’s likely timescales, this business case work was progressed with these conflicts still within the timetable.

Timetable development work undertaken by Atkins for the SOBC was developed using 2017 Train Planning Rules. Timetables were developed for AM Peak, PM Peak and Off-Peak hours in both directions matching formats supplied for the Thameslink timetable. For appraisal purposes the:

- The AM peak is assumed to operate for 0700-0959 arrivals into London;
- The PM peak is assumed to operate for 16:00-1859 departures from London;
- The off-peak operates at all other times.

At the start and end of the day, service levels were reduced slightly, broadly in line with Atkins’ previous Midland Main Line timetabling work and with the current timetable. The assumptions on infrastructure and rolling stock are outlined below and, where necessary, the application of the planning rules was amended to suit.

The timetable development considered its interaction with other operators on the route, as the future timetable(s) have to be integrated with other services according to the planning rules set out above. In summary with regard to other operator services:

- South of Wigston North Junction, all trains were timetabled in full. To the North of Wigston North Junction, only Midland Main Line long distance services were timetabled, with the assumption that other services could be altered to suit. (This identified a number of conflicts between the MML off-peak 6-path indicative service specification and Cross Country paths between Derby and Sheffield and at Leicester.)
- Freight SRTs were supplied by Network Rail from b-plan and paths were timetabled for the following Class 6 freight services each hour:

Table 1. Freight Services (MML SOBC)

	Down	Up
Via Market Harborough	1 No. 2200t 1 No. 800t	2 No. 2200t
Sheffield via Corby	1 No. 2200t* 1 No. 800t*	1 No. 2200t* 1 No. 2600t*

\* South of Kettering, these services would use the same path as freight routed via Market Harborough.

##### 3.1.2. KO1 FBC Timetable Development

Given the critical nature of the timetable for this business case additional timetable development has been undertaken for this business case. This has been undertaken in advance of further industry development of the 6tph timetable, which does not fit within the delivery timescales for this business case.

The KO1 timetable development is an evolution of the ‘2019 timetable’ produced for the SOBC. Since summer 2016, the Thameslink timetable has evolved and the KO1 timetable developed in this study was based on the December 2016 (Iteration 1) cut of the Thameslink timetable supplied by Network Rail (NR), modified where necessary. As the Iteration 1 timetable included a whole SX day (i.e. weekdays), a better understanding of the service that would operate in the counter-peak direction was now possible. The KO1 timetable also utilised MML timetabling work undertaken by Atkins for the DfT to determine the optimal clock face pattern of services (i.e. shifting departures and arrivals for all trains without modifying service intervals or stopping patterns) to minimise conflicts north of Wigston North Junction. Since the Iteration 1 timetable was produced, the Thameslink timetable has continued to evolve. In particular, the SRTs used at Iteration 1 have been superseded by the output of the TRIP programme (see footnote 2). This generally increases running times between St Pancras and Bedford.

The KO1 timetable considers TRIP and, significantly in terms of progress from the SOBC, timetables trains for their full journey on the MML (as far as Nottingham and Sheffield) alongside expected changes to the Cross Country timetable according to their aspirations. Inevitably, both these factors increase journey times compared to the SOBC timetable. Journey times are also increased by the use of 100mph rather than 110mph EMUs on Corby services and assuming existing Class 375 SRTs where they exist. Standard off-peak, AM peak and PM peak hour timetables were produced. The assumptions are set out in the appendix.

TRIP is undergoing a process of review and is continually evolving. The SRTs used in the FBC timetable are taken from Version 3. Since this timetable was produced, Version 4 of TRIP was issued. This reduces the impact on MML services, with many SRTs reverting to their current values. The impact on Class 222 non-stop running times reduces to just 1 minute in each direction and this will, inevitably, have an impact on the business case that has not been assessed in the FBC. All discrepancies between existing SRTs and those in Version 4 have been disputed by EMT.

3.1.3.      FBC Do Something Timetable

In general, TRIP causes a net increase in running time of up to 3 minutes, depending on rolling stock and stopping pattern. However, once timetabled, the impact on end-to-end journey times is more complex. In some cases, there is no increase to end-to-end journey time: this is because the increase south of Bedford eliminates the need for pathing time either south of Bedford or elsewhere on the MML. However, in other cases, TRIP results in an end-to-end journey time increase of up to 2 minutes more than the direct impact: this is because the change in SRTs necessitates a change to the pattern of arrivals and departures across the throat at St Pancras which introduces pathing time into some trains.

In order to present the separate impact of TRIP and pathing to accommodate other services north of Wigston North Junction, a ‘clean’ KO1 timetable was also produced. This included TRIP, along with any indirect impact of TRIP, and, like the ‘2019 timetable’, also included any pathing time required to accommodate freight via Market Harborough. North of Wigston North Junction no pathing time was added. Whereas the KO1 timetable seeks to provide a realistic representation of end-to-end running times from the introduction of the 6-path timetable, the ‘clean’ timetable demonstrates the additional benefits that would be released if MML / Cross Country timetable could evolve in the longer term so as to reduce the pathing time imposed on EMT services.

The incremental impact on end-to-end journey times from the SOBC timetable, to the ‘clean’ timetable, and through to the KO1 timetable, is in Table 3-2 below. Note the difference between the direct SRT penalty imposed by TRIP and the impact on end-to-end journey times once timetabled.

Table 3-1      December 2020: 6tph Down Timetable

Stock	222	222	HST	222	EMU	EMU
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
SOBC JT	1h59	2h04	1h42	1h35	1h07	1h07
TRIP (direct penalty)	+2	+2	+½	+2	n/a	n/a
‘clean’ JT	2h01	2h05	1h42	1h37	1h12	1h12

change	+2	+1	0	+2	+5	+5
KO1 JT	2h01	2h06	1h42	1h38	1h12	1h12
change	0	+1*	0	+1**	0	0

\* This is caused by conflicts between Chesterfield and Sheffield  
\*\* This is caused by a conflict with Leicester – Nottingham local services

Table 3-2      December 2020: 6tph Up Timetable

Stock	222	222	HST	222	EMU	EMU
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
SOBC JT	2h00	2h02	1h42	1h34	1h08	1h08
TRIP (direct penalty)	+3	+3	+1	+3	n/a	n/a
'clean' JT	2h03	2h07	1h45	1h39	1h16	1h16
change	+3	+4	+3	+5	+8	+8
KO1 JT	2h03	2h07	1h46	1h40**	1h16	1h16
change	0	0	+1*	+1	0	0

\* This is caused by pathing at Leicester for the Leicester – Birmingham service

\*\* The maintenance of a 1h40 journey time on this service is hindered by a conflict with the Cross Country Nottingham – Cardiff service. This causes 4 minutes' pathing to the Class 222 Nottingham to St Pancras service. As the Cross Country service crosses immediately in behind an EMT Down service at Trent East Junction and is sandwiched between EMT services at Derby, this penalty cannot be removed simply by flexing. Similarly, as this conflict occurs between Nottingham and Trent East Junction, the option of swapping the Beeston stop from the HST service into this service would have no benefit. For the purpose of FBC timetabling the journey time on the EMT Nottingham service has been maintained at 1h40 (rather than increased to 1h44) through more dramatic extensions to the Cross Country journey time, adding 9 minutes to the Nottingham to Cardiff journey time between Nottingham and Derby (this action is forecast to result in a net improvement to national rail revenues relative to the reversal maintaining the current Cross Country times). As the GTR and MML timetable development is ongoing, it may evolve in such a way that these conflicts no longer exist. A draft version of EMTs May 2018 5-path timetable suggests a different clockface pattern to that explored here has been utilised, which will change the nature of the conflicts. Alternatively, if a change in rolling stock from the existing 100mph Class 170s on this route to 125mph stock were ever considered, this might be an opportunity to investigate the possibility of providing a better path to EMT.

Although the increase in end-to-end journey time reduces turnaround times, the impact was not deemed sufficient to warrant a change to the previous SOBC stock working and diagramming. The impact on turnarounds is summarised below. The most concerning would be the reduction in turnaround at Nottingham to less than 20 minutes if the Nottingham – Cardiff service cannot be amended as described above. However, it should also be noted that the reduction in turnaround at Corby has a benefit for freight as Up freight trains will have a larger window to pass through the station.

**Table 3-3      Turnaround at destination (minutes)**

Stock	222	222	HST	222	EMU	EMU
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
SOBC WTT turnaround	41	33	69	23	21	21
KO1 WTT turnaround	40	30	69	21	13	13
change	-1	-3	0	-6	-8	-8
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
SOBC WTT turnaround	23	23	30	31	25	25
KO1 WTT turnaround	20	20	26	26	22	22
change	-3	-3	-4	-5	-3	-3

**3.1.4.    FBC Do Minimum**

The SOBC Do Minimum timetable was assumed to be identical to the existing timetable, with a shift in the clockface to suit GTR, and no detailed timetabling work was undertaken. As part of the KO1 business case, the do minimum was updated by fully timetabling a standard off-peak hour as well as approximately 3 AM and PM peak hours. The same assumptions were made regarding Derby remodelling and Cross Country as with the Do Something timetable; then, to create a scenario where Derby is not remodelled, journey times were extended to remove any benefits at Derby. The impact of TRIP was also included and, like the Do Something timetable, the progression from the SOBC Do Minimum end-to-end running time (identical to existing), to a ‘clean’ Do Minimum, through to the Do Minimum used in the business case is summarised in the table below. Note that, despite TRIP, some journey times are less than today’s. This is because the timetable development indicates that there may be opportunities to remove pathing time from some services. This is particularly noticeable on the slower St Pancras to Sheffield services, which currently have an extended dwell at Derby and pathing time between Derby and Ambergate Junction. However, it should be noted that there is a risk to realising these improvements in a 5-path scenario where Derby is not remodelled.

**Table 3-4      December 2018: 5tph Down Timetable**

Stock	222	222	HST	222	222	
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
<b>SOBC JT</b>	<b>2h01</b>	<b>2h15</b>	<b>1h40</b>	<b>1h49</b>	<b>1h10</b>	
TRIP (direct penalty)	+2	+2	+½	+½	+½	
‘clean’ JT	2h01	2h11	1h39	1h48	1h09	
change	0	-4	-1	-1	-1	
<b>KO1 JT</b>	<b>2h01</b>	<b>2h13</b>	<b>1h40</b>	<b>1h48</b>	<b>1h09</b>	
change	0	+2*	+1*	0	0	

\* This is caused by conflicts at Leicester

Table 3-5        December 2018: 5tph Up Timetable

Stock	222	222	HST	222	EMU	
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
SOBC JT	2h02	2h10	1h42	1h51	1h10	
TRIP (direct penalty)	+3	+3	+1	+3	+3	
'clean' JT	2h02	2h13	1h42	1h54	1h14	
change	0	+3	0	+3	+4	
KO1 JT	2h03	2h15	1h42	1h54	1h14	
change	+1*	+2*	0	0	0	

\* This is caused by conflicts at Leicester

3.1.5.    HST replacement

The option of replacing the HST fleet was considered in both the Do -Something and the Do Minimum. The use of Class 222s (or trains with equivalent performance) instead of HSTs has the potential to save 7 to 8 minutes in end-to-end running time.

In the Do Minimum, the structure of the timetable is such that the lower performance of the HST path opens a gap for freight. Replacing HSTs with higher performing stock would close this gap and reduce freight capacity on the route, eliminating the current heavy freight paths via Market Harborough. To avoid this, the new paths would have to be slowed with pathing time or options for a more significant recast of the timetable would have to be explored. Any reduction in running time would lengthen the already-substantial layovers at Nottingham, thereby risking negatively impacting on station capacity. In the Down direction, there is also a risk to realising any journey time benefits owing to conflicts with other services at Leicester and the journey time saving could be as little as 2 minutes.

Unlike in the Do Minimum, replacing HSTs in the Do- Something timetable provides more flexibility for freight owing to the way trains are flighted north of Kettering. The reduction in end-to-end running time also permits a reduction in fleet size (as per the SOBC). However, there is a risk to realising these benefits owing to conflicts with other services at Leicester and between Trent and Nottingham. The journey time saving in the Down direction could be reduced to 2 minutes in the Down direction and 0 minutes in the Up direction.

3.1.6.    Comparison of SOBC and FBC end-end journey times

The tables below present a summary of changes in off-peak end-end journey times. This is a summary of data presented in Section 3.1.3 and Section 3.1.4 above.

Table 3-6        Down Timetable: SOBC and FBC Journey Times

	Do Minimum (5tph Timetable)			Do Something (6tph Timetable)		
	SOCB	FBC	Change	SOCB	FBC	Change
Sheffield	2h01	2h01	-	1h59	2h01	+2
Sheffield	2h15	2h13	-2	2h04	2h06	+2
Nottingham	1h40	1h40	-	1h42	1h42	-
Nottingham	1h49	1h48	-1	1h35	1h38	+3
Corby	1h10	1h09	-1	1h07	1h12	+5
Corby	-	-	-	1h07	1h12	+5

Table 3-7      Up Timetable: SOBC and FBC Journey Times

	Do Minimum (5tph Timetable)			Do Something (6tph Timetable)		
	SOCB	FBC	Change	SOCB	FBC	Change
Sheffield	2h02	2h03	+1	2h00	2h03	+4
Sheffield	2h10	2h15	+5	2h02	2h07	+5
Nottingham	1h42	1h42	-	1h42	1h46	+4
Nottingham	1h51	1h54	+3	1h34	1h40*	+6
Corby	1h10	1h14	+4	1h08	1h16	+8
Corby	n/a	n/a		1h08	1h16	+8

*\*1h40 journey time enabled by extending journey times on the Cross Country Nottingham – Cardiff service by 9 minutes between Derby and Nottingham.*

The tables above show that:

- There are ‘risks’ to the KO1 journey times as presented in the SOBC. This is partly a result of TRIP although is also an impact of timetabling trains in full to the North of Wigston North Junction, replacing the SOBC assumption that other services could be altered to suit.
- There is a narrowing of journey times between the Do Minimum and the Do Something. This is because, in the SOBC, a theoretical, and clean, Do Something timetable was compared against a real, operational Do Minimum timetable that accounted for all other users of the railway throughout the day. In the FBC, the Do Something timetable has evolved to consider the interaction with other operators, thereby becoming more realistic with extensions to journey times. At the same time despite TRIP some Do Minimum journey times are less than today’s. This is because the timetable development indicates that there may be opportunities to remove pathing time from some services. This is particularly noticeable on the slower St Pancras to Sheffield services, which currently have an extended dwell at Derby and pathing time between Derby and Ambergate Junction.
- In itself, increasing the Do Something journey times would not impact on the business case for the KO1 investment programme, however a narrowing of the increment between the Do Minimum and Do Something cases will reduce the benefits of the timetable change and will reduce the resulting revenue transfer and user benefits.

3.1.7.      Industry Development of Timetables

3.1.7.1.    Introduction

At the time of preparation of this business case no definitive version of the baseline May\December 2018 timetable exists. Timetabling work above has been undertaken to feed into this business case ahead of further industry development which does not fit into the timescales for this assessment.

At the time of writing (10<sup>th</sup> August 2017) Atkins have not had sight of the current Thameslink timetable although are aware that this contains significant changes from the 2016 version used for timetable development within this study. The following sections describe wider ongoing development of Do Minimum and Do Something timetables relevant to this business case.

3.1.7.1.1. May 2018 Timetable

In order to meet milestone dates for the development of the industry May 2018 timetable operator bids were required to be submitted to Network Rail on 11th August 2017. For the purposes of delivering the Thameslink Services by GTR, EMT were directed to submit a timetable that was non-compliant with their Service Level Commitment (SLC) for the May 2018 timetable. Principally this removes peak stops from Luton and Bedford whilst also making changes to today’s journey times (some detrimental, some beneficial). Currently the consensus is that EMT would also require an additional 3 HSTs to run the revised timetable. This timetable still reflects the initial timetable proposal to NR; the definitive milestone for the development of the May 2018 timetable is the 17th November 2017, when Network Rail publish the new working timetable.

An earlier, developmental, version of the EMT timetable was made available for this business case. In addition to the above this also removed peak stops at Luton Airport – and otherwise achieved the same

journey times in the final version from 11<sup>th</sup> August. Notably this timetable is considerably more pessimistic than the Do Minimum version of the timetable as developed for the assessment of the MML KO1 business case.

### 3.1.7.1.2. Do Something 6tph Timetable

Both Network Rail and East Midlands Trains have existing remits to further develop the KO1 timetable:

#### Network Rail

The remit is covered in the document 'Network Strategy and Capacity Planning: Capability & Capacity Analysis MML2019 KO1 Timetable Analysis Remit'. The aim of the study is to inform Network Rail's investment decision for Midland Main Line (MML) Key Output 1 (KO1), and to provide an understanding of the whole system impacts of interventions in the East Midlands. The study will develop timetable options for 2019 as it will follow the introduction of the Dec 2018 Thameslink timetable as well as the infrastructure interventions scheduled to deliver the KO1 outputs.

#### East Midlands Trains Remit

'Timetable Strategy and Capacity Planning MML '6 trains per hour Timetable' – Outline Remit' (6tph Timetable Joint Working Remit.docx – this document pre-dates to finalise the scope of this remit). Commissioned by the Midland Main Line Programme Board at the highest level this workstream is ultimately seeking to maximise the benefits of Key Output 1 (London to Corby) infrastructure enhancement programme. The study shall seek to demonstrate that there is a timetable which will deliver 6 train paths an hour which offers the greatest possible opportunity to maximise journey time reduction and additional capacity for Long Distance High Speed services. This will identify if the full outputs of KO1 are deliverable with the current GTR timetable and will identify potential resolutions and timetable schemes which are likely to improve challenges identified. The delivery date for this study in September 2017.

### 3.1.8. Treatment of Timetables for the KO1 FBC

Given ongoing developments to the GTR2018 timetable, which impacts on both the baseline position and the development base for the KO1 timetable, considerable uncertainty remains on the final timetable for both December 2018 and with the introduction of KO1 and the 6<sup>th</sup> path. Consequently, for the business case three scenarios have been examined:

- **Timetable Scenario 1** presents results using the timetables developed as part of this remit and as described in Section 3.1.2 through to Section 3.1.5.
- **Timetable Scenario 2** presents results using the KO1 6tph timetable as developed above. However, in this instance a modified version of EMTs earlier bid timetable (also removing Luton Airport peak hour stops) has been used to represent the Do Minimum. This reflects that this latest industry development presents a more pessimistic version of this timetable than developed above. In agreement with the Department this timetable has been modified to reinsert Luton Airport, Luton and Bedford stops, reflecting the impact this would have on onward journey times (modified to account for stopping times but not otherwise to retain operability. (The raw impact of this timetable on national rail revenues is similar prior to and post modification as described above. Relative to the baseline developed for this FBC the EMT 5tph timetable results in a net reduction to national rail revenues of £5.7m<sup>7</sup> prior to modification and of £6.4m post modification).
- **Timetable Scenario 3.** Presents results using timetables developed in the SOBC reflecting a scenario whereby conflicts north of Wigston Junction can be resolved by retiming other operators' services with little net detriment (Corby times in the Do Something are modified as reported above)

These present a range of scenarios for MML Key Output 1. It is anticipated that the likely final position within this range will begin to emerge as further timetable development identified above is delivered.

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<sup>7</sup> Initial analysis on EMTs amended version of this timetable suggests that the net reduction in rail revenues falls from £5.7m to £4.7m following the reintroduction of stops at Luton Airport.

## 4. Demand & Revenue Forecasting

### 4.1. Introduction

This section presents the demand and forecasting methodology and the key assumptions used for each component of the appraisal. It then goes on to present the impact of options on demand and revenue and the consequent impact on crowding levels.

### 4.2. Forecasting methodology

#### 4.2.1. Demand and Revenue Forecasts

Demand and revenue forecasts have been developed using the comparator model developed for use on the ongoing East Midlands Franchise Competition. The development of the revenue model is guided by the Passenger Demand Forecasting Handbook (PDFH) in accordance with DfT TAG guidance (unit M4, 2014).

The revenue model developed for the franchise competition produces forecasts of passenger fare-box earnings, operating journeys, and passenger miles by ticket type from a 2016/17 base-year populated with LENNON<sup>8</sup> data. The LENNON data is processed into 27 flow groups and eight separate ticket categories. This disaggregates demand for forecasting purposes to consider:

- The necessity to disaggregate flows in accordance with response drivers on different flows, for instance GDP per capita elasticities are different on Intercity and SE-London flows. For 'non-London' demand responses to changes in the 'External Environment' (economic growth), PDFHv5.1 introduced separate drivers for flows to/from Britain's eleven Core cities and between (a defined set of 38) major cities - reflecting strong growth in these markets over recent years.
- Separation of 'To London' and 'From London' travel (where the former has an outward leg of journey towards the Capital), reflecting separate PDFH elasticity recommendations, in some cases.

Rail demand forecasting requires consideration of both 'exogenous' and 'endogenous' impacts.

- Exogenous demand drivers are factors which influence rail demand but are outside of the direct control of the rail industry and therefore are unchanged between options. Typically, this relates to the external environment and inter-modal competition. For this appraisal rail fares are treated as exogenous changing only with fares policy.
- Endogenous effects are factors that are within the rail industries control and generally drive the difference between baseline and options forecasts. For this study these drivers are primarily those associated with the Midlands Main Line timetable changes.

The exogenous forecasts for the model are taken from the July 2017 release of the DfT's Demand Driver Generator outputs as produced/supplied by DfT. Exogenous forecasts are converted to rail demand impacts (i.e. percentage year-on-year changes) using a range of 'elasticities' recommended by PDFH. For example, if GDP per capita is forecast to rise by 2% in a given future year, and a GDP per capita elasticity of 1.5 is applicable according to PDFH, then the contribution of rising productivity (per capita income) to rail demand and revenue will be 3.01%. The EMRF revenue model adopts fare elasticities from PDFH v4.0 and non-fare elasticities from PDFH v5.1 (excluding car fuel costs where PDFH v5.0 is retained) as a central case but with the option of v5.0 for sensitivity setting.

The revenue model is supported by dedicated sub-modelling in a number of instances:

- Timetable impacts which are modelled using MOIRA <sup>9</sup> – with both 'Generalised Journey Time' and 'ORCATS'<sup>10</sup> influences reflected (i.e. overall timetable quality and revenue allocation between TOCs, respectively). The revenue model forecasts revenue changes to the franchise revenues as well as knock-on revenue impacts on other franchises; both revenue change estimates are forecast using the previously

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<sup>8</sup> LENNON is a database that stores ticket sale data from all purchased rail tickets in the UK rail network.

<sup>9</sup> MOIRA 1 is a piece of software used to forecast the impact of timetables on passenger demand and revenue.

<sup>10</sup> ORCATS (Operational Research Computerised Allocation of Tickets to Services) is a centralised system that is used to divide farebox revenue when a ticket or journey involves trains in a route served by multiple operators, based on previously undertaken surveys.

presented methodology. This appraisal has been based upon the Wednesday timetable (as a proxy for a typical weekday timetable) assuming that changes to demand and revenue will be scaled proportionally for the Saturday and Sunday timetables.

- Management initiatives which are modelled as a proportional or absolute increase in journeys by flow group. This provides an overlay for non-timetable related initiatives which drive demand which are calculated externally using PDFH guidance; for instance the impact of rolling stock ambience.
- Crowding modelling within a standalone sub model. The crowding model produces suppression factors which reflect DfT guidance<sup>11</sup> by adopting the modelling approach recommended in Section B6 of the Passenger Demand Forecasting Handbook (PDFH) version 5.1); The EMRF model has the following attributes:
  - MOIRA1 (version OR55 DfT Midlands) is used to output predicted Standard Class loads – i.e. boarding, alighting and total load by journey arc on all EMT services in the Wednesday timetable at demand levels in the year to March 2017. As it is not possible to factor directly to counts following a significant timetable change the appraisal of crowding is undertaken using MOIRA loadings. Whilst MOIRA loadings are uncalibrated (i.e. do not necessarily match actual passenger counts at boarding and alighting) and unconstrained (i.e. passengers' behaviour is not affected by the capacity or crowding at each of the trains, that may displace demand to other services) at the train level, this just means that MOIRA is a modelled reflection of passengers intention to board each train. However, MOIRA forecasts were found to provide a reasonably good match to actual passenger counts for the Do Minimum scenario during the development of the original business case;
  - A train formation specific to the option is assigned to each service, allowing a loading level on each arc to be derived;
  - The train loading is converted into an overall 'Value of time multiplier' referencing loading and recommended value-of-time multipliers from PDFH 5.1 Table B6.2.
  - The arc times and boarding/alighting profiles are then used to derive an average journey time for boarders and alighters at each station.
  - The loss of demand due to crowding (i.e. suppressed demand) is calculated for boarders and alighters at each station by combining the percentage increase in (perceived) journey time with an IVT (In-Vehicle Time) elasticity  $[(\text{crowded} + \text{uncrowded mins}) / \text{uncrowded mins}]$  IVT elasticity.
  - Following the first calculation the model then iterates to equilibrium, reflecting the fact that - as some passengers are 'crowded off' - conditions for residual demand are improved. The suppression factor outputs from the crowding model are taken as the average of the final two iterations.
  - The crowding model is then run with uniform growth of between 0% and 50%. Suppression factors for each flow-group and peak/off-peak travel are transferred to the revenue model. Growth for each flowgroup and ticket type growth for any given year is then directly referenced within the revenue model. It should be noted that First Class revenue is assumed never to be suppressed as fares/yields can be increased to price off demand, and to thereby restore earnings (on an assumption of a unitary fare elasticity). However, the revenue model does not explicitly allow for this
  - As well as forecasting suppression, the crowding model includes calculations to derive the perceived crowded hour on each service. This is to allow for the economic benefits of timetable changes to be assessed. This is taken as the sum of the additional minutes of perceived crowded minutes multiplied by the number of passengers on each link. Crowded minutes are split by journey purpose using mapping from PDFH5.0 Tables B0.1 – B0.9.

The table below shows the factors included in the demand and revenue forecasts and the assumptions with relation to the inputs and elasticities:

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<sup>11</sup> TAG Unit M4, November 2014

**Table 4-1      Revenue Forecasting Specification and Parameters**

Item	Assumption	Source
Revenue model price base	Previous financial year 2016/17	Assumption
Demand cap	20 years after year in which appraisal is undertaken. Demand assumed to be capped from 2036/37 onwards. Forthcoming changes A5.3 (November 2017) applied to extrapolation of long term benefits.	2.3.1, TAG A5-3
Base Demand	Year ending March 2017	LENNON
<b>Exogenous Drivers</b>		
GDP or employment	Input: EDGE <sup>12</sup> , Elasticity: PDFH 5.1	Table 1, TAG Unit M4
Population	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Car ownership	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Car fuel costs	TAG data book July 2017, PDFH5.0	Table 1, TAG Unit M4
Car journey Time	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Bus Cost	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Bus Journey Time	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Bus Headway	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Air Cost	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Air Headway	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Underground Cost	DDG July 2017, PDFH5.1	Table 1, TAG Unit M4
Rail Fares	Input: EDGE, Elasticity: PDFH 4.0	Table 1, TAG Unit M4
<b>Endogenous Drivers</b>		
Generalised Journey Time (Timetable changes)	MOIRA OR55, PDFH5.1	Table 1, TAG Unit M4
Ticket Type to Journey Purpose conversions	PDFH 5.0	Table 1, TAG Unit M4
Rolling stock ambience	PDFH5.1	Table 1, TAG Unit M4
Crowding		
Crowding methodology	PDFH 5.1	8.4, TAG Unit M4 (June 2014)
Value of Time Multipliers	Intercity <sup>13</sup>	PDFH5.0 Table B6.2
Train Loadings	MOIRA: OR55	
Crowding: average journey time elasticities	Average derived for EMRF LDHS services = ██████ Average derived for EMRF 'other' services = ██████	Crowding Model
Crowding annualisation	253	Regional PLANET AM Factor
Rolling stock capacities	Existing Rolling Stock: PDFH5.0, Table B7.1 & Passenger Counts See Section 4.2.1.1 for amendments New Rolling Stock: DfT	Table 3, TAG Unit A5.4

**4.2.1.1.    Rolling Stock**

Analysis of present day loadings has shown that the current capacity issue is exacerbated by an imbalance in the First/Standard class seat provision, particularly for 7-car Class 222s. This is evidenced both by an analysis

<sup>12</sup> Exogenous Growth Demand Estimation (EDGE) inputs provided by the DfT (Forecasting Source: July 2017)  
<sup>13</sup> The Intercity value-of-time multipliers are applied as the best fit to the route. This may lead to additional suppression on some of the shorter distance movements over an application where these were considered as 'London & South Eastern'.

of current loading and by the balance of seating of proposed rolling stock. Given the high levels of passenger growth forecast over the appraisal period, a Do Minimum baseline position has considered rebalancing the rolling stock capacities for the existing fleet to partly mitigate high levels of crowding in the baseline. The table below shows the current rolling stock capacity and the rolling stock capacity assumed for the appraisal. Rolling stock capacity is taken from PDFH5.1 Table B7.1 where possible (e.g. where the rolling stock operates on current UK franchises) and is shown in the table below. Capacities for replacement 125mph DMU rolling stock are taken from capacities for IEP rolling stock provided by the DfT. However, these capacities have been pro-rated assuming a maximum vehicle length of 24m, rather than 26m, to avoid exceeding maximum platform lengths for the route (c.240m).

Table 4-2      Rolling Stock Capacity

Rolling Stock	Current Rolling Stock Capacity			Appraisal Rolling Stock Capacity		
	Standard Seats	Standard Class Standing Capacity m <sup>2</sup>	1 <sup>st</sup> Class Seats	Standard Seats	Standard Class Standing Capacity m <sup>2</sup>	1 <sup>st</sup> Class Seats
HST	■	■	■	■	■	■
222 4-car	■	■	■	■	■	■
222 5-car	■	■	■	■	■	■
222 7-car	■	■	■	■	■	■
125 mph DMU 5-car				■	■	■
125 mph DMU 8-car				■	■	■
100 mph EMU 4-car				■	■	■

### 4.3.      Appraisal of Benefits

The Revenue Model developed for the East Midlands franchise competition is used to forecasts demand, revenue, and user time savings in annual hours separately for the baseline and each option. Do Minimum and Do Something scenarios are carried over to the appraisal model where the increment is used to assess scheme benefits. Calculations of economic benefits are based around guidance in TAG Unit A5.3 Rail Appraisal (July 2017) and include the following:

- **Rail revenues** are a product of the demand forecasting accounting for changes to passenger demand and average yields (from the RPI+1% fares policy from January 2021). As the proposed scheme is planned to be implemented outside of the current franchise period, all extra revenue is accrued to the Government and is essentially set against costs for appraisal purposes. For appraisal purposes the wedge between RPI (used to set fares) and the GDP deflator (used as the general measure of inflation) also leads to rising real revenue over time (up to the demand cap)
- **User Benefits** the impacts of timetable changes have been modelled in MOIRA, which provides an estimate of the change in user time savings, and in savings for ‘switchers’, for whom the ‘rule-of-half’ is applied. The VoTs in MOIRA are based on the values in the April 2009 version of TAG unit 3.5.6 and consequently are rebased to updates values using a mapping spreadsheet. This maps ticket types to journey purposes using the TAG data book table A5.3.2 with values of time taken from TAG data book Table A1.3.1. Values of time are taken as shown in the table below:

<sup>14</sup> This appraisal not made any alterations to seating or standing capacities on HSTs because of PRM TSI requirements.

Table 4-3      Values of Time

Purpose	Distance	£/ hour (2010 prices)
Business	0-50 km	£10.02
Business	50-100 km	£16.21
Business	100-200 km	£28.23
Business	200+ km	£40.72
Commuting	All Distances	£9.95
Other non-work travel	All Distances	£4.54

- **Crowding User Benefits:** are calculated as a product of weighted in-vehicle time for loading scenarios given annual loading levels. The franchise crowding model has been extended to consider the impact of alterations to the MML timetable on GTR crowding.
- **Rolling stock ambience:** Is calculated as a weighted in-vehicle time and making the following assumptions with relation to rolling stock:
  - New 125mph DMU will deliver in-vehicle equivalent to existing Class 222s or HSTs
  - A 100mph outer-suburban EMU will deliver a 1.0% increase in in-vehicle time relative to an existing Class 222 or HST. This is to reflect a detriment from the replacement of high quality inter-city rolling stock for services to Corby with suburban style EMUs in the central case. These factors are judgements based on the evidence presented in PDFHv5.1 and values applied for appraisal purposes in other contexts.
- **Greenhouse Gas Emissions:** the monetary value of proposed electrification on greenhouse gasses has been calculated in accordance with TAG Unit A3 Environment Impact Appraisal. Emissions arising from electricity consumption in transport are in the traded sector and therefore are internalised in the operating cost of the trains. However, emissions from diesel fall in the untraded sector; as a result the carbon costs saved can be considered as additional to any operating cost saving, and therefore they have been monetised using carbon values in the TAG databook and included in the numerator of the BCR.
- **Performance:** Performance forecasting for the EMRF has forecast scenarios both retaining and replacing HSTs. These forecasts have been used within the appraisal for the MML Upgrade Programme, however this does not play a significant role in the business case as HSTs are replaced in 2030/31 in both the Do Minimum and Do Something scenarios. Operational performance of the 6tph timetable is assumed to be the same as the Do Minimum 5tph timetable, with the infrastructure works of the scheme supporting a neutral overall performance impact.

## 4.4.      Forecasting Results

This section presents the results of the demand and revenue forecasting exercise and examines the consequent impact on capacity requirements and crowding levels. This presents the following:

- The initial impact of the timetable change for each option, running with the projected journey times from each timetable scenario.
- The impact of the timetable change on train loads and the subsequent impact on revenues from crowding relief;
- The forecast change in demand over the appraisal period and build-up of appraisal benefits.

### 4.4.1.      Forecast Revenue Impacts

#### 4.4.1.1.      Net Revenue Changes from December 2020 timetable changes

The table below shows the net changes in revenue as a result of each timetable scenario change. This shows the raw impact of the timetable change using 2015/16 demand and revenue levels, prior to any differences as

a result of altered levels of crowding. The table shows the net changes resulting from each timetable change in the top three rows (increases/decreases/loss-gain) with additional detail on the main changes by origin-destination following beneath.

Table 4-4      Forecast Net Revenue Impacts (£k per annum, 2015/16 Demand and Prices)

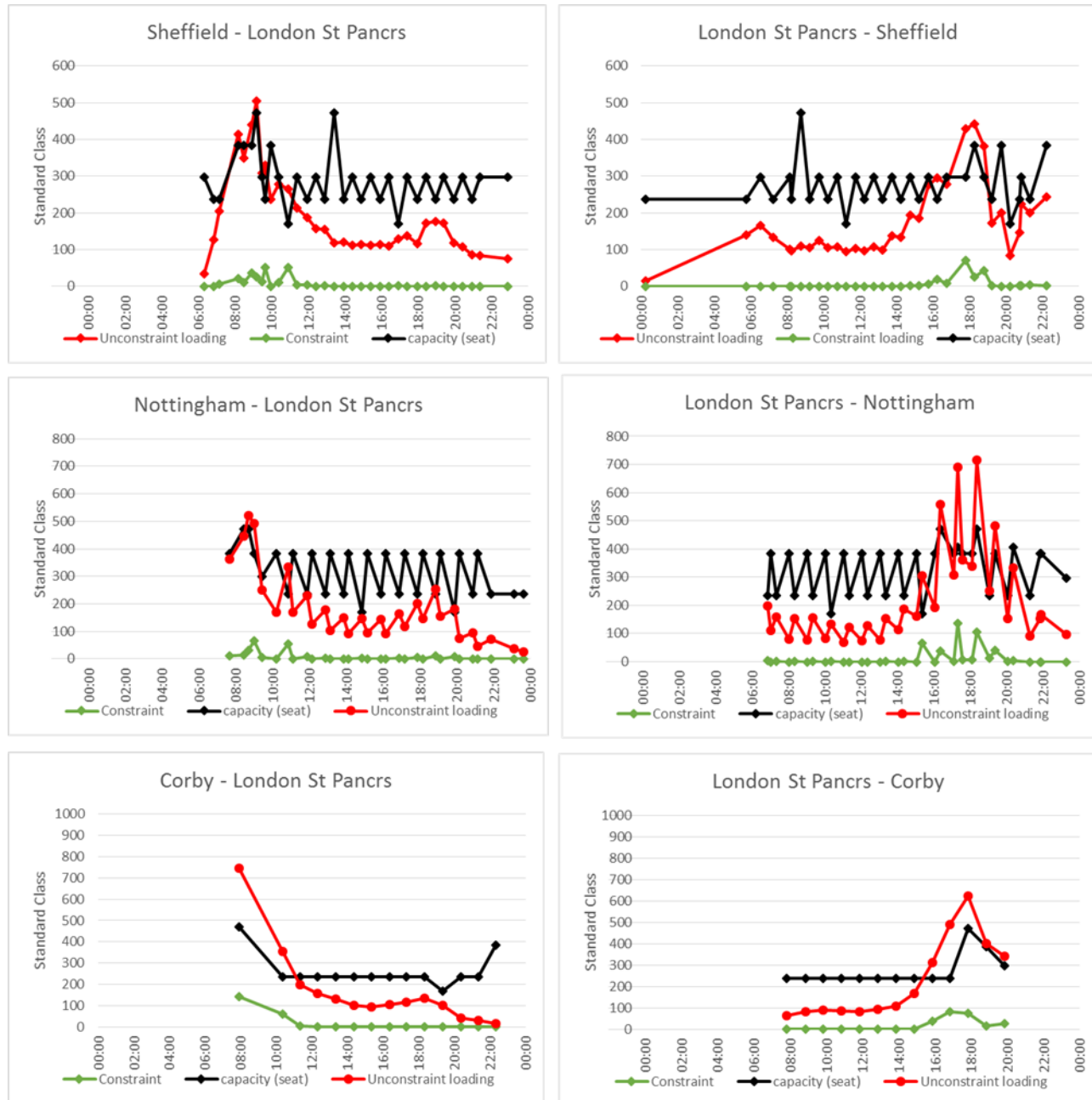
Timetable Scenario 1		Timetable Scenario 2		Timetable Scenario 3	
Net Change					
	Change £k		Change £k		Change £k
Increases	██████	Increases	██████	Increases	██████
Decreases	██████	Decreases	██████	Decreases	██████
Loss/Gain	██████	Loss/Gain	██████	Loss/Gain	██████
Top 10 flows with increased Revenue					
Origin-Destination	Change £k	Origin-Destination	Change £k	Origin-Destination	Change £k
██████████	██████	██████████	██████	██████████	██████
██████████	██████	██████████	██████	██████████	██████
██████████	██████	██████████	██████	██████████	██████
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██████████	██████	██████████	██████	██████████	██████
Top 10 flows with decreased Revenue					
Origin-Destination	Change £k	Origin-Destination	Change £k	Origin-Destination	Change £k
██████████	██████	██████████	██████	██████████	██████
██████████	██████	██████████	██████	██████████	██████
██████████	██████	██████████	██████	██████████	██████
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██████████	██████	██████████	██████	██████████	██████

- The key points to note from the table above are that:
- The net revenue impact of each timetable scenario is a balance of increases and decreases caused by the timetable change. The primary impact of the proposed timetable (driven by the service pattern) is to increase ██████████ through line speed improvements. This comes at the expense of ██████████, and small percentage changes on ██████████. The net impact in each instance is positive.
  - Timetable Scenario 3 taking clean journey times north of Wigston Junction produces ██████████.
  - Timetable Scenario 1 (using timetables developed during the FBC) produces similar ██████████) although as a result of ██████████
  - Timetable 2 is ██████████

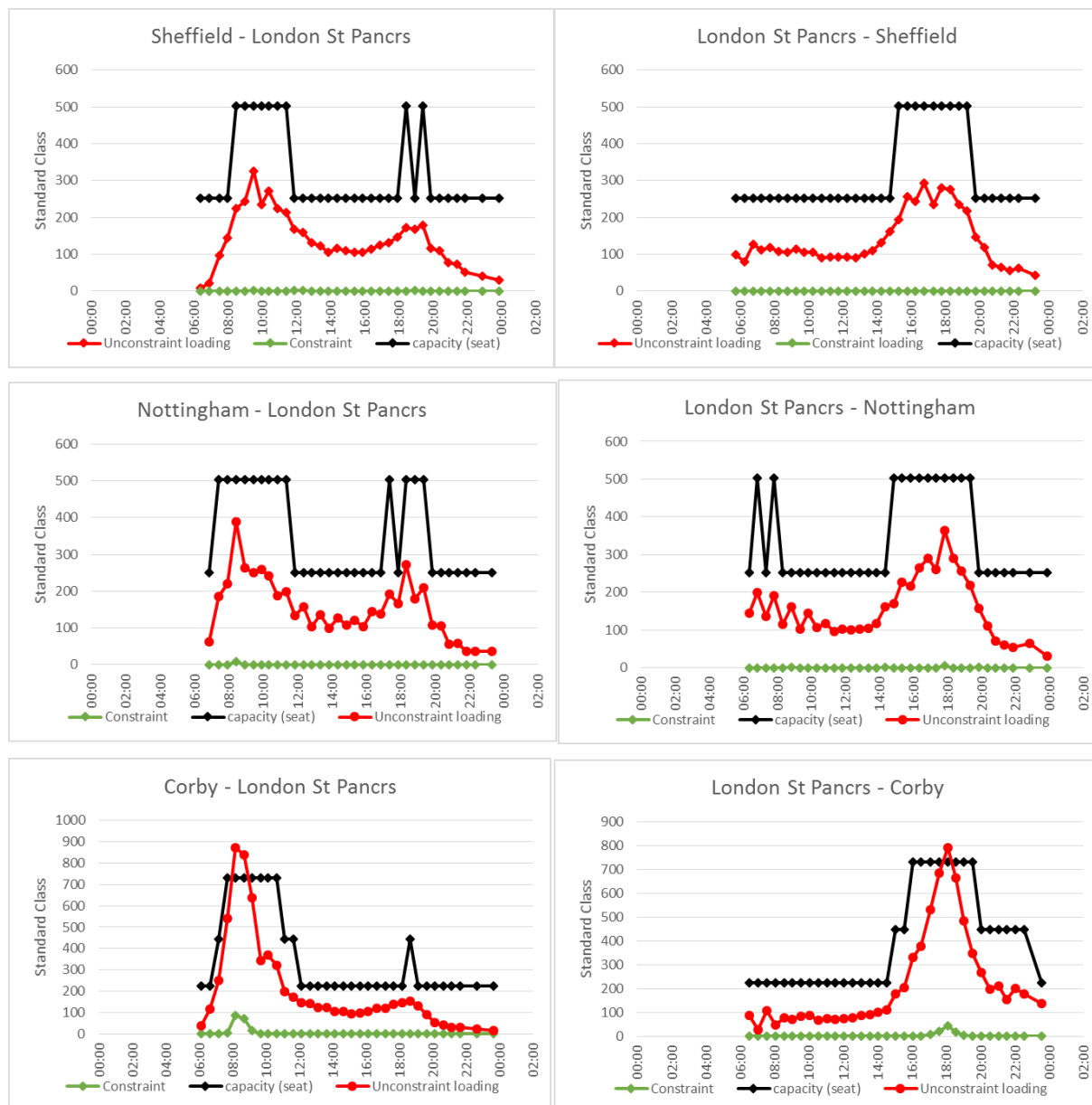
## 4.4.2. Capacity and Crowding

The charts below present train loading forecasts (current day demand) for the baseline and central case timetables. The intention is to show the impact the proposed timetable has on train loading and the impact the proposed service pattern has on requirements for train capacity.

**Figure 4-1 Do Minimum: Critical Loading for each Arrival/Departure (2015/16 Demand)**



**Figure 4-2 Do Something Central Case: Critical Loading for each Arrival/Departure (2015/16 Demand)**



The charts above show that<sup>15</sup>:

- With the current timetable there is an existing inability of the current, or proposed, rolling stock to meet existing demand on Nottingham and Sheffield services. This is particularly pronounced on the stopping service from London St Pancras to Nottingham (calling at Bedford, Luton Airport Parkway and Wellingborough), although the impact is observed on each existing service in the peak due to these stops being supplemented in peak hours.
- There is reduced loading on Nottingham and Sheffield services with the option timetable. This is because the proposed stopping pattern removes stops south of Market Harborough from the Sheffield and Nottingham services; constraining the pronounced peak in demand from commuter flows onto the shorter Corby services.
- The more pronounced peaks on the Corby services resulting in the need for significant peak, and to a lesser extend off-peak, lengthening with 100 mph EMUs.

<sup>15</sup> The loadings in the charts above are shown as per the SOBC timetable. The concept behind the loading profile changes is primarily a function of the service patterns which are consistent between each timetable scenario. Central Case shows capacity with the replacement 5-car fleet from 2030/31.

- The current stopping pattern results in crowding on the existing Nottingham and Sheffield services. This is magnified in future years by exogenous growth in rail demand. The figures above show that capacity constraint on these services is significantly reduced primarily as a result of the implementation of the 6<sup>th</sup> path allowing for the revised stopping pattern, and also through peak strengthening of rolling stock. Although this results in high peak loading on the Corby service there is also a net reduction in crowding from stations south of Kettering which are currently served by the congested Nottingham service. In addition, the implications of constraint are much lower on the Corby service. Revenues between London and Corby totalled █████ in 2015/16, compared to a combined revenue of █████ between London and stations north of Kettering.

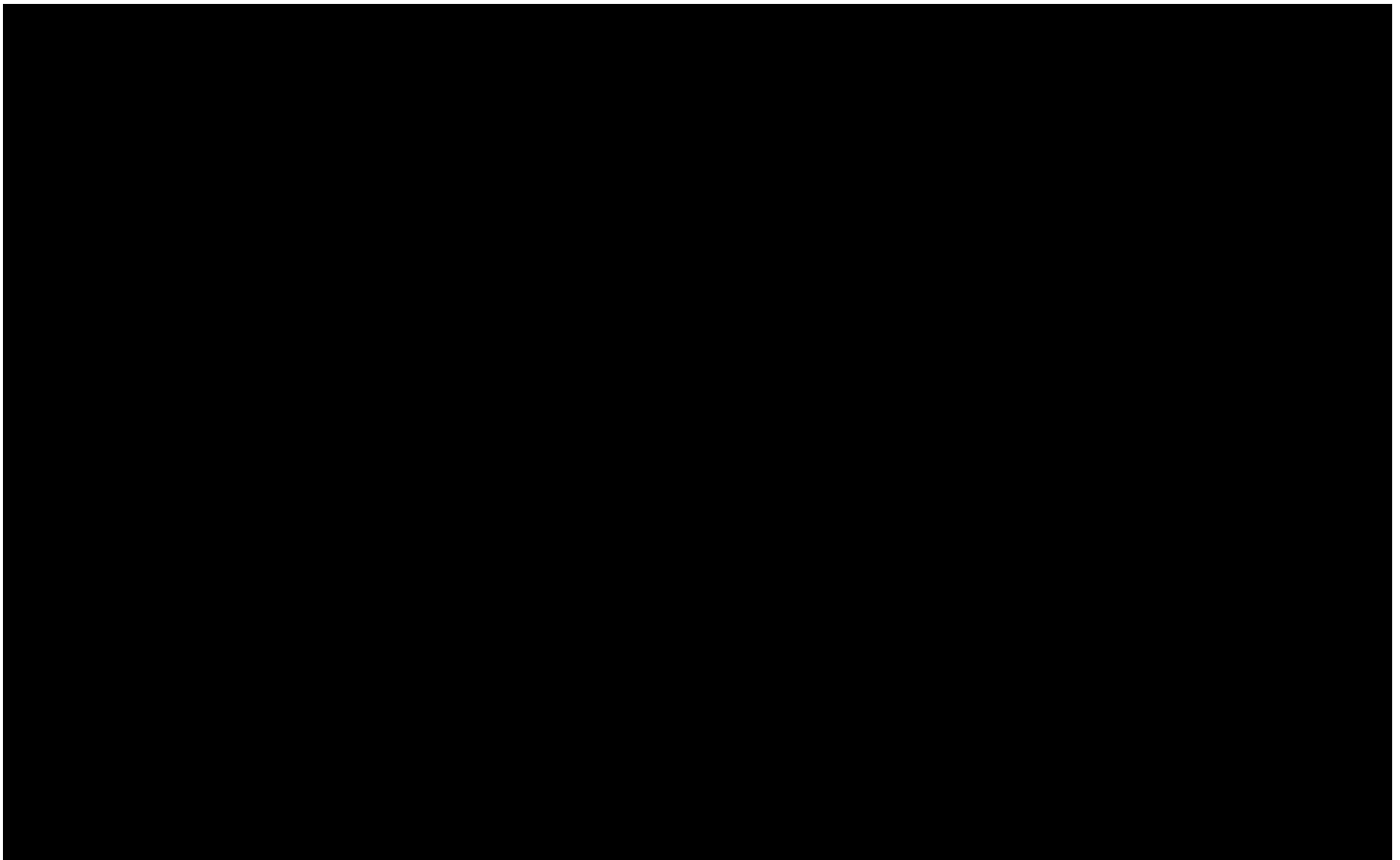
**Table 4-5 East Midlands Trains London Revenues (£k, 2015/16 demand and prices)**

Station A	Station B	2015/16 Revenue £k
London BR	Luton Airport Pwy	████
London BR	Luton	████
London BR	Bedford Midland	████
London BR	Wellingborough	████
London BR	Kettering	████
London BR	Corby	████
London BR	Market Harborough	████
London BR	Leicester	████
London BR	Loughboro Leics	████
London BR	East Midland Pwy	████
London BR	Long Eaton	████
London BR	Beeston	████
London BR	Nottingham	████
London BR	Derby	████
London BR	Chesterfield	████
London BR	Sheffield	████

Source: MOIRA OR55

The impact of the revised stopping pattern on crowding results in un-suppression of existing constrained demand on the Midland Main Line services. Upon implementation, this adds approximately █████ to the increased revenue from the timetable change alone. Post 2030/31 the impact of unconstraint increases as the replacement 5-car fleet is better suited to match demand profiles on the Nottingham and Sheffield services.

**Figure 4-3 Central Case: Net Annual Incremental Revenue over the Baseline Scenario, EMT Revenue (2016/17 prices)**



The table below shows projected standard class seating capacity under each timetable scenario. Seating capacities are presented for the long distance MML high speed services on arrival at London St Pancras in the morning high-peak hour (08:00 – 08:59). This is presented for the central case with steps in LDHS capacity.

**Table 4-6 Peak hour (08:00-09:00) standard seating capacities into London**

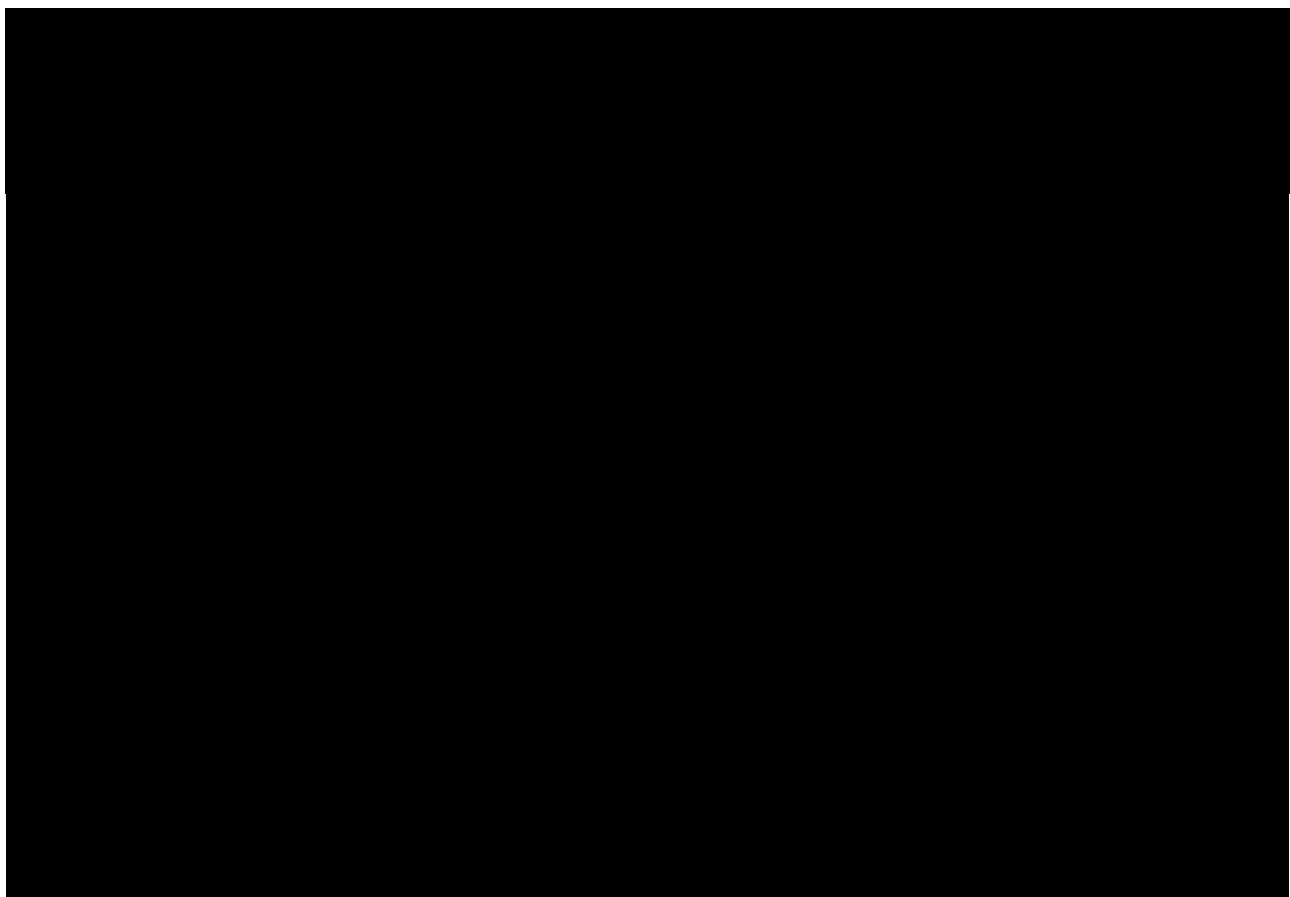
Timetable	Rolling Stock	Standard Seats	Workings
5-path (May 2016)	Existing Fleet	[REDACTED]	[REDACTED]
			[REDACTED]
5-path (May 2016)	Existing Fleet (Reconfigured)	[REDACTED]	[REDACTED]
			[REDACTED]
6-path (Dec 2020)	Existing Fleet (Reconfigured) & 100 mph EMUs	[REDACTED]	[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
6-path (Dec 2020)	5-car 125mph DMUs +100 mph EMUs	[REDACTED]	[REDACTED]
			[REDACTED]

### 4.4.3. Growth in Demand over the Appraisal Period

As an example of revenue growth across the appraisal period and the resulting benefits accrued under Timetable Scenario 3 the chart below shows:

- The annual revenue forecast for the EMT franchise (minus changes to other operator revenues) services under the base and option (depicted by the grey and black line graph)
- The cumulative appraisal benefits accrued over the appraisal period – as the shaded area chart. (Note: for appraisal purposes the increased revenue is essentially treated as a reduction in costs).

**Figure 4-4 Growth in Demand and Benefits Over the Appraisal Period**



Key points to note from the chart above are:

- Revenue forecasts between the baseline and option diverge in 2020/21 with the introduction of the MML KO1 timetable:
  - Total growth in real revenue between 2016/17 and 2036/37 in the Do Minimum totals [REDACTED]
  - Total growth in real revenue between 2016/17 and 2036/37 in the Do Something totals [REDACTED]
- Demand and Revenue continue to trend with population growth following 2037/38 as per Forthcoming changes A5.3 (November 2017)

## 5. Rolling Stock

### 5.1. Introduction

The calculation of operating costs for the appraisal requires the size of fleet required to operate the timetable described in Chapter 3 to be estimated for each option. This chapter sets out the approach to establishing the size of fleet for the rolling stock options that are the subject of testing in the business case appraisal.

The rest of this chapter:

- Sets out the baseline fleet assumptions used in the appraisal;
- Describes the approach to estimating the size of fleet required to operate the standard hour timetable; and
- Details the approach to the estimation of additional units required for peak strengthening.

The ongoing development of the Thameslink timetable for May 2018 has introduced considerable uncertainty around both the Do Minimum 5 tph timetable and the Do Something 6tph timetable. While this uncertainty primarily revolves around assumed journey times and timings around the clock, it may also influence rolling stock requirements. Atkins' understanding of the latest May-18 timetable position is that EMT have been instructed to lease an additional ■ HST sets in order to maintain capacity on MML services in the May-18 timetable. This change is not currently reflected in the modelled Do Minimum scenario or the Do Something. While this assumes the incremental fleet requirements do not differ from the previous MML SOBC, the changes to rolling stock requirements as a result of the Thameslink timetable could result in additional efficiency savings from the Do Something 6tph timetable, or require additional rolling stock to resource. This position will become clearer towards the end of 2017 and will need to be kept under review.

### 5.2. Baseline Fleet Assumptions

The baseline fleet was based on East Midlands Trains current inter-city rolling stock fleet. This is comprised of a mixture of 4, 5 and 7-car Class 222 (Meridian) DMUs and a small number of HST sets which are predominantly used on services between London and Nottingham during the day, with services to/from Sheffield and Leeds in at the start/end of service to allow rolling stock to reach Neville Hill depot. The size of the current fleet is detailed in the table below.

**Table 5-1 Baseline Fleet Assumptions**

Rolling Stock	Length	No. of Sets	No. of Vehicles
Class 222	4 car	■	■
Class 222	5 car	■	■
Class 222	7 car	■	■
HST (Power Car + Mk3 Coaches)	2+8	■	■

\* includes spare vehicles and set currently sub-leased to VTEC that will transfer to VTEC at the end of the current lease.

Source: East Midlands Comparator Suite

In 2030/31 it is assumed that the fleet is replaced by an equivalent DMU fleet, although with all stock capable of meeting Class 222 sectional running times.

## 5.3. Establishment of Rolling Stock Fleet for Modelled Options

Fleet sizes have been estimated using the same approach used for the earlier SOBC appraisal. The following section summarises this approach, and then provides information on the assumed fleet sizes for the Central Case.

A two stage approach was adopted to establish the size of fleet required for each of the modelled options:

- Stage 1: estimate the number of units required to operate the standard hour timetable, including an allowance for spares; and
- Stage 2: identify the number of additional units required for peak strengthening based on analysis of demand forecasting and crowding outputs.

### 5.3.1. Estimation of Standard Hour Fleet

The minimum number of units required to sustain the standard hour timetable has been calculated based on the running times and turnarounds in the timetable. An allowance was then added on for spare sets, assumed to be 10% of the number of sets required to operate the standard hour. The amount of rolling stock assumed to be required to operate the standard hour timetable including spares is shown in Table 5-2.

**Table 5-2 Standard Hour Fleet Requirements Including Spares (No. of Sets)**

	4-car 125mph DMU	5-car 125mph DMU	7-car 125mph DMU	HST (2+8 cars)	4-car 100mph EMU
KO1 6tph: Pre 2030/31 (with strengthening)	■	■	■	■	■
Post 2030/31 (without strengthening)	■	■	■	■	■

\* ■ complete HST sets, plus some spares, i.e. ■ powercars and ■ coaches

### 5.3.2. Peak Strengthening

The approach to peak strengthening was based on an examination of an initial set of loadings from the crowding model. In the first instance, trains were lengthened where demand would otherwise be constrained with 50% growth above the base year. A 50% growth above the base year has been assumed to proxy unconstrained growth up to the demand cap and, therefore, used as a criterion to select which trains were to be strengthened. Where forecast demand was found to exceed the maximum capacity (with lengthening) services either side of the strengthened service(s) were then lengthened as a proxy for peak spreading. Note that the crowding model does not estimate the potential for displacement in arrival time, and consequently does not forecast benefits as a result of this additional lengthening. The extent of lengthening and loading applied to each service on a train-by-train basis is shown for each option in Table 5-3. Basic diagramming was then undertaken to estimate the number of additional units required for both morning and evening peak strengthening.

Peak strengthening is particular to both the set of assumptions used in this appraisal and to the notional timetable developed for the business case testing described in Chapter 3, with loadings assigned by MOIRA. Alterations to the timetable assumptions, e.g. the introduction of additional stops, would result in a different loading profile and alter the requirements for peak strengthening and the likely fleet size.

The table below shows the number of units assumed to be required for peak strengthening.

**Table 5-3 Peak Strengthening Fleet Requirements (No. of Sets)**

	4-car 125mph DMU	5-car 125mph DMU	7-car 125mph DMU	HST (2+8 cars)	4-car 100mph EMU
KO1 6tph (Post 2030/31)	1	2	1	1	2

### 5.3.3. Total Estimated Fleet Requirements

The following table shows the total fleet (standard hour plus additional peak units) assumed to be required for each option.

**Table 5-4 Total Estimated Fleet Requirements (No. of Sets)**

	4-car 125mph DMU	5-car 125mph DMU	7-car 125mph DMU	HST (2+8 cars)	4-car 100mph EMU
KO1 6tph (Post 2030/31)	1	2	1	1	2

**The estimated fleet sizes presented in the table above have been provided for business case comparison purposes only. These numbers should in no way be viewed as recommendations for the optimum fleet size on the upgraded route, which should be the subject of further detailed analysis.**

Prior to 2030/31, it is assumed that the current Meridian fleet is retained and that from the original HSTs (24 powercars and 84 coaches) part of them are no longer necessary due to the introduction of the electric fleet in the Corby services, with a requirement of 2 powercars and 2 coaches – including spares – as shown in Table 5-2.

## 6. Operating Costs

### 6.1. Introduction

Operating costs were estimated for each modelled option using the Comparator Suite developed for the East Midlands franchise competition. The model estimates costs for the franchise with operation of the long distance services on the MML in the baseline scenario and with the revised six train per hour timetable. The difference between the option costs and the baseline cost is the figure carried forward to the appraisal.

The operating cost model considered the variable elements of operating costs only, as follows:

- Network Rail infrastructure costs;
- Diesel and electricity costs;
- Capital lease costs;
- Non-capital lease costs;
- Maintenance costs; and
- Staff costs.

Within the operating cost model, the following inputs are used to drive changes in the operating costs:

- Estimated rolling stock fleet size (number of trains and number of vehicles);
- Requirement for additional staff to operate the 6<sup>th</sup> path;
- Forecast train and vehicle mileages;
- Light and heavy maintenance materials and depot staff (for HSTs).

The following sections provide further details on the input costs, growth rates and other assumptions for each of the above cost areas.

### 6.2. Train and Vehicle Mileages

Train and vehicle mileages are required for the calculation of infrastructure costs (variable track access charge, capacity charge, electrification asset usage charge, energy costs (diesel and electric power) and maintenance costs). Annual train and vehicle mileages were calculated based on the timetable developed for business case testing and are shown for the respective rolling stock options in the table below. Note that the vehicle mileages also account for the additional mileage incurred through peak strengthening of services. Mileage associated with empty coaching stock (ECS) moves were estimated based on the high level diagramming exercise undertaken to determine fleet requirements for the new timetable.

Mileages in the base scenario were calculated based on diagramming information provided by East Midlands Trains and are presented alongside the option mileages for comparison purposes.

**Table 6-1 Annual Train and Vehicle Mileages**

Annual Mileage		4-car 125mph DMU	5-car 125mph DMU	7-car 125mph DMU	HST (2+8 cars)	4-car 100mph EMU	Total
Baseline	Train mileage	██████	██████	██████	██████	I	██████
	Vehicle mileage	██████	██████	██████	██████	I	██████
KO1 6tph (Pre 2030/31)	Train mileage	██████	██████	██████	██████	██████	██████
	Vehicle mileage	██████	██████	██████	██████	██████	██████
KO1 6tph (Post 2030/31)	Train mileage	██████			I	██████	██████
	Vehicle mileage	██████			I	██████	██████

Table 6-1 shows that vehicle mileage in with the KO1 6tph timetable remains similar with both the existing fleet and with a replacement fleet of 5-car 125mph DMUs in 2030/31 (although in the latter the mileage is better matched to demand). In the Do Something case there is approximately a 10% reduction in diesel vehicle mileage. However, total vehicle miles increase by over 20% with the introduction of the 6<sup>th</sup> path.

## 6.3. Infrastructure Cost Inputs

Network Rail infrastructure costs are made up of the following elements:

- Capacity charges;
- Variable track access charges; and
- Electrification asset usage charges.

The cost of traction electricity consumption (electric current for traction or 'EC4T') is a further charge recovered by NR from train operators and would normally be considered as an infrastructure charge along with the above items. However, for the purpose of this report, electricity costs are considered in a separate section on energy costs alongside diesel costs for the existing East Midlands Trains long-distance fleet on the MML.

Further details on the derivation of the inputs to the operating cost model are provided in the following sections.

### 6.3.1. Capacity Charge Rates

Capacity Charge rates are paid by the Train Operating Company to Network Rail based on train mileage these rates are grouped by operator and by service group, differentiating the weekday and weekend rates. The capacity charge was introduced in 2002 with the view to allow Network Rail to recover additional Schedule 8 costs (beyond the baseline) associated with the increased difficulty of recovering from incidents of lateness as the network becomes more crowded. Capacity charge rates were based on the latest Network Rail CP5 charges. The rates (weekday and weekend) for each EMT long-distance service group used in the opex model are shown in the following table.

**Table 6-2 Capacity Charge Rates**

Service Group	Price Year	Weekday Rate (£ per train mile)	Weekend Rate (£ per train mile)
EM1500: STP - Sheffield/Leeds	2015/16	2.026	1.357
EM1520: STP – Derby/Sheffield	2015/16	2.283	1.529
EM1530: STP – Nottingham Fast	2015/16	1.948	1.305
EM1540: STP – Nottingham Slow	2015/16	2.212	1.482
EM1560: STP – Kettering/Corby	2015/16	2.202	1.475

For the option testing, services to Sheffield were allocated to service group EM1500, while services to Nottingham were assumed as being in EM1530 (Nottingham fast). Capacity charges are in 2015/16 prices and in the model are assumed to grow in line with RPI over the appraisal period.

### 6.3.2. Variable Track Access Charge (VTAC) Rates

Variable Track Access Charge (VTAC) rates are paid by the Trains Operating Company to Network Rail for use of its infrastructure. The purpose of the charge is to allow Network Rail to recover its efficient operating, maintenance and renewal costs that vary with traffic (e.g. track wear and tear costs). Variable track access rates used in the opex model are listed in the following table. For existing rolling stock types currently in operation on the UK rail network, VTAC rates were taken from the EMRF comparator suite (based on the values in Network Rail's CP5 price list). The new DMUs deployed to replace the HSTs and Meridians are assumed to have the same VTAC rates as Class 222 Meridians.

VTAC rates are in 2015/16 prices and in the model are assumed to grow in line with RPI over the appraisal period.

**Table 6-3 Variable Track Access Charge Rates**

Rolling Stock	Price Year	Source	VTAC Rate (pence per vehicle mile)
Class 222 Meridian	2015/16	East Midlands Comparator Model Suite	11.83
HST	2015/16	East Midlands Comparator Model Suite	13.59
DMU (replacement for Meridians and HSTs)	2015/16	Assumption	11.83
100 mph 4-car EMU	2015/16	East Midlands Comparator Model Suite	7.14

### 6.3.3. Electrification Asset Usage Charge

The Electrification Asset Usage Charge (EAUC) rates are charged to the operator for the usage of the electric installations in the infrastructure, for instance, the wires. Therefore, this is only charged to electric trains and is based on vehicle mileage. Electrification asset usage charge rates applied to electric vehicles in the opex model are listed in the following table. This is based on the rate provided in NR's CP5 price list. The EAUC rate is given in 2015/16 prices and is assumed to grow in line with RPI over the appraisal period.

**Table 6-4 Electrification Asset Usage Charge Rates**

Rolling Stock	Price Year	Source	EAUC Rate (pence per vehicle mile)
100 mph 4-car EMU	2015/16	East Midlands Comparator Model Suite	1.73

## 6.4. Fuel Costs

Fuel costs in the opex model are calculated by multiplying the cost of fuel by the volume of fuel consumed. The following sections set out the traction energy consumption rates and fuel costs assumed in the opex model. Note that diesel costs are required for the calculation of operating costs in the baseline scenario.

### 6.4.1. Diesel Consumption Rates

The rates applied in the opex model are shown in the table below.

**Table 6-5 Diesel Consumption Rates**

Rolling Stock	Unit	Source	Diesel Consumption Rate
Class 222 Meridian	litres per vehicle mile	East Midlands Comparator Model Suite	0.94
Class 43 HST	litres per vehicle mile	East Midlands Comparator Model Suite	0.71 <sup>16</sup>
DMU (replacement for Meridians and HSTs)	litres per vehicle mile	East Midlands Comparator Model Suite	0.94

### 6.4.2. Diesel Fuel Prices

Diesel price growth is based on the values for Gas Oil (resource cost plus duty) provided in Table A1.3.7 of the WebTAG databook (March 2017). The prices quoted in the WebTAG databook correspond to the latest Department for Energy and Climate Change (DECC) forecasts. Prices in the databook are quoted in calendar years, and these were subsequently converted to financial years for input into the financial model, which allowed us to derive the diesel price growth series. This growth series was applied to the diesel price inputs in the East Midlands Comparator Model Suite, which presented a diesel spot price value of 36.2p per litre from 2018/19 onwards (in 2015/16 prices) and a duty of 11.1p per litre, to which the real growth to diesel prices was applied. A blended growth forecast was applied to the total diesel price accounting for the resource cost and the duty element of this price.

### 6.4.3. Electric Current for Traction Consumption Rates

Energy consumption rates for electric traction were provided by DfT Rail Analysis and are shown in the table below.

**Table 6-6 Electric Traction Consumption Rates**

Rolling Stock	Unit	Source	Electric Traction Consumption Rate
100mph Suburban EMU – 4 car	kWh per vehicle mile	DfT Rail Analysis	3.47

### 6.4.4. Electric Fuel Prices

Electricity price growth is based on the values for Electricity provided in Table A1.3.7 of the WebTAG databook (March 2017). The prices quoted in the WebTAG databook correspond to the latest DECC forecasts. Prices in the databook are quoted in calendar years, and these were subsequently converted to financial years for input into the financial model, which allowed us to derive the electricity price growth series. This growth series was applied to the electricity price inputs in the East Midlands

<sup>16</sup> Per vehicle mile of a total set (10)

Comparator Model Suite, which presented an electricity price value of 9.09p per kWh (in 2015/16 prices), to which the real growth to electricity prices was applied.

## 6.5. Lease Costs

Lease cost inputs are comprised of two elements: capital and non-capital lease costs. In both cases, the costs are driven by the size of the required rolling stock fleet in terms of number of vehicles. The base fleet and fleets required for the 5 options were detailed in Chapter 5.

### 6.5.1. Capital Lease Costs

Capital lease costs were provided by DfT Rail Analysis. The base costs and price base assumptions are shown in the following table.

**Table 6-7 Capital Lease Costs**

Rolling Stock	Price Year	Source	Unit	Capital Lease Cost (£)
Class 222 Meridian	2015/16	East Midlands Comparator Model Suite	£ per veh per annum	██████
Class 43 HST	2015/16	East Midlands Comparator Model Suite	£ per veh per annum	██████████
Mk3	2015/16	East Midlands Comparator Model Suite	£ per veh per annum	██████████
100 mph Suburban EMU – 4 car	2020/21	Atkins Assumption	£ per veh per annum	██████
DMU (replacement for Meridians and HSTs)	2020/21	DfT Rail Analysis	£ per veh per annum	██████

**Class 222.** Capital lease costs for the Class 222 fleet remain constant until 2018/19, based upon the rates offered by Eversholt to EMT for the Direct Award. Post-2018/19 lease costs are increased to account for reconfiguration of the trains into alternative formations with fewer first class seats.

**HST** capital lease rates reflect the agreed rates offered by Porterbrook to EMT for the Direct Award period. PRM-compliant rates would assume a switch to refurbished HSTs (with MTU power cars) and include a capitalised rental of the anticipated expenditure required to make the trailer cars PRM-compliant and fitted with CETs (██████ per vehicle). These costs are based upon a financing rate of ██████████, financed over the lifetime of the franchise. However, these PRM-compliance refurbishment costs are considered to be a one-off payment for the appraisal purposes (i.e. the cost of refurbishing the full HST fleet would have to be paid in full regardless of how many units are no longer required after introduction of the EMUs), therefore considered equally in the Do Minimum and Do Something and not impacting the economic appraisal.

#### 6.5.1.1. Treatment of Future Capital Lease Costs

The treatment of future capital lease costs was undertaken in accordance with the guidance in TAG Unit A5.3.

### 6.5.2. Non-Capital Lease Costs

Non-capital lease costs were not used to model the rolling stock maintenance costs. The costs to maintain the rolling stock are dependent on the lease agreement – dry, soggy or wet, reflective of the

degree of maintenance interventions which are undertaken by the operator– and are reflected in Section 6.6.

## 6.6. Maintenance Costs

Maintenance costs are dependent on the type of lease agreement signed by the TOC for each rolling stock. For MML business case purposes, the assumptions on maintenance are as follows:

- HSTs are maintained through a dry lease, where the TOC carries out the entire maintenance. Therefore, in appraisal terms, only maintenance costs are captured and considered variable. These costs cover light and heavy maintenance materials and have been extracted from the latest East Midlands comparator model.
- Class 222's maintenance follows the current TSA agreement assumptions, which set out a maintenance cost per mileage band;
- The remaining rolling stock's maintenance costs are purely mileage-based, as reflected in the table below.

In all cases, when applicable, costs were assumed to increase in line with RPI until the demand cap year (2036/37) after which they were assumed to be fixed in real terms, as per the recent guidance issued by DfT.

**Table 6-8 Mileage-Based Maintenance Rates**

Rolling Stock	Price Year	Source	Unit	Maintenance Rate
Class 222 Meridian	2015/16	East Midlands Direct Award TSA	£ per vehicle mile	████
HSTs	2015/16	East Midlands Direct Award TSA	£ per vehicle mile	████
DMU (replacement for Meridians and HSTs)	2015/16	DfT Rail Analysis	£ per vehicle mile	████
100mph EMU – 4 car	2015/16	DfT Rail Analysis	£ per vehicle mile	████

\* The mileage-based maintenance rate indicated for Class 222 Meridians is an indication of the average per-mile rate calculated from the TSA for the fleet's mileage range. For scenarios adjusting Class 222 mileage rates have been forecast at £████ per vehicle mile.

<sup>1</sup> The mileage-based maintenance rate indicated for HSTs is an indication of the average per-mile rate calculated for the fleet's mileage range and given the heavy and light maintenance materials costs. Note that staff costs savings linked to fewer HST units needed to be maintained at Neville Hill are assessed separately in the staff section.

## 6.7. Staff Costs

The 6<sup>th</sup> path delivered by the scheme which facilitates an additional hourly service to Corby will require the operator to recruit additional drivers to operate this service. Indicative analysis was undertaken to estimate the total additional driver establishment required.

Based on an end-to-end journey time of approx. 1 hour, it was assumed that 1 driver can undertake 2 round trips per diagram. With 16 hours of daily operation, the number of driver diagrams required to operate this service was indicatively estimated as 8 diagrams per day. An utilisation factor of 0.46 based on the ratio of driver establishment to driver diagrams for EMT's intercity services on the MML (sourced from analysis produced for the EMT Direct Award) was used, giving a total establishment of 17 drivers for the MML SOBC. Further refinements to estimate the number of drivers required were undertaken for the development of the East Midlands Comparator Suite, which resulted in a final driver establishment figure of 20 FTEs, plus an additional Driver Support FTE. For the central case, Corby services are assumed to run under driver only operation (DOO).

The reduction in the number of HSTs needed to be maintained at the Neville Hill depot following the introduction of the electric fleet drives a reduction in the required number of staff at the depot. It has been considered that the number of staff required to maintain the fleet is proportional to the size of the fleet, therefore bringing in a reduction in 40 FTEs from 2020/21, with all staff removed following HST replacement.

The appraisal has assumed that on-board staff on Corby services in the Do Minimum would be redeployed onto Sheffield and Nottingham services to cover the requirement for extra on-board staff resulting from the additional peak strengthening in this scenario. It has been estimated that from the introduction of the electric fleet until the replacement of the Meridians and HSTs in 2030/31, 9 FTE (Full Time Equivalents) on-train staff would be no longer necessary, as the remaining could cover the strengthened trains. From 2030/31 on, when the diesel fleet is replaced by a uniform 5 car strengthened fleet, an extra 14 FTE on-trains staff would be required to cover the needs for strengthening compared to the baseline position. These estimates are based on the mileage where doubled units are required, in which case it is assumed that two on-train staff would be required.

## 6.8. Operating Costs

Total operating costs (in nominal, undiscounted values) calculated for the 60 year appraisal period are shown for each the Do Minimum and Do Something scenarios below. With the exception of capital lease costs, costs are presented for the EMRF franchise as a whole.

**Table 6-9 Total Operating Costs (60 years, £bn, nominal undiscounted)**

	Baseline	Central Case
Staff Costs	32.11	32.23
Rolling Stock Capital Lease Costs	4.32	4.87
Rolling Stock Fixed Maintenance Costs	0.00	0.00
Capacity Charge	2.95	3.38
VTAC	1.25	1.34
EC4T	0.00	1.12
EAUC	0.00	0.05
FTAC	5.20	5.20
Other Charges (Stations, Depots, etc.)	19.02	19.16
Diesel	6.07	5.56
Variable Maintenance Costs (Calc. on a per mile basis)	9.66	10.49
Materials Costs for Maintenance	0.87	0.93
<b>Total</b>	<b>81.45</b>	<b>84.33</b>
<b>Total: Option - Base</b>		<b>2.88</b>

## 7. Scheme Capital Costs

### 7.1. Capital Cost Estimates

Capital cost estimates for the infrastructure upgrade were supplied by the DfT sponsor based on information received from Network Rail. Please note that these costs were not reviewed, checked or audited as part of this work.

The costs supplied by NR were supplied with an annual profile in nominal prices. Each element of the scheme included an overlay showing the GRIP stage and existing allowances for risk and contingency. Each component of the scheme has been adjusted with reference to its stage of development to produce a risk and optimism bias adjusted costs as advised in WebTAG. Additionally costs which have already been incurred and have been committed prior to this economic assessment have been removed, as sunk costs (which represent expenditure incurred prior to the scheme appraisal and the decision to go ahead) are not considered in appraisal. A summary of the scheme cost estimates are shown in Table 7-1.

**Table 7-1 Scheme Capital Cost Estimates (£k, nominal prices)**

Scheme	GRIP	Total AFC	COWD (as of P3 2017/18)	Contracted Commitments	P80 value (shown for GRIP1/2)
CP5 MML Kettering to Corby Capacity	6	131,170	103,629	27,541 <sup>17</sup>	-
Derby Remodelling	6	188,291	30,774	157,517 <sup>18</sup>	-
<b>KO1 Other Sub-total (K2C &amp; Derby Remodelling)</b>	<b>6</b>	<b>319,461</b>	<b>134,403</b>	<b>185,058</b>	<b>-</b>
Derby to Sheffield JTI KO1	1	15,405	1,089		1,934 <sup>19</sup>
Market Harborough	3	53,392	7,457		-
Leicester South LSI	2	7,399	168		1,800
Contingency/unallocated for PJIF	n/a	680	0		-
Ambergate Enhancement contribution to renewal	2	3,000	0		600
<b>PJIF Sub-total</b>	<b>varies</b>	<b>79,876</b>	<b>8,714</b>	<b>0</b>	<b>2,400</b>
MMLE - Overarching GRIP 1 to 8	3	28,005	21,725	29,678	-
L2C Track and civils project	3	147,048	22,504		-
Grid Supply Points	3	87,600	19,409		-
L2C Route Clearance	3	91,953	43,057		-
L2C Kettering Electric Stabling	3	19,272	3,161		-
L2C Primary	3	166,394	73,278		-
L2C AT	3	0	0		-
L2C Distribution	3	98,673	4,625		-
L2C Enabling	3	28,795	5,198		-
L2C OLE	3	150,668	9,670		-
L2C Ops and maintenance	3	5,851	123		-
L2C Powerlines	3	33,239	47		-
L2C Schedule 4 & Possession management	3	36,107	3,582		-
L2C Signalling & Telecoms	3	82,487	8,693		-
L2C Stations	3	42,795	4,870		-
<b>L2C Sub-total</b>	<b>3</b>	<b>1,018,887</b>	<b>219,942</b>	<b>29,678</b>	<b>-</b>
<b>Total</b>	<b>varies</b>	<b>1,418,225</b>	<b>363,058</b>	<b>214,736</b>	<b>4,344</b>

<sup>17</sup> NR advise that all further work is committed for this project, and project is in construction, so total cost included in work committed.

<sup>18</sup> NR advise that all contracts have been let for this project, and that there is potential financial exposure for the full amount of the AFC. This remains under review between DfT and NR, and should works be halted on this project there is a chance that some costs of work contracted may be recouped.

<sup>19</sup> Taken of the original budget of £37,5050 with a P80 value of £24,023 and the AFC value of £15,405 following overlay transferred back to PJIF Fund Holder with reduction in AFC/budget. Assumes budget transfer in CP5 of £22.1m to L2C

## 8. Economic Appraisal

### 8.1. Introduction

This chapter presents the results of the economic appraisal for the Midland Main Line upgrade. The assessment has been undertaken using the Department for Transport's standard approach to the economic appraisal of transport infrastructure investment as set out in WebTAG with particular focus on the guidance for appraisal of rail schemes provided in TAG Unit A5.3.

The chapter covers:

- The derivation of the scheme costs, which describes the methodology for converting base costs into a present value of costs used in the economic appraisal;
- The source of the scheme benefits, providing a summary of the source of the benefits estimated for the respective timetable scenarios which are included in the present value of benefits;
- The results of the appraisal, which presents summary economic statistics (Present Value Benefits (PVB), Present Value Costs (PVC), Net Present Value (NPV) and Benefit Cost Ratio (BCR)) for each of the timetable scenarios.
- The results of a series of tests undertaken to understand the robustness of the business case to changes in a range of key assumptions, including journey times, capital costs and demand growth; and

Standard assumptions used in the appraisal are set out in Table 8-1 below.

**Table 8-1 Core Appraisal Assumptions**

Item	Assumption
Appraisal period	60 years
First year of appraisal	2019/20
Last year of appraisal	2079/80
Discount rate	3.5% for 30 years from current year, 3% - years 31-60
Present value year	2010

### 8.2. Derivation of Scheme Costs

The costs associated with the MML upgrade business case were discussed in detail in Chapters 6 and 7. The following sections detail how these costs were converted for use in the economic appraisal.

#### 8.2.1. Capital Costs

The base scheme capital costs are presented in Chapter 7. The costs supplied by NR were supplied with an annual profile in outturn prices. Each element of the scheme included an overlay showing the GRIP stage and existing allowances for risk and contingency. Each component of the scheme has been adjusted with reference to its stage of development to produce a risk and optimism bias adjusted costs as advised in WebTAG. Additionally costs which have already been incurred have been removed in line with guidance; sunk costs (which represent expenditure incurred prior to the scheme appraisal and the decision to go ahead) are not considered in appraisal. Finally, costs are converted to 2010 prices and values and are presented in a market price base. A summary of the scheme cost estimates is shown in Table 8-2. Values are presented throughout the adjustment

process for inclusion in the appraisal, including risk and contingency adjustment, removal of sunk costs and application of optimism bias. The costs in the final column were taken forward into the appraisal. This shows:

- Costs as supplied by Network Rail. Nominal (Outturn) costs inclusive of sunk cost and risks
- Removal of sunk costs (including Cost Of Work Done (COWD) and Contracted Commitments)
- Removal of risk and contingency from the costs supplied
- Addition of optimism bias relevant to the GRIP stage of each part of the programme
- Costs discounted to 2010 prices and values and presented in market prices.

**Table 8-2 Scheme Capital Costs Included in the Appraisal (£k, nominal prices, except for appraisal values which are in 2010 present values prices and discounted)**

Scheme	AFC	COWD & Contracted Commitments Removed <sup>20</sup>	Risk and Contingency Removed (GRIP 1/2)	Optimism Bias Included	Appraisal (£k, 2010 prices, discount.)
CP5 MML Kettering to Corby Capacity	131,170	0	0	0	0.00
Derby Remodelling	188,291	0	0	0	0.00
Derby to Sheffield JTI KO1	15,405	14,316	12,382	20,307	14,125
Market Harborough	53,392	45,935	45,935	54,203	43,162
Leicester South LSI	7,399	7,231	5,431	8,907	7,379
Contingency/unallocated for PJIF	680	680	0	0	0
Ambergate Enhancement contribution	3,000	3,000	2,400	3,936	3,145
L2C Sub-total	1,018,888	769,270	769,270	907,738	703,163
<b>Total</b>	<b>1,418,225</b>	<b>840,432</b>	<b>835,418</b>	<b>995,092</b>	<b>770,975</b>

## 8.2.2. Treatment of Operating Costs in the Economic Appraisal

The assumptions underpinning the calculation of the base operating costs are set out in Chapter 6. This section presents the operating costs included in the economic appraisal, which form part of the overall PVC for each rolling stock option, summarised in Table 8-3 below.

**Table 8-3 Incremental Operating Costs Included in the Appraisal (£m, 60 years)**

Rolling Stock Option	Scheme	Total Nominal Undiscounted Factor Costs	Total Discounted Factor Costs (2010 present values)	Total Discounted Opex (Market Prices)	Total Discounted Opex with OB (Market Prices & OB)
<b>Central Case</b>	5-car 125mph EMU / 100mph EMU	■	■	■	■

## 8.3. Derivation of Scheme Benefits

The primary source of benefit in the appraisal is that derived from rail users; these benefits have been estimated in accordance with the methodology described in Chapter 4. In addition, the appraisal has also estimated decongestion benefits for existing road users, and the reduction in other 'external' costs, including accidents, noise, local air quality, and greenhouse gas emissions, both of which result from mode switch from car to rail as a result of the MML upgrade programme. These external benefits have been calculated using the methodology provided in WebTAG Unit A5.4 – Marginal External costs which is based on assumptions relating to the change in distance travelled by car

<sup>20</sup> See Table 7-1 Scheme Capital Cost Estimates (£k, nominal prices) for detail.

drivers as a result of changes in the distance travelled by rail passengers. Additionally, carbon and air quality benefits have been appraised using the methodology provided in WebTAG Unit A3 – Environmental Impact Appraisal.

### 8.3.1. Indirect Tax Impacts

Indirect tax impacts have been calculated using the methodology provided for rail schemes in Appendix a of TAG Unit A5.3. There are three main sources of indirect tax effects in rail: (a) expenditure shifts from/to goods or services due to rail revenue changes, as VAT is not levied on rail fares; (b) changes in fuel taxation due to mode shift from road to rail, which is higher than the average level of indirect taxation and (c) indirect tax effect in rail diesel, which is subject to duty, as an effect of rail diesel vehicle kilometres changes. This will result in a loss of indirect tax revenues to central government and a subsequent reduction in the present value of benefits, since indirect tax revenues are treated as negative benefits in the appraisal.

In addition, the appraisal has also considered the indirect tax impacts of a change in diesel train use with reductions in diesel mileage in the scheme allowing an electric fleet to run to Corby.

## 8.4. Economic Appraisal Results

### 8.4.1. Summary

Summary economic statistics for each timetable scenario are presented below in Table 8-4. Full TEE tables (Transport Economic Efficiency tables) are provided for each option in 11. Appendix D. PVC is comprised by investment costs, changes to operating costs and revenue transfer. Where a scheme generates significant revenue the later can offset the former with schemes becoming financially positive, where schemes are not financially positive but where revenue transfer offsets a significant proportion of costs, BCRs can become particularly sensitive to additional changes in costs/revenues. As a result the three major contributing factors to PVC are shown in the table below.

**Table 8-4 Economic Summary Statistics (£m, 2010 present values)**

Timetable Scenario	Scenario 1	Scenario 2	Scenario 3
<b>PVB</b>	<b>673</b>	<b>1,066</b>	<b>1,113</b>
<i>Investment Costs</i>	<i>771</i>	<i>771</i>	<i>771</i>
<i>Operating Costs</i>	■	■	■
<i>Revenue</i>	■	■	■
<b>PVC</b>	<b>399</b>	<b>155</b>	<b>21</b>
<b>Resulting Net Present Value</b>	<b>274</b>	<b>911</b>	<b>1,092</b>
<b>BCR</b>	<b>1.69</b>	<b>6.87</b>	<b>52.87</b>

Department for Transport Value for Money (VfM) Guidance identifies the following categories for defining the VfM of a scheme<sup>21</sup>:

- Poor VfM if BCR is below 1.0
- Low VfM if the BCR is between 1.0 and 1.5
- Medium VfM if the BCR is between 1.5 and 2.0
- High VfM if the BCR is between 2.0 and 4.0
- Very High VfM if the BCR is greater than 4.0

Based on the results presented in Table 8-4 Key Output 1 of the Midlands Main Line Upgrade package represents

- Medium VfM using FBC development undertaken on the December 2016 (Iteration 1) cut of the Thameslink timetable;
- Very High VfM assuming that the Do Minimum scenario above is amended to reflect the EMT version of the timetable provided in July 2017 removing EMT stops at Bedford, Luton and Luton Airport Parkway during peak hours
  - A modified version of this timetable was supplied on 11th August 2017 reinstating peak hour stops at Luton Airport Parkway.
- Very High VfM assuming conflicts in the Do Something timetable north of Wigston Junction can be resolved by retiming other operators' services with little net detriment (as per the SOCB)

#### 8.4.2. Changes from the SOBC

Even with Timetable Scenario 3 (taking clean benefits from the Do Something timetable) the NVP of the business case for the Key Output 1 appraisal has reduced relative to that produced during the SOBC. This is primarily for two reasons:

- Due to reduced socio-economic forecasts post Brexit, and less favourable projections of changes in service levels and costs of competing modes, the forecast increase in rail demand over the appraisal period has reduced significantly since the production of the SOBC. Changes to DDG drivers between January 2016 and July 2017 reduce real revenue growth on the EMRF franchise (to the 20-year demand cap) from 120% to 88% (CAGR 3.83% to 3.05%) and demand growth from 59% to 39% (CAGR from 2.23% to 1.58%). This results in lower compounding on timetable benefits, and reduced return on capacity improvements.
- The SOBC assumed that the Do Minimum timetable would operate with SRTs enabled by the existing fleet throughout the appraisal period. On a comparable basis with the Do Minimum timetable, this FBC assumes that the replacement fleet in 2030/31 would be capable of achieving Class222 SRTs; saving approximately 8 minutes on the end-end journey time between Nottingham and London St Pancras.

A 'bridge' presenting the impact of the above two items on the KO1 Business Case is presented in Appendix A.

#### 8.4.3. Disaggregation of User Benefits

Table 8-5 provides a breakdown of the Present Value of Benefits:

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<sup>21</sup> Value for Money Assessment: Advice Note for Local Transport Decision Makers December 2013

**Table 8-5 Disaggregation of Present Value of Benefits (£m, 2010 present values)**

<b>Timetable Scenario</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>
Noise	2	2	3
Local Air Quality	2	2	2
Greenhouse Gases	56	58	60
Journey Quality	282	282	279
Physical Activity	0	0	0
Accidents	24	32	35
Rail Economic Efficiency (Commuting)	-33	36	-10
Rail Economic Efficiency (Other)	-2	47	45
Rail Economic Efficiency (Business)	181	396	453
Road Economic Efficiency (Commuting)	107	139	157
Road Economic Efficiency (Other)	119	156	175
Road Economic Efficiency (Business)	51	66	75
Wider Public Finances (Indirect Taxation Revenues)	-115	-152	-162
<b>PVB</b>	<b>673</b>	<b>1,066</b>	<b>1,113</b>

As can be seen from the table above:

- For Timetable Scenario 3 rail user benefits account for around 60% of the present value of benefits; of this 63% is derived from rail user savings with 37% crowding benefits. Reduced highway congestion accounts for another 32% of the benefits. Improvements to air quality only account for 5% of the total benefits as the Nottingham and Sheffield services continue to be diesel operated.
- In Timetable Scenario 1 with a lower incremental uplift from the timetable change the rail economic efficiency benefits are reduced as journey time savings are lower. This also reduces road economic efficiency as modal shift is lower. Air quality and crowding benefits remain similar to the original timetable scenario.
- There is a negative impact on the PVB of all scenarios as a result of losses in indirect tax. This is primarily as a result of increased expenditure on public transport which is zero-rated for VAT purposes, and a reduction in diesel use on the rail network due to the switch to electric traction which reduces Government fuel duty receipts. Reductions in road vehicle mileage also lead to lower fuel duty receipts. This negative impact of lost indirect taxation revenues offsets approximately 14% of the economic benefits from the scheme.

## 9. Sensitivity Tests

### 9.1. Introduction

A number of sensitivity tests have been undertaken; these are split into two categories as follows:

- To quantify the potential for additional benefits not included within the central business case including:
  - The impact of freight benefits (as described in the Section above);
  - A high-level quantification of Cross Country's timetable aspirations following Derby Remodelling; and
  - Sensitivity testing with interim air quality values as provided in supplementary guidance to TAG Unit A3 (February 2016)
- To understand the robustness of the business case to changes in key variables, including:
  - Resilience to increases in capital costs;
  - High and Low growth scenarios for rail;
  - Sensitivities around the 20-year demand cap;
  - The impact of delayed investment on the business case;
  - Alterations to future rolling stock formations; and
  - Resilience to alternative rolling stock strategies requiring onwards investment

The results of sensitivity testing are presented below. Unless stated otherwise sensitivity tests have typically been undertaken based on Timetable Scenario 3; for sensitivity testing this is hereafter referred to as the 'Central Case'.

### 9.2. Sensitivity Testing: Additional Benefits

#### 9.2.1. Sensitivity Test B1: Freight

The purpose of this sensitivity test is to present the impact the central estimate of freight benefits would have on the central case appraisal. It should be noted that, although the specification for timetable development mandated the increased provision of freight paths, no benefits from this provision are included in the central case appraisal. The methodology and detailed analysis relating to this sensitivity test are presented in Appendix B Freight Benefits. In summary, the appraisal of freight benefits is based on the Departments set of HGV specific Marginal External Costs, which monetise the benefits of a reduction in HGV miles realised through additional rail freight.

**Table 9-1 Sensitivity Test 1: Economic Summary Statistics (£m, 2010 present values)**

Scenario	PVB	PVC	NPV	BCR
Central Case	1,113	21	1,092	52.87
STB1 Freight	1,426	-24	1,450	Fin+

The addition of freight benefits under this sensitivity test adds £358k of NPV (a range surrounding this value is discussed in Appendix B Freight Benefits). Costs are reduced by £45m through changes in road related infrastructure costs whilst the £313m of additional benefits are primarily realised through reduced congestion and a reduction in greenhouse gas emissions.

#### 9.2.2. Sensitivity Test B2: Cross Country Post Derby Remodelling

Cross Country have aspirations to achieve journey time savings following Derby remodelling, concentrating on the Birmingham – Newcastle (via Doncaster) service in the northbound direction only. A study examining this opportunity was supplied by XC (September 2015) concluded that it

appears possible to save up to 28 minutes on the Birmingham – Newcastle (via Doncaster) service with minimal changes to other operators' services post the remodelling of Derby station. There are currently significant dwell times on this service; working backwards the crucial factor is to get in front of the VTEC services at Doncaster and around xx55ish.

With regard to this saving, the present study recognises that there will be considerable clashes with freight services, particularly in the Water Orton, Sheffield and Doncaster areas, unless amendments are made to the freight timetable. These have not been considered a constraint and it is assumed any clashes could be resolved during formal timetable development work. Where another operators' paths need wholesale retiming, alternative options for these paths have not been explored and, again, it's assumed this would take place during the formal timetable development work.

These benefits have not been included in the central case, partly to exclude these benefits as costs associated with Derby Remodelling are contracted commitments, and therefore are treated as 'sunk' costs within this appraisal. A sensitivity has been undertaken providing a high-level monetisation of the above aspiration; this has:

- Coded in a 28-minute saving to Cross Countries Birmingham – Newcastle (via Doncaster) services through reducing existing dwell times at York, Derby and Birmingham New Street making no changes to other operators' services
- Assumed no resulting changes to operating costs, although it is noted that this change may allow Cross Country to require one fewer set.

The resulting timetable adds █████ to net national rail revenues (2016/17) over the core 6tph timetable. The impact on the wider appraisal is shown in the table below:

**Table 9-2 Sensitivity Test 2: Economic Summary Statistics (£m, 2010 present values)**

Scenario	PVB	PVC	NPV	BCR
Central Case	1,113	21	1,092	52.87
STB2 XC Derby Remodelling	████	██	████	████

Relative to the central case scenario XCs timetable aspirations reduce the costs over the appraisal period by █████ (NPV), through increases to rail revenues. Proposals also add █████ to the PVB through journey time savings associated with the timetable change, and through reductions in marginal external cost. The net effect is to increase the net NPV of the scheme by █████. As the net costs of the central case are █████, this additional reduction in costs results in a financially positive appraisal<sup>22</sup>.

### 9.2.3. Sensitivity Test B3: Higher Air Quality Benefits

A sensitivity test using higher damage costs for NOx emissions shall be undertaken as defined in TAG Unit A3 air quality guidance, forthcoming changes (March 2017). This guidance proposes a higher damage cost for NOx emissions, which is also disaggregated by geographical area and use.

In September 2015 the Department for Environment, Food & Rural Affairs (Defra) published new guidance for valuing air quality impacts on a damage cost basis. New interim values for NOx emissions are given on a damage cost basis and are disaggregated by source of origin. For transport, values are presented for a range of geography types.

<sup>22</sup> Investment schemes which have capital cost in early years but deliver large operating cost savings or generate large revenues that passes back to the broader transport budget in later years (as is the case in this appraisal) can result in low net costs or financially positive schemes. Where net costs approach zero the BCR of a scheme can become highly sensitive to small increments to cost.

In agreement with the DfT this sensitivity test has assumed that NOx emissions from diesel can be taken to be in the order of 80 grams per kilometre per train (as per TAG Unit A3 Environmental Impact Assessment) with no NOx emissions from electrical rolling stock.

Where a sensitivity test has been carried out using the guidance outline in the previous section, the results should be reported in the 'Quantitative' column of the 'Air Quality' row of the Appraisal Summary Table, but should not be included in the 'Monetary £(NPV)' column.

**Table 9-3 Sensitivity Test 2: Economic Summary Statistics (£m, 2010 present values)**

Scenario	PVB	PVC	NPV	BCR
Central Case	1,113	21	1,092	52.87
STB3 Higher Air Quality Benefits	1,170	21	1,149	55.71

The revised values for air quality benefits increases the monetary valuation of reduced emissions by £58m. The impact of Air Quality benefits on the appraisal remains limited due to diesel operation continuing to Sheffield and Nottingham.

### 9.2.4. Additional Benefits Summary

The sensitivity tests presented above would have the same magnitude of effects on each timetable scenario and are broadly independent from each other. The table below summarises the scale of the sensitivity tests above on each timetable scenario investigated.

**Table 9-4 Additional Benefits Scenarios Summary (£m, 2010 present values)**

Timetable Scenario	Timetable 1		Timetable 2		Timetable 3	
	NPV	BCR	NPV	BCR	NPV	BCR
<b>Central Case</b>	274	1.69	911	6.87	1,092	52.87
STB1 Freight	632	2.78	1,269	12.53	1,450	Fin+
STB2 XC Derby Remodelling	■	■	■	■	■	■
STB3 Higher Air Quality Benefits	331	1.83	968	7.25	1,149	55.7
<b>STB1 + STB2</b>	837	4.07	1,474	53.47	1,655	Fin+

The table above shows that the potential benefits additional to the central case are of significant value to the appraisal with an increment of ■ associated with increased provision for freight and Cross Country's timetable aspirations following Derby Remodelling. The impact on the BCR is dependent on the net benefits and costs of each scenario. The addition of freight benefits would uplift the BCR in the most pessimistic timetable scenario from 1.7 to 2.8 (High VfM) the additional consideration of Cross Country's timetable aspirations would further uplift this to ■

## 9.3. Sensitivity Testing: Robustness

### 9.3.1. Resilience to increases in capital costs

The resilience of the business case to changes in the capital costs has been examined. This has examined the level of additional capital cost that could be incurred under each timetable scenario whilst still delivering a BCR of >2.0 'High VfM'. The table below shows the results of this test with the change in capital costs (£NPVm 2010) presented in brackets.

Scenario	PVB	PVC	NPV	BCR
<b>Timetable 1</b>	673	399	274	1.69
BCR = 2.0	673	337 (-63)	337	2.00
<b>Timetable 2</b>	1,066	155	911	6.87
BCR = 2.0	1,066	533 (378)	533	2.00
<b>Timetable 3</b>	1,113	21	1,092	52.87
BCR = 2.0	1,113	556 (535)	556	2.00

The table above shows that:

- Under Timetable Scenario 1 the scheme would require costs to reduce by £63m before the BCR reached high value-for-money.
- Under Timetable Scenario 2 the scheme could incur additional capital costs of £378m (NPV, 2010 values) before the BCR reduced to <2.0
- Under Timetable Scenario 3 the scheme would require costs to increase by £535m before the BCR reached the high value-for-money threshold.

### 9.3.2. Sunk Costs

The sensitivity tests below show the impact of treating only COWD as sunk costs (removing contracted commitments from sunk costs). This treats all contracted commitments as retrievable although this is not likely to be realistic:

- NR have advised that all further work for MML Kettering to Corby Capacity is committed so total cost included in work committed.
- NR advise that all contracts for Derby Remodelling have been let, and that there is potential financial exposure for the full amount of the AFC. This remains under review between DfT and NR, and should works be halted on this project there is a chance that some costs of work contracted may be recouped.

The impact of removing contracted commitments from 'sunk costs' is shown in the table below

Scenario	PVB	PVC	NPV	BCR
<b>Timetable 1</b>	673	399	274	1.69
Timetable 1: Sunk Costs	673	543	130	1.24
<b>Timetable 1</b>	1,066	155	911	6.87
Timetable 2: Sunk Costs	1,066	298	767	3.57
<b>Timetable 1</b>	1,113	21	1,092	52.87
Timetable 3: Sunk Costs	1,113	164	948	6.76

### 9.3.3. Impact of High and Low growth scenarios for rail

High and Low growth scenarios for rail shall be examined as defined in TAG Unit M4 Forecasting and Uncertainty Section 4.2. The results of high and low growth scenarios for rail are presented in the table below:

- High and Low growth scenarios for rail shall be examined as defined in TAG Unit M4 Forecasting and Uncertainty Section 4.2;

**Table 9-5 Sensitivity Test 4: Economic Summary Statistics (£m, 2010 present values)**

Scenario	PVB	PVC	NPV	BCR
Central Case	1,113	21	1,092	52.87
High Growth	1,215	-88	1,303	Fin+
Low Growth	1,019	134	885	7.62

The sensitivity test shows that the business case performs better in high growth scenarios. This is due to higher crowding levels in the baseline timetable which magnifies the revenue benefits of the 6-path timetable with additional demand growth. Additional growth also increases compounding of the revenue resulting from the journey time savings.

It could be speculated that high growth scenarios may be considered likely given that the PDFH forecasting framework has tended to under forecast rail demand growth over recent years and does not account for endogenous initiatives to promote growth (other than those which are appraised as part of this business case).

## 9.4. Delayed investment

Reference Class Forecasting shows a level of schedule slippage can be expected based on previous comparable programmes. Given the schedule risk around Key Output 1, the franchise competition had assumed a 12-month buffer between the entry into service date for the infrastructure and the timetable change date. The original date for delivery of KO1 infrastructure was December 2019, so benefits under the franchise were assumed from the timetable change date of December 2020. In order to inform the benefits of a buffer between the entry into service date for infrastructure and the timetable change date the following sensitivity tests have been undertaken.

- The impact of a 12-month delay to benefits realisation has been assessed (i.e. through an assumed 12-month buffer between the entry into service date for the infrastructure and the timetable change date) through incorporating a sensitivity applying the timetable change from December 2019 instead of December 2020 as in the central case.
- The impact of a late delivery of infrastructure has then been appraised through re-applying a 12-month delay to the start date of the timetable alongside the inclusion of overlapping costs on rolling stock, drivers and maintenance (assuming 100EMUs are cascaded into the franchise as scheduled with a delay in the infrastructure preventing their entry into service).

The impact of these tests is presented in the table below:

**Table 9-6 Delayed Investment Sensitivity Tests**

Scenario	PVB	PVC	NPV	BCR
Central Case	1,113	21	1,092	52.87
December 2019 Operation	<b>1,121</b>	<b>20</b>	<b>1,101</b>	<b>56.12</b>
Only Costs from December 2019	<b>1,112</b>	<b>36</b>	<b>1,077</b>	<b>31.01</b>

The sensitivity tests above show that:

- Bringing the timetable change forward 1-year to the delivery date of the infrastructure would bring £9m of additional benefits with a net cost saving of £1m (Operating costs of £15m offset by a revenue transfer of £16m. This increases the appraisal NPV by £9m (rounding applies).
- Slippage to the implementation date of the infrastructure delaying the timetable implementation back to the original date would then result in £15m of cost incurred with no additional of revenue or benefits over the central case, reducing the NPV of the appraisal by £15m.
  - At first sight the impact on BCR is significant. This due to a the net costs of the scheme approaching zero due to revenue transfer (a change from £20m to £36m, relative to initial capital costs of £771m)

This sensitivity is of low significance to the 60-year appraisal of the infrastructure (impacting on 1<sup>st</sup> year costs and benefits only). This is likely to be of more significance to franchise affordability which is over a shorter period.

## 9.5. Rolling Stock Formation (8-car DMU)

This sensitivity examines a Do Something scenario whereby the existing Class222/HST fleet is replaced by an 8-car 125mph fleet in 2030/31 rather than a 5-car 125mph fleet.

**Table 9-7 Sensitivity Test 4: Economic Summary Statistics (£m, 2010 present values)**

Scenario	PVB	PVC	NPV	BCR
Central Case	1,113	21	1,092	52.87
8-car 125 DMU (Replacement)	1,044	173	871	6.02

The sensitivity test above shows that the NPV of the scheme reduces from £1,113m with a 5-car fleet to £1,044m. The BCR of 6.0 remains 'Very High'. The 8-car option delivers most of the user benefits and revenue transfer of the 5-car fleet. However, the additional costs associated with running an 8-car service throughout the day (maintenance & fuel costs) are projected to more than offset savings from a reduced fleet size and savings in on-board crew through removing the need for doubling-up of on-board crew when 5-car services operate in coupled pairs.

## 9.6. Rolling Stock Strategy and Onwards Investment

### 9.6.1. Introduction

As a sensitivity test on future investment (and with regard to current considerations on the EMRF) this sensitivity test below examines the impact of replacing the existing fleet with a replacement fleet 8-car 125mph Bi-Modes in 2023/24. This fleet would be assumed to be capable of meeting the SRTs of the existing Class 222 trains: running in electric mode south of Kettering then diesel mode north of Kettering. At present, the Hitachi AT300 bi-mode trains are limited to 100 mph maximum speed in diesel mode and are not designed to match Class 222 acceleration in diesel mode. However alternative manufacturers are also anticipated to offer potentially suitable designs. The timetable for the Midland Main Line would not be able to be delivered without a 125 mph capable bi-mode in both diesel and electric mode.

Estimating the costs for rolling stock that does not yet exist is challenging. The following assumptions have been made for this sensitivity test:

- **Capital Lease Costs** of [REDACTED] (2020/21 prices) assuming construction in 2020/21, capital cost of [REDACTED] in today's prices and a financing rate of [REDACTED]. (Consistent with the EMRF Rolling Stock Business Case, December 2017 and identical to that assumed for new 125mph DMUs)

- Based upon a Class 800/AT300 **diesel consumption rates** are taken as 1.11 litres per vehicle mile, 18% higher than a Class 222 (consistent with the EMRF Rolling Stock Business Case)
- The **VTAC Rate** is taken as 13.24 pence per mile in 2015/16 prices. Rates are 12% higher than for a Class 222 reflecting the greater weight per vehicle. (Consistent with assumptions from the EMRF Rolling Stock Business Case)
- **Maintenance Costs** of [REDACTED] per vehicle mile.
- Electric Current for Traction consumption rates of 3.47 kWh per vehicle mile based upon Class 800/AT300 consumption rates
- EAUC rate 1.73 pence per vehicle mile.

Additional capital costs required to deliver 125mph OHLE (Over Head Line Equipment) south of Bedford and capability for a 6tph electric service south of Kettering have been provided by Network Rail via the Department. A summary of the scheme capital cost estimates for the staged appraisal are shown in the table below presenting the adjustment process for inclusion in the appraisal

**Table 9-8 Incremental Appraisal: Scheme Capital Cost Estimates (£k, 2010 present values)**

Scheme	GRIP	AFC	COWD Removed	Risk and Contingency Removed (GRIP 1/2)	Optimism Bias Included	Appraisal (£k, 2010 prices, discount.)
Cabling back or OHLE solution between Braybrook and Kettering	1/2	85,801	85,801	29,172	47,843	33,239
Power/Neutral sections/signalling South of Bedford	1/2	45,284	45,284	42,024	68,919	47,881
OLE 125 mph	1/2	50,000	50,000	35,000	57,400	39,878
OLE to Market Harborough	1/2	8,000	8,000	5,600	9,184	6,381
<b>Total</b>	<b>1/2</b>	<b>189,085</b>	<b>189,085</b>	<b>111,796</b>	<b>183,346</b>	<b>127,379</b>

The results below show the impact of the sensitivity test on the economic appraisal:

**Table 9-9 Sensitivity Test 4: Economic Summary Statistics (£m, 2010 present values)**

Scenario	PVB	PVC	NPV	BCR
Central Case	1,113	21	1,092	52.87
8-car 125 DMU (Replacement)	1,044	173	871	6.02
Bi-Mode Test (8-car)	<b>1,300</b>	<b>252</b>	<b>1,049</b>	<b>5.17</b>

The VfM of the overall investment remains 'very high' including the additional costs incurred to operate the Bi-Mode services under the wires to Kettering.

Relative to the 8-car 125 DMU replacement option the BI-Mode test delivers an NPV of £1,300m against an NPV of £1,044. The two BCR is lower due to the balance of benefits to costs. The Bi-Mode requires additional capital costs for the infrastructure, this is partly offset through additional revenue transfer from running a full timetable with stock assumed to be capable of Class 222 sectional running times from 2023/24, and in increasing seating capacity above that provided with the existing fleet.

Bi-Modes also realise air quality benefits (although this is tempered by the assumption that diesel consumption is assumed to be 18% higher than an existing Class 222).

The balance in the NPV of the Bi-Modes and the 8-car DMU test is highly sensitive to different cost assumptions for each type of stock, whilst the differences to the 'Central Case' are impacted on by different assumptions on rolling stock formation.

# 10. Impact of HS2 Phase 2 on MML Upgrade Programme

## 10.1. Introduction

As agreed with the Department a sensitivity test assessing the impact of HS2 on the KO1 FBC has been undertaken using the methodology and PLANET Framework Model runs from the MML SOBC. This is outlined below.

## 10.2. Overview

HS2 Phase 2 is currently expected to open in 2033, providing fast services to Sheffield, Derby and Nottingham which will abstract demand from conventional services on the MML, and have a potentially detrimental impact on the investment case for the MML upgrade programme. The analysis in this section investigates the impact of HS2 Phase 2 on the value for money of the MML upgrade programme, taking account of the demand abstracted by HS2 services. This refreshes similar analysis from the SOBC.

The analysis was undertaken using the assumptions for HS2 contained in the published HS2 Business Case as developed at the time of the SOBC. This assumes that Nottingham and Derby are served by HS2 via a parkway station at Toton, requiring an interchange for city centre journeys. Sheffield is assumed to be served by a new station at Meadowhall, again requiring an interchange for trips to and from Sheffield City Centre. It should be noted that the changes to the Phase 2 alignment announced in July 2016, and proposals for HS2 to now serve Sheffield city centre directly are not reflected in the analysis.

The HS2 Business Case released capacity specification for the MML currently assumes a reduced train service specification of 5tph on the MML post-opening of HS2. This effectively assumes that the additional capacity created by the enhancement programme which facilitates an LDHS (Long Distance High Speed) frequency of 6tph to/from London St Pancras is not utilised following the introduction of HS2 Phase 2. For this analysis, an alternative released capacity specification was defined for long distance services on the MML based on 6tph to/from London St Pancras, maximising the capacity created by the upgrade programme.

Different analytical approaches were used to determine the impacts described above. However, the first step for both involved a single run of the PLANET Framework Model (PFM) v6.1b to model the alternative 'released capacity' service specification for LDHS services on the MML. PFM is able to reliably forecast the net UK impact on demand, revenue and benefits of HS2 Phase 1, 2a and the Full Y for any particular year. The outputs from this run were then used to inform the separate impacts of an alternative MML TSS on the HS2 Business Case and the impact of HS2 on the VfM of the MML programme. Note that this run also included changes to the Do Minimum MML specification assumed in the HS2 Business Case (based on 5tph to Leicester) to reflect the timetable developed for this Business Case which assumes 4tph to Leicester and 2tph to Corby.

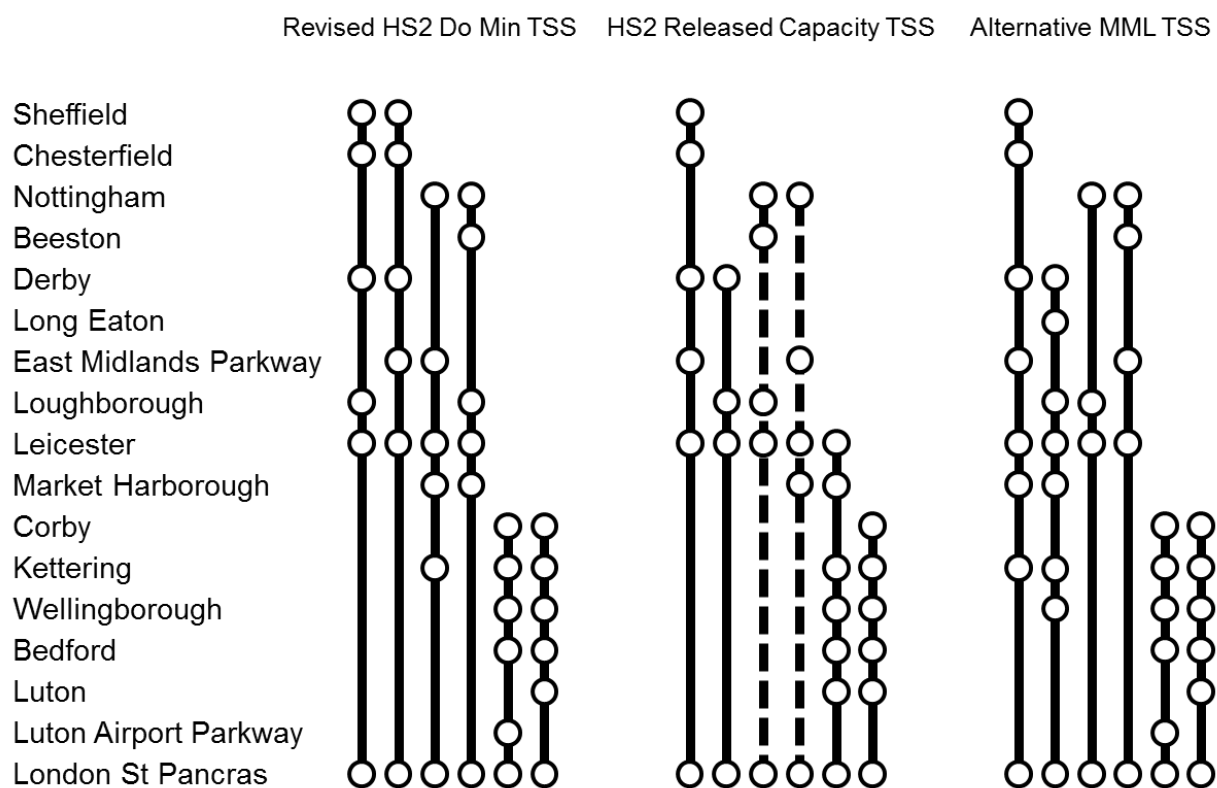
## 10.3. Analytical Approach

### 10.3.1. Alternative MML Released Capacity Specification

As noted above, an alternative released capacity specification for long distance services on the MML based on 6tph to/from London St Pancras was jointly defined by DfT and Atkins, with support from HS2 Ltd and is shown in the figure below. Also, presented for comparison is the released capacity

TSS currently assumed in the HS2 Business Case, along with the timetable developed for this Business Case, which forms the Do Minimum specification for HS2.

**Figure 10-1 Alternative MML Released Capacity Specification**



Note:

Solid line represents 1tph

Dashed line represents 0.5tph

Derby service in HS2 released capacity specification also includes a call at Toton (not shown)

Notable differences of the alternative released capacity TSS are:

- Compared to the 'pre-2033' MML TSS, the swapping of Market Harborough and Kettering calls from the Nottingham services into the Derby and Sheffield services facilitate further speeding-up of the Nottingham services and utilizes capacity on the Derby/Sheffield services freed up by the transfer of long-distance trips to HS2.
- Compared to the existing HS2 released capacity specification, the provision of 2tph all-day to Nottingham, facilitating twice hourly calls at Loughborough and East Midlands Parkway and hourly calls at Beeston against 1.5 and 0.5 calls in the HS2 TSS.
- Compared to both the pre-2033 and existing release capacity specifications, connectivity enhancements at Kettering (4tph all-day) and Wellingborough (3tph all-day).

Note the following additional TSS changes made to non-MML services in the alternative specification:

- Introduction of a Leicester-Toton-Derby shuttle to maintain connectivity.
- The East-West Rail service in the HS2 released capacity specification that extends north of Bedford to Nottingham via Toton was curtailed at Bedford.
- Introduction of an additional 1tph Leicester-Toton-Nottingham shuttle to maintain connectivity, with stopping pattern mirroring the curtailed EWR service north of Leicester.
- St Pancras to Bedford additional Thameslink commuter service in the Phase 2 released capacity specification was retained.

### 10.3.2. Appraisal Approach

The impact of the alternative MML TSS on the overall HS2 business case was appraised by running the outputs from the PFM run through the HS2 economic appraisal framework, enabling a direct comparison with the HS2 central case and calculation of the incremental benefit and revenue changes associated with the revised MML TSS. The impact of the alternative TSS on operating costs has not been assessed at this stage as Atkins do not have access to the HS2 cost models to enable a comparison to be undertaken on a like-for-like basis. Given this, the assessment of the impact of the alternative TSS is therefore limited to a comparison of the benefits and revenues with the HS2 central case.

An alternative approach was adopted for assessing the impact of HS2 on the VfM of the MML upgrade programme. For consistency with the earlier part of the appraisal (i.e. the period between 2020 and 2033) it was not appropriate or possible to use outputs from the HS2 appraisal framework for this purpose. Instead, the approach adopted was to use demand outputs from the PFM run to adjust the demand forecast in the existing appraisal. This enabled the demand abstracted by HS2 from services on the MML to be reflected in the appraisal while retaining demand (and hence benefits) for movements not affected by HS2 such as London to Leicester as well as intermediate movements along the route. It also enabled any additional benefits arising from the alternative TSS to be captured. The approach to adapting PFM demand outputs for use in the MML appraisal was based on the methodology developed by Atkins for use on the ICWC franchise, summarized as follows:

- A process known as select line analysis was used to extract from PFM the station to station demand by TOC and journey purpose, both with and without HS2.
- Select line analysis has the property of double counting trips in which passengers use two different TOCs to make their journey. The station to station demand extracted using the select line analysis was filtered to remove these double counted trips and allocate an appropriate portion across different TOCs. This was undertaken by comparing on the selected flow the number of trips for each flow in the PLD matrix to the aggregated number of trips across the given TOCs from the select line analysis. Where the difference was more than 10 trips per day, these additional trips were allocated across the respective TOCs on the basis of the distance to/from the likely interchange location. Note that the extent of double-counting on the MML was limited due to the lack of competition between operators with the majority of the long-distance market captive to EMT.

The filtered PFM station to station demand reflects the proportion of MML demand which would be retained in a post HS2 scenario between each origin and destination station pairing. Using PFM to provide a percentage change in demand, rather than an absolute change in demand, ensures that the impact of HS2 pivots off the MML base demand and revenue used to forecast revenue prior to 2033. The table below shows the proportion of demand forecast to be retained on MML services for key London movements after the introduction of HS2 Phase 2.

**Table 10-1 Proportion of Demand Retained on MML for Key London Movements**

Station A	Station B	Retained Demand
London BR	Leicester	85%
London BR	Loughboro Leics	72%
London BR	East Midland Pwy	25%
London BR	Long Eaton	66%
London BR	Beeston	41%
London BR	Nottingham	42%
London BR	Derby	29%
London BR	Chesterfield	27%
London BR	Sheffield	7%

The scaling factors were then mapped to the MML appraisal process using the following methodology:

- The PFM demand uplifts/downlifts were then imported into the demand model as a timetable change in 2033 over the baseline timetable and Do Something timetables. The resultant impact on the appraisal is to factor the incremental benefit of the timetable change to retain the uplift on the proportion of passengers who remain on the MML. For example, 85% of the revenue uplift is retained at Leicester compared to only 42% at Nottingham.
- The Alternative MML TSS timetable was coded into MOIRA to obtain proxy GJTs for the revised specification. Journey time savings derived by MOIRA were factored to current values as with other option tests. Benefits by origin-destination pairing were factored, similarly to demand and revenue, to represent the proportion of demand which would still benefit in a post-HS2 scenario (i.e. 85% of passengers on Leicester and London would the forecast journey time saving, compared to only 7% of passengers between Sheffield and London.)
- Factors were used to apply scaling factors to loading by origin-destination pair within MOIRA. This effectively outputs a forecast post-HS2 loading factor for each service in the base, which were then ran through the crowding model as with other options.

Rolling stock assumptions for the alternative TSS were based on the central case for the core business case tests i.e. 100mph suburban EMUs for Corby and 5 car 125mph EMUs on the other LDHS services. Crowding levels following application of the adjustment factors were examined to Loadings were examined to determine the extent of required peak strengthening. In summary, the abstraction of long-distance demand to Derby, Sheffield and to a lesser extent Nottingham by HS2, and a rebalancing of the stopping pattern to transfer Kettering and Market Harborough demand from the Nottingham services onto the Derby/Sheffield services, reduced the amount of strengthening required for peak services, facilitating a reduction in fleet size post-2033, delivering operating cost savings compared to the central case. The size of fleet required to operate the alternative Phase 2 MML TSS is shown in the table below.

**Table 10-2 Fleet Requirements for HS2 Phase 2 Alternative MML TSS (No. of Units)**

	Central Case	Alternative MML TSS	Change
125mph 5 car EMU	39	31	-8

The reduction in strengthening also lowers requirement for on-board staff. A net reduction with the Central Case of 19 FTE for on-board is achieved through the reduction in unit strengthening, as is shown in the table below.

**Table 10-3 On-Board Staff Requirements for HS2 Phase 2 Alternative MML TSS (No. of FTEs, difference with respect to today's staff levels)**

	Central Case	Alternative MML TSS	Change
125mph 5 car EMU	+14	-5	-19

## 10.4. Appraisal Results

### 10.4.1. Impact of HS2 on Value for Money of MML Upgrade Programme

The table below shows the impact of HS2 on the benefits delivered by the MML upgrade programme:

**Table 10-4 Disaggregation of Present Value of Benefits (£m, 2010 present values)**

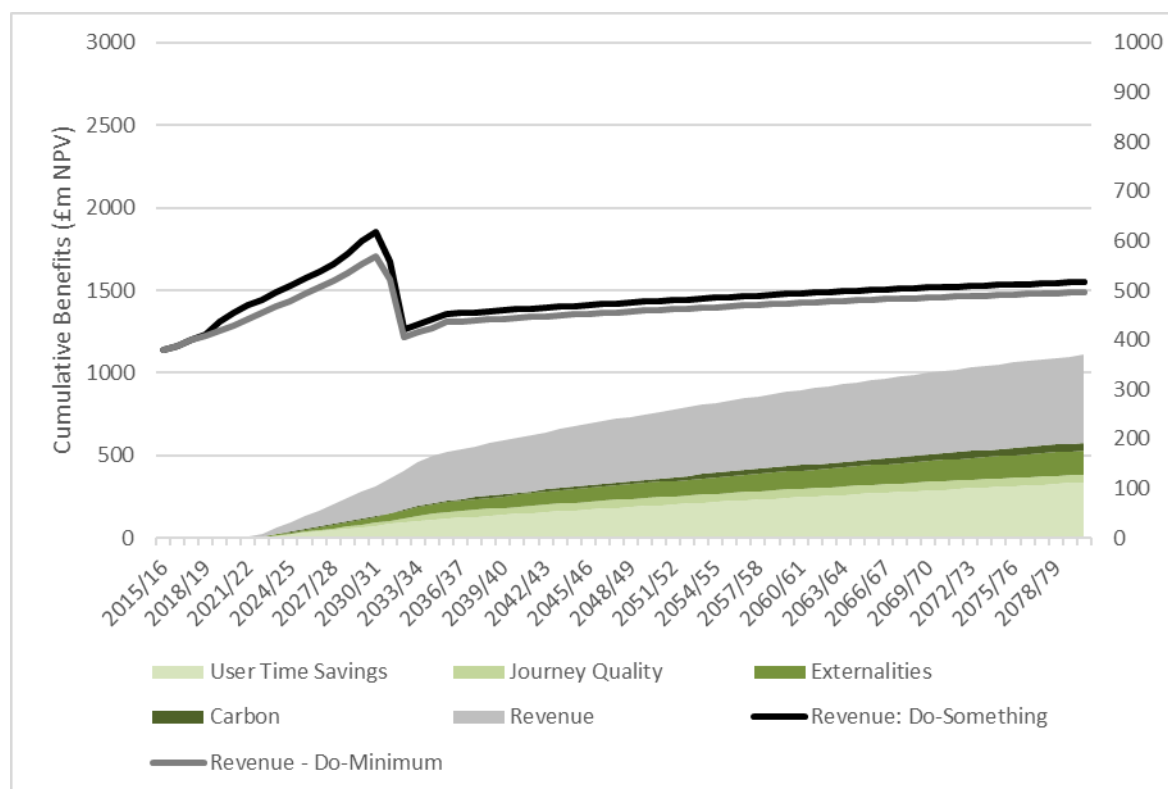
	Central Case	HS2 Test
Noise	3	1
Local Air Quality	2	2
Greenhouse Gases	60	93
Journey Quality	279	49
Physical Activity	0	0
Accidents	35	13
Rail Economic Efficiency (Commuting)	-10	-20
Rail Economic Efficiency (Other)	45	12
Rail Economic Efficiency (Business)	453	257
Road Economic Efficiency (Commuting)	157	55
Road Economic Efficiency (Other)	175	61
Road Economic Efficiency (Business)	75	26
Wider Public Finances (Indirect Taxation Revenues)	-162	-88
<b>PVB</b>	<b>1,113</b>	<b>462</b>

The table shows that with the introduction of HS2 the upgrade programme would only deliver 50% of the PVB of the same scheme without HS2. The upgrade programme would deliver the same benefits up to 2033 however following the introduction of HS2, the scheme would only retain:

- 28% of annual revenue benefits
- 35% of user time savings
- 14% of journey quality savings

The impact on revenue and cumulative benefits of the appraisal period is shown in the Figure below. This can be contrasted to Figure 4-4 presenting the same analysis for the central case.

**Figure 10-2 Growth in Demand Over the Appraisal Period**



The table below shows the impact on the BCR of the scheme:

**Table 10-5 Impact of HS2 on MML Upgrade Programme: Economic Summary Statistics (£m, 2010 present values)**

DS Timetable	Central Case	HS2 Sensitivity
<b>PVB</b>	<b>1,113</b>	<b>462</b>
<i>Investment Costs</i>	<i>771</i>	<i>771</i>
<i>Operating Costs</i>	■	■
<i>Revenue</i>	■	■
<b>PVC</b>	<b>21</b>	<b>501</b>
<b>Resulting Net Present Value</b>	<b>1,092</b>	<b>-39</b>
<b>BCR</b>	<b>52.87</b>	<b>0.92</b>

The table above shows that the introduction of HS2 Phase 2 would have a material impact on the value-for-money of the Midland Main Line (MML) Upgrade Programme, reducing the BCR from 52.3 to 0.9. This BCR is sensitive to the proposed opening date of HS2 and of the wider sensitivity tests undertaken around the central case above. Sensitivity testing presented around the investment case with HS2 is presented in the table below. Each test is carried out in isolation around the central case with combined tests following.

**Table 10-6 HS2 Sensitivity Testing**

Ref	Scenario	PVB	PVC	NPV	BCR
<b>Central</b>	<b>Central Case (HS2)</b>	<b>462</b>	<b>501</b>	<b>-39</b>	<b>0.92</b>
a	Freight (to 2033)	481	492	-11	0.98
b	XC Aspirations <sup>23</sup> (to 2033)	■	■	■	■
c	High Growth	510	455	55	1.12
d	Delayed Implementation of HS2 (2036)	513	429	84	1.20
a + b	Freight + XC	■	■	■	■
a + b + c	Freight + XC + High Growth	■	■	■	■

The results of the sensitivity tests show the following;

- Freight benefits have been applied as in the sensitivity test around the central case without HS2. Freight benefits are, conservatively, taken only to the opening of HS2. This adds £28m to the NPV of the scheme with HS2 resulting in a BCR of 0.98. (Freight benefits are strongly backended in the appraisal due to the growth of freight, increasing congestion and growth in the value-of-time and carbon costs).
- As with freight benefits above it is assumed that Cross Country's timetable aspirations will only result in a benefits prior to the introduction of HS2. This is forecast to reduce net costs by £■ adding ■ of benefits and raising the BCR of the programme with HS2 to ■.
- Higher growth scenarios result in an improvement to the business case. In this scenario tested. In line with TAG Unit M4 Forecasting and Uncertainty Section 4.2 higher growth results in a BCR of 1.12.
- As would be anticipated the impact of HS2 on the business case for the MML KO1 Upgrade Programme is sensitive to the opening date of HS2. Delayed opening of HS2 from 2033 to 2036 adds £125m to the NPV of the scheme, increasing the BCR to 1.20.

<sup>23</sup> CrossCountry benefits are realised post Derby remodelling, which is treated as a sunk cost. Therefore the benefits included in this sensitivity should be regarded as well as sunk benefits.

# 11. Summary & Conclusions

On the basis of the analysis conducted the following results are noted:

At the time of preparation of this business case no definitive version of the baseline May\December 2018 timetable exists. This introduces considerable uncertainty around both the Do Minimum 5 tph timetable and also the Do Something 6tph timetable. This position will become clearer towards the end of 2017 and will need to be kept under review.

Timetables have been treated in three scenarios as below:

- **Timetable Scenario 1** presents results using the timetables developed during the FBC.
- **Timetable Scenario 2** presents results using the KO1 6tph timetable as developed above. However, in this instance a modified version of EMTs earlier bid timetable which presents a more pessimistic view of the baseline timetable than the development work.
- **Timetable Scenario 3.** Presents results using timetables developed in the SOBC reflecting a scenario whereby conflicts north of Wigston Junction can be resolved by retiming other operators services with little net detriment (Corby times in the Do Something are modified as reported above)

The table below summarises the key results for the options tested around the core specification timetable.

Timetable Scenario	Scenario 1	Scenario 2	Scenario 3
<b>PVB</b>	<b>673</b>	<b>1,066</b>	<b>1,113</b>
<i>Investment Costs</i>	<i>771</i>	<i>771</i>	<i>771</i>
<i>Operating Costs</i>	■	■	■
<i>Revenue</i>	■	■	■
<b>PVC</b>	<b>399</b>	<b>155</b>	<b>21</b>
<b>Resulting Net Present Value</b>	<b>274</b>	<b>911</b>	<b>1,092</b>
<b>BCR</b>	<b>1.69</b>	<b>6.87</b>	<b>52.87</b>

Based on the results presented in Table above Key Output 1 of the Midlands Main Line Upgrade package represents

- Very High VfM assuming conflicts in the Do Something timetable north of Wigston Junction can be resolved by retiming other operators' services with little net detriment (as per the SOBC)
- Very High VfM assuming the Do Something timetable is as developed during this business case and the Do Minimum timetable reflects the EMT version of the timetable provided in July 2017; removing EMT stops at Bedford, Luton and Luton Airport Parkway during peak hours<sup>24</sup>.
- Medium VfM using FBC development undertaken on the December 2016 (Iteration 1) cut of the Thameslink timetable. In this timetable the end-end journey time savings to Nottingham and Sheffield are reduced lowering the net benefits of the timetable change.

<sup>24</sup> A modified version of this timetable was supplied on 11th August 2017 reinstating peak hour stops at Luton Airport Parkway.

## Sensitivity Testing

A number of sensitivity tests have been examined to monetise the scale of potential benefits which are not included in the central case above. These tests include:

- Freight Benefits. An estimate of benefits resulting from increased freight provision on the route. The appraisal of freight benefits is based on the Departments set of HGV specific Marginal External Costs monetising the benefits of a reduction in HGV miles realised through additional rail freight.
- Cross Country timetable aspirations. Cross Country aspire to achieve journey time savings following Derby remodelling, concentrating on the Birmingham – Newcastle (via Doncaster). Proposals save up to 28 minutes on the Birmingham– Newcastle (via Doncaster) service with minimal changes to other operators' services.
- NOx emissions. A sensitivity test using higher damage costs for (March 2017).

The results of these sensitivity tests are presented below:

Timetable Scenario	Timetable 1		Timetable 2		Timetable 3	
	NPV	BCR	NPV	BCR	NPV	BCR
Central Case	274	1.69	911	6.87	1,092	52.87
Freight Benefits	632	2.78	1,269	12.53	1,450	Fin+
XC Timetable Aspirations	■	■	■	■	■	■
Higher Air Quality Benefits	331	1.83	968	7.25	1,149	55.7

The table above shows that the potential benefits additional to the central case are of significant value to the appraisal, with an increment of ■ associated with increased provision for freight and Cross Country's timetable aspirations following Derby Remodelling. The impact on the BCR is dependent on the net benefits and costs of each scenario. The addition of freight benefits would uplift the BCR in the most pessimistic timetable scenario from 1.7 to 2.8 (High VFM); the additional consideration of Cross Country's timetable aspirations would further uplift this to ■

## High Speed 2

Further sensitivity testing examined the impact of HS2 on the economic case of the programme. This found that the introduction of HS2 Phase 2 (2033) would have a material impact on the value-for-money of the Midland Main Line (MML) Upgrade Programme, reducing the BCR from 52.9 to 0.9. The upgrade programme can therefore be categorised as providing 'poor' value for money with HS2 Phase 2. In this instance, abstraction of the long-distance market to Sheffield, Derby and, to a lesser extent, Nottingham reduces the future revenue and user benefits delivered by the 6<sup>th</sup> path.

This sensitivity test is sensitive to the introduction data of HS2, a delayed implementation date to 2036 would raise the BCR back to the vicinity of 1.2. The BCR of this sensitivity test is also sensitive to growth rates, a high growth scenario consistent with TAG Unit M4 Forecasting and Uncertainty Section 4.2 would take the BCR to 1.1.

## Caveats and Limitations on Analysis

It is important to note the limitations on the analysis undertaken in certain areas:

- At the time of preparation of this business case no definitive version of the baseline May/December 2018 timetable exists. This introduces considerable uncertainty around both the Do Minimum 5 tph timetable and also the Do Something 6tph timetable. While this uncertainty primarily revolves around assumed journey times and timings around the clock, it may also influence rolling stock requirements. Atkins' understanding of the latest May-18 timetable position is that EMT have been instructed to lease an additional 3 HST sets in order to maintain capacity

on MML services in the May-18 timetable. This change is not currently reflected in the modelled Do Minimum scenario or the Do Something. While this assumes the incremental fleet requirements do not differ from the previous MML SOBC, the changes to rolling stock requirements as a result of the Thameslink timetable could result in additional efficiency savings from the Do Something 6tph timetable obtained through rediagramming the new required rolling stock fleet. This position will become clearer towards the end of 2017 and will need to be kept under review

- The GTR 2018 timetable is still undergoing development. The timetables for this study were developed using the latest version of the GTR 2018 timetable made available to this study (December 2016, Iteration 1). Atkins have been made aware that there have been significant changes to the GTR timetable since this time.
- The estimated fleet sizes presented in this report are provided for business case comparison purposes only. These numbers should in no way be viewed as recommendations for the optimum fleet size on the upgraded route, which should be the subject of further detailed analysis.
- Changes to DDG drivers between January 2016 and July 2017 reduce real revenue growth projections on the EMRF franchise over the next 20 years from 120% to 88% (CAGR from 3.83% to 3.05%) and demand growth from 59% to 39% (CAGR from 2.23% to 1.58%). This substantially reduces the NPV of the Key Output 1 investment proposals. Atkins are aware of the PDFH6.0 may contain significant changes to the exogenous growth framework. Any revisions to growth rates could have a significant impact on the appraisal results.
- Revenue transfer from crowding relief is subject to the methodological application of the PDFH approach. If longer distance journeys are subject to a lower level of constraint (for example through a high use of advance purchase with seat reservations) then this approach may overstate revenue transfer from crowding relief. This benefit is attributed to the capacity works required to provide the 6<sup>th</sup> path which offers very high value for money and would be resilient to lower capacity relief.

# Appendix A. Appraisal Bridge

## A.1. Bridge between SOBC and FBC Appraisals

£m 2010 PV	SOBC	BRIDGE		
Scenario	KO1 With Electrification (SOBC)	Revised appraisal with old Jan 2016 DDGs & SOBC Timetables	DDG July 2017	Revised Corby journey times (TT3)

VfM	Fin+	Fin+	Very High	Very High
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PVB	1,692	1,495	1,171	1,113
PVC	-134	-334	11	21
Resulting Net Present Value	1,826	1,829	1,160	1,092
BCR	Fin+	Fin+	110.39	52.87

### Operating Costs Summary

Operating Costs	■	■	■	■
Revenue	■	■	■	■
Investment Costs	972	771	771	771
PVC	-134	-334	11	21

### Benefits Summary

Economic Efficiency Rail	784	651	547	488
Economic Efficiency Road	630	553	419	407
Journey Quality	413	383	268	279
Greenhouse Gases	31	65	60	60
Other External	59	54	42	40
Indirect Taxation	-224	-210	-165	-162
<b>Economic and Environmental Benefits</b>	<b>1,692</b>	<b>1,495</b>	<b>1,171</b>	<b>1,113</b>

Major Changes	n.a	CAPEX (Contracted Commitments)	Updates for DDG July 2017	Revised Corby journey times (Move to TT Scenario 3)
		Replace HSTs in baseline (2030/31)		
		TAG Unit A5.3 Forthcoming Changes		
		TAG Unit A5.3 Forthcoming Changes		

# Appendix B. Freight Benefits

## B.1. Introduction

The upgrade and electrification of the Midland Main Line (MML) and associated enhancement plans provide opportunities to run additional freight trains, providing the potential for benefits from removing HGV traffic from roads along the corridor.

A high-level approach has been developed to allow an assessment of the potential order of magnitude for freight benefits along the route. The appraisal is based on the Departments set of HGV specific Marginal External Costs and the assumptions as set out below.

## B.2. Approach

The appraisal model applies a Marginal External Cost (MEC) approach to estimating the potential benefits of the additional rail freight paths. External costs are those imposed on others, and not paid for directly by the person/company imposing that cost. In the case of this appraisal, the External Costs considered include:

- Congestion – Impact an extra HGV on the road has on the journey time of other road users as a result of increases in congestion<sup>25</sup>;
- Infrastructure – Cost of damage to the road infrastructure as a result of an additional vehicle using the road;
- (Road) Accidents – Additional traffic will increase the risk of accidents and so an increase in the cost of accidents for all road users;
- Local Air Quality – Additional emissions from road or rail users will have an impact on levels of NO<sub>x</sub> and PM<sub>10</sub>, which imposes costs on everyone in that locality;
- Noise – Increases in road and rail vehicle movements will also increase noise levels in that area, impacting on everyone in that locality;
- Greenhouse Gas (GHG) emissions - Increased road and rail movements results in increased GHG emissions, with associated costs and risks of climate change;
- - Indirect Tax – Reflecting the fact that increases in road traffic will increase fuel consumption and the associated tax revenues.

The approach used ignores changes in private costs, including (for rail) infrastructure costs, which are assumed to be fully internalised through Track Access Charges. This implies some (restrictive) assumptions on the nature of competition in the sector – which effectively implies that changes in private costs (e.g. the cost of running additional freight trains) can be ignored. As such the appraisal model only provides an order of magnitude estimate of the potential benefits of additional freight paths on the MML.

### B.2.1. Calculating the Benefits of Freight Mode Shift

The benefits of freight mode shift from road to rail is based on DfT MECCs of Artics as presented in Air quality sensitivity workbook: MECs<sup>26</sup>. This provides an estimate of the external cost of each of the above categories for a range of road types.

Data was available in 5 year intervals from 2010 to 2035. For the purpose of the appraisal the data was converted to annual data (using extrapolation) and extended to 2079 by assuming:

- Congestion costs increase in line with the value of time
- Accident, local air quality and noise increase in line with GDP per capita
- GHG costs change in line with the central cost of carbon

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<sup>25</sup> Note that the cost of congestion experienced by the HGV (driver) is a private cost. External costs only cover the fact that an extra vehicle will result in slower traffic – thereby increasing journey times for other road users.

<sup>26</sup> <https://www.gov.uk/government/publications/webtag-environmental-impacts-worksheets>

- Infrastructure and indirect tax effects are assumed to be constant in real terms

Scheme specific average values were calculated based on the most appropriate mix of road types – reflecting the likely route of HGVs on an equivalent route to the rail freight route. In this case an exemplar route was considered between London Gateway Port and the Sheffield International Rail Freight Terminal.

The Department's Freight Grants Tool was used to consider the likely route and road types that might apply. The tool provides the following mix of roads:

**Table 11-1 Mix of Road Types reported by Freight Grants Tool for trip between London Gateway Logistics Park and Sheffield International Rail Freight Terminal**

Road Type	Proportion of Trip
'High' Motorway	41%
Standard Motorway	52%
Standard A road	6%
Standard Other Road	1%

These categories do not match the categories provided by DfT in the MEC data, so some interpretation was required.

- 'High' Motorway reflected roads – mainly the M25 – which have higher external costs associated with them. To reflect this higher cost, the category of 'Inner/Outer Conurbation Motorway' was applied to this section of the route
- Standard Motorway – Assumed MECs associated with the 'Rural Motorway' category
- Standard A and Other Roads – Most of these roads were on the outskirts of London and Sheffield. Therefore the 'Other Urban A Roads' and 'Other Urban Other Roads' categories were applied.

Table 11-2 shows the resulting average MECs for HGV travel per km and per trip avoided (based on 309km trip).

**Table 11-2 Average Marginal External Costs of HGV travel on Exemplar Route (2020 values, 2010 prices)**

Cost Category	Cost per average km (pence)	Cost per trip avoided (£)
Congestion	9.4p	£29.15
Infrastructure	5.6p	£17.36
Accidents	0.5p	£1.64
Local Air Quality	0.2p	£0.47
Noise	6.6p	£20.38
GHG	4.7p	£14.55
Indirect Tax	- 20.7p	- £64.09
Total	6.3p	£19.46

This suggests that each HGV removed from the road (and using rail freight) results in highway benefits of around £19.46.

### B.2.2. Scale of Mode Shift to Rail

The above calculations provide an estimate of the value of removing an HGV from the exemplar route. An estimate of the number of total number of HGV movements is required to convert this into the total benefits of the additional freight paths. The following approach has been undertaken to estimate the total number of HGV movements removed with increased freight provision on the MML.

Unconstrained freight forecasts for future years (up to 2043/44) in tonnes per annum produced for the Freight Market Study (2013), and as used in the Freight Network Study (2017), have been provided by Network Rail. This study has used the forecast for the arc between Flitwick and Bedford.

A supply capacity has been derived for freight based on the existing freight paths and with paths as mandated by the 6tph timetable specification and presented below

Timetable	Direction	Freight Paths
Existing Service (& 5 -path post 2018)	Down	2 x 600t (not all utilised due to conflicts with Up freight at Kilby Bridge Jct)
	Up	1 x 2000t + 1 x lightweight non-passenger path
6tph OBC Remit	Down	1No. 2200t + 1No. 800t
	Up	1No. 2200t + 1No. 2200t / 2600t (via Corby only)

Annual capacity in tonnes per annum was calculated from the provision above assuming:

- 16 hours a day operation
- An assumption of 5-days operation in 2011/12 ramping up to 6-days operation in 2033.
- Finally, the above factors alone do not fully represent the total capacity for rail freight due to consideration of the following two factors:
  - Infrastructure\Path utilisation – not all freight train paths in the timetable are used, this is because flexibility is required to cater for different volumes or destinations at different times of the week or year. Therefore, the number of paths required in the timetable is greater than the number trains that will operate.
  - Train Utilisation– not all freight trains run at 100% capacity

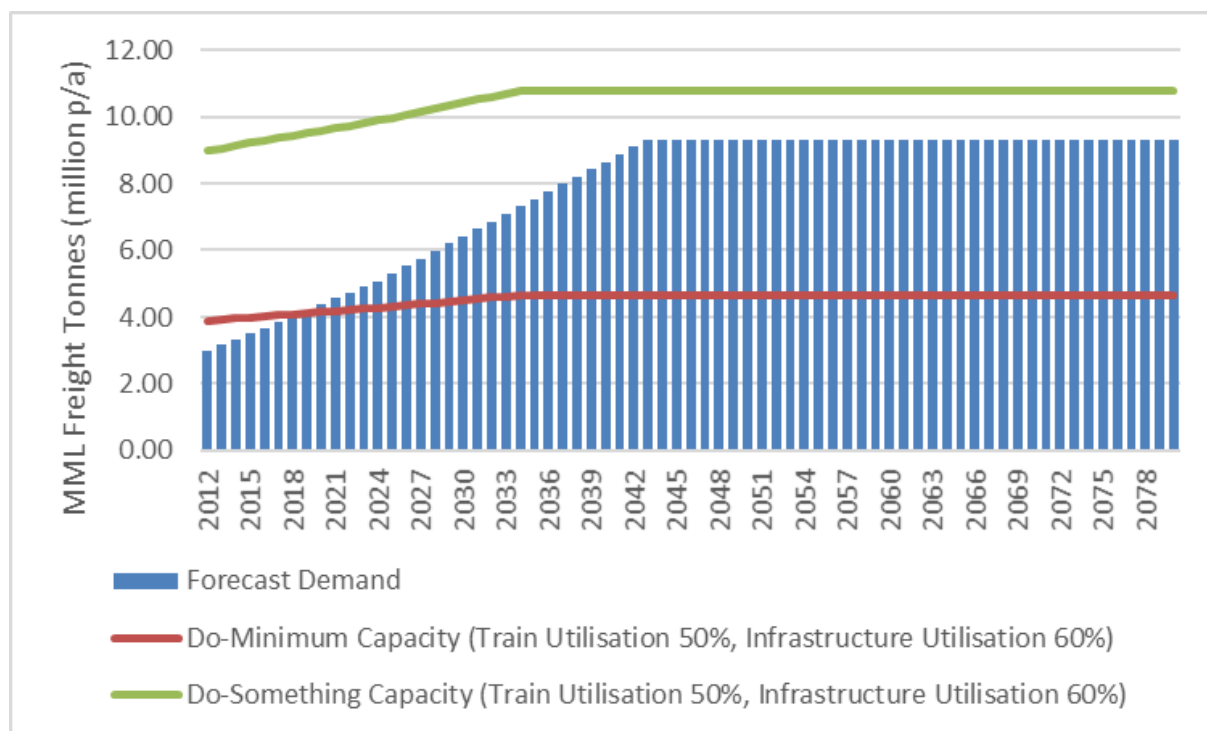
The above factors are treated as a sensitivity although are informed by the table below reproduced by the Network Rail 'Long Term Planning Process: Freight Market Study' (October 2013)

**Table 11-3 Assumptions used for days of operation per week, net tonnes per train and path utilisation**

	2011-12			2033		
	Days of Operation	Net tonnes per train	Path utilisation	Days of Operation	Net tonnes per train	Path utilisation
Automotives	5	292	50%	6	292	50%
Biomass	5	856	75%	6	1160	75%
Chemicals	5	890	50%	6	890	50%
Coal Other	5	1390	45%	6	1390	45%
Construction materials	5	1416	37%	6	1500	37%
Channel Tunnel intermodal	5	560	85%	6	672	85%
Domestic Intermodal	5	560	85%	6	672	85%
Domestic Waste	5	1224	50%	6	1224	50%
ESI Coal	5	1440	45%	6	1440	45%
General Merchandise	5	706	50%	6	706	50%
Industrial Minerals	5	960	50%	6	960	50%
Iron Ore	5	1700	50%	6	1700	50%
Metal	5	1220	51%	6	1220	51%
Petroleum	5	1626	56%	6	1626	56%
Ports Intermodal	5	560	85%	6	672	85%

The chart below shows forecast below shows the freight forecasts (Flitwick – Bedford) and calculated capacity given the stated assumptions of: train utilisation = 50% and infrastructure utilisation = 60%.

**Figure 11-1 Freight forecast (Flitwick - Bedford) and calculated capacity**



The number of HGV trips removed per tonne of rail freight carried has been calculated based on the forecasts demand carried in the Do Something beyond the capacity provided in the Do Minimum. The uses the assumption that each HGV is operating at the legal maximum weight of 44 tonnes. The 44-tonne limit includes the weight of the lorry itself, this is assumed be 14.9 tonnes per HGV, and has been netted off leading to an average load of 29.1 tonnes per HGV<sup>27</sup>.

### B.2.3. Marginal External Costs of Rail Freight

Mode shift towards rail will reduce the external costs associated with road transport. However, increasing the number of trains running will also impose some external costs.

The costs valued for rail freight are:

- Local air quality
- Noise
- Greenhouse Gas emissions
- Indirect Tax

Other costs are assumed to be either not relevant or internalised through relevant charges (specifically infrastructure costs are assumed to be included in Track Access Charges).

Data on rail external costs is less readily available than highway costs. Estimates were derived as follows – applying WebTAG guidance as far as reasonably possible:

- Values of NOx emissions from rail freight were taken from WebTAG (80 grams/km) and applied to the estimated kilometrage of the additional freight trains. The value of NOx damage was taken from the WebTAG Local Air Quality Worksheet
- Noise costs were taken from the Mode Shift Benefit Technical Note and grown in line with GDP/Capita growth.

<sup>27</sup> This approach is consistent with that used in 'Value and Importance of Rail Freight' (Network Rail, July 2010)

- Greenhouse Gas emissions were derived from an assumption of fuel consumption of 4.8 litres/km for a freight train derived from the Mode Shift Benefits Technical Note. Emissions factors and values were then applied using WebTAG guidance
- Indirect tax was estimated using the above fuel consumption figures and data from WebTAG on Duty levels for Gas Oil.

### B.3. Results

The resulting estimate of benefits of the additional freight paths are outlined in the table below presenting a range of benefits based on assumed infrastructure and train utilisation:

- The highlighted scenario of infrastructure utilisation 85%, train utilisation 35% is taken to reflect heavy transportation of Domestic Intermodal;
- The highlighted scenario of infrastructure utilisation 45%, train utilisation 65% is taken to represent heavy transportation of aggregates such as coal or construction materials.
- The infrastructure utilisation of 60%, train utilisation 50% is taken to reflect a mix.
- Scenarios highlighted grey are where current capacity would equate to less than current demand.

**Table 11-4 Freight Appraisal Scenarios (£m NPV, 2010 present values)**

		Infrastructure Utilisation									
		40%	45%	50%	55%	60%	65%	70%	75%	80%	85%
Train Utilisation	35%										361
	40%										
	45%										
	50%	347	378	404	391	358	325	292	259		
	55%	373	402	391	355	318	282	246	211		
	60%	395	398	358	318	278	239	202	165		
	65%	411	368	324	281	239	198	159	121		
	70%	385	338	291	245	201	158	118	80		

For the calculated benefit of £358m (2010 NPV) the table below presents the benefits the analysis of monetised costs and benefits. (As directed by Network Rail freight forecasts have used the Higher Construction forecasts to reflect stronger than anticipated growth. A sensitivity test reverting to the central forecasts for all commodities reduces the £358m NPV to £147m (2010, NPV).

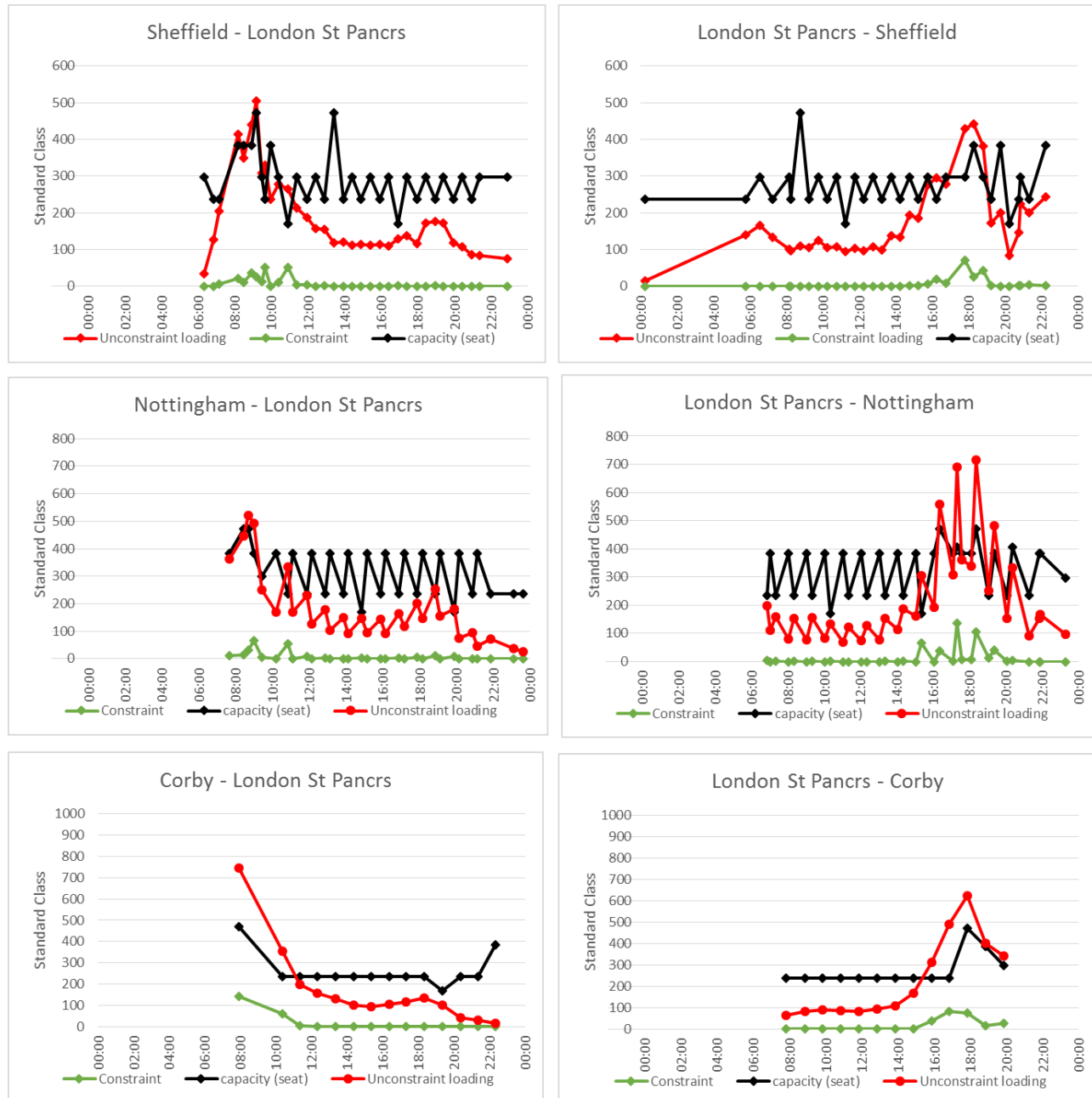
**Table 11-5 Freight Appraisal, Monetised Costs and Benefits (£m NPV, 2010 present values)**

Noise	75.02
Local Air Quality	1.30
Greenhouse Gases	86.78
Journey Quality	
Physical Activity	
Accidents	6.75
Economic Efficiency: Consumer Users (Commuting)	67.80
Economic Efficiency: Consumer Users (Other)	177.27
Economic Efficiency: Business Users and Providers	30.25
Wider Public Finances (Indirect Taxation Revenues)	-132.23
Present Value of Benefits (see notes) (PVB)	312.95
Broad Transport Budget	-44.99
Present Value of Costs (see notes) (PVC)	-44.99
<b>OVERALL IMPACTS</b>	
<b>Net Present Value (NPV)</b>	<b>358</b>
<b>Benefit to Cost Ratio (BCR)</b>	<b>Fin +</b>

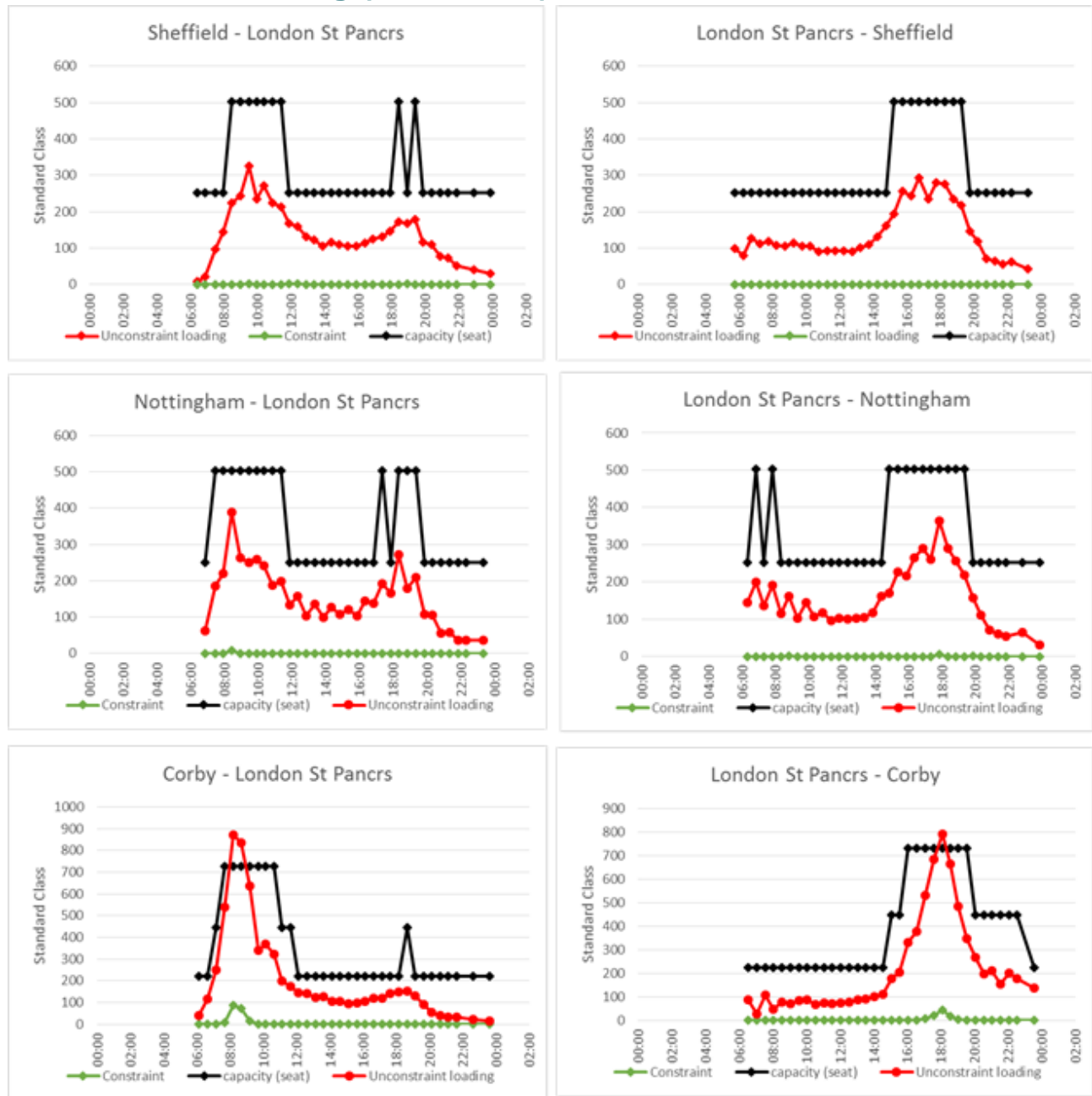
## Appendix C. Crowding Charts

The charts below present train loading forecasts (2015/16) for SOBC timetables. The intention is to show the impact the proposed timetable has on train loading and the impact the proposed service pattern has on requirements for train capacity.

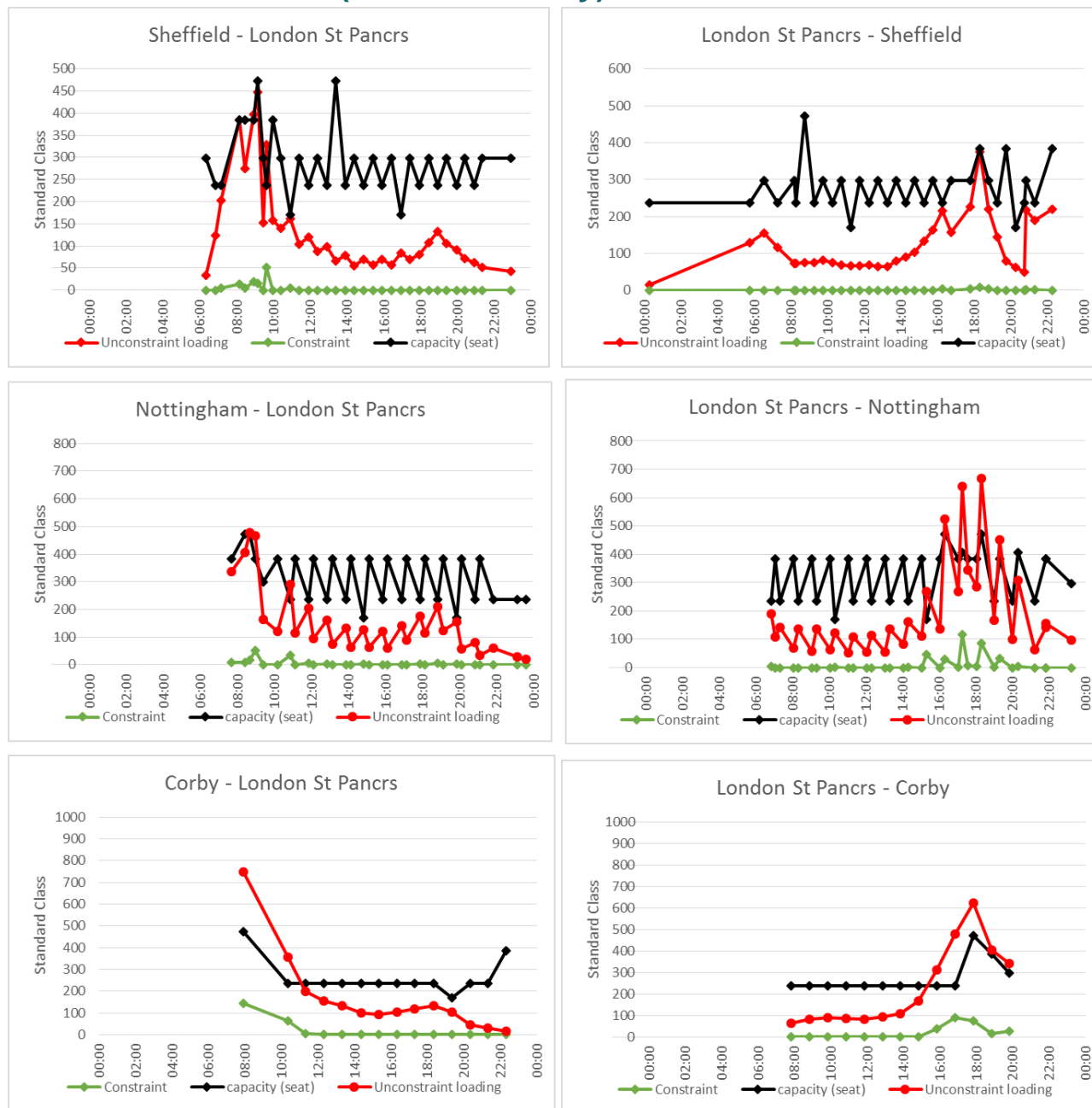
### C.1. Do Minimum



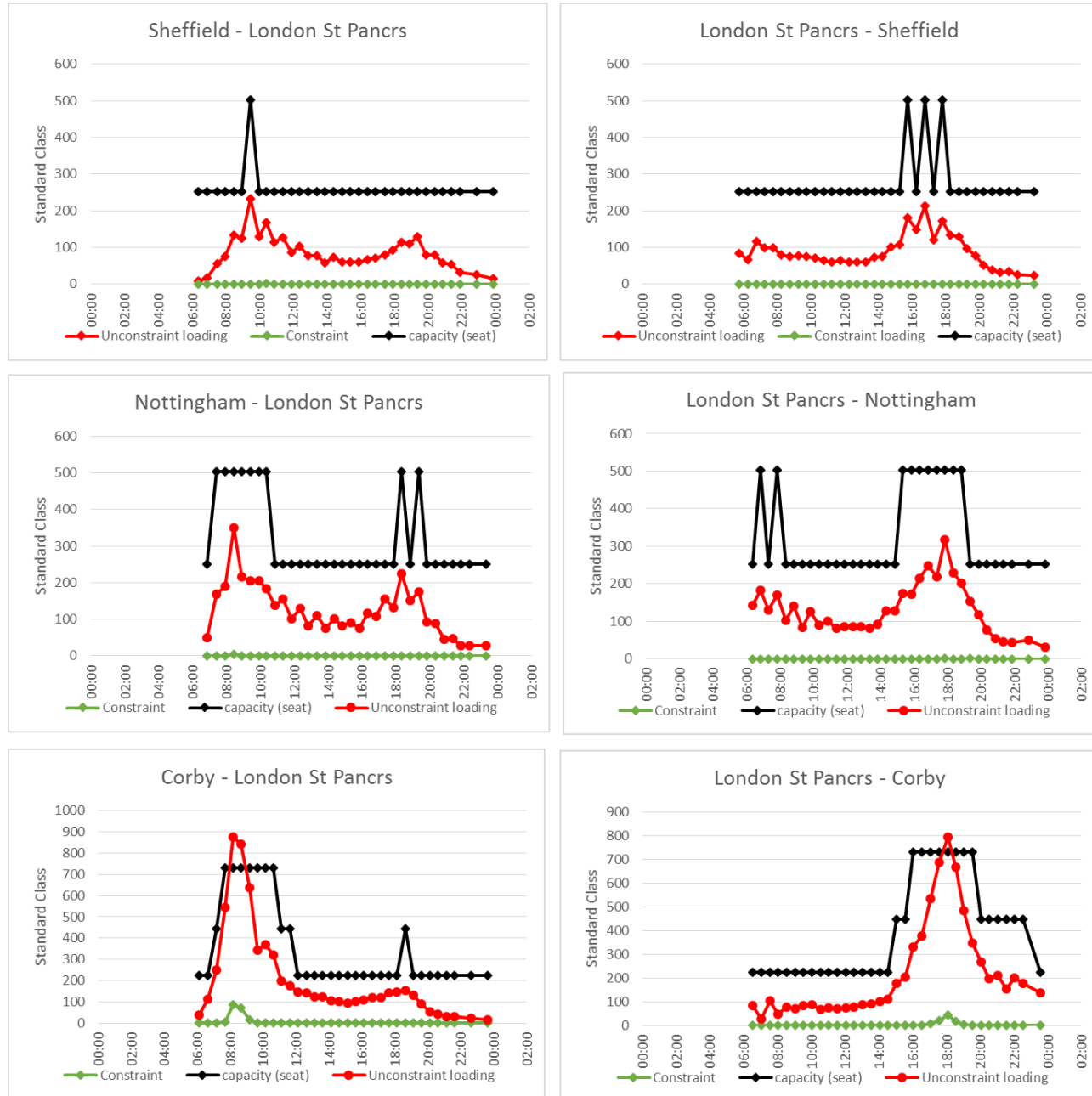
## C.2. Do Something (5-car DMU)



### C.3. Do Minimum (HS2 Sensitivity)



## C.4. Do Something (HS2 Sensitivity)



# Appendix D. TEE Tables

## D.1. Timetable Scenario 3

Table 1: Economic Efficiency of the Transport System (TEE)

Non-business: Commuting			
User Benefits	ALL MODES TOTAL	ROAD	RAIL
Travel Time	147,092	156,671	-9,580
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>NET NON-BUSINESS BENEFITS: COMMUTING</b>	147,092 (1a)	156,671	-9,580
Non-business: Other			
User Benefits	ALL MODES TOTAL	ROAD	RAIL
Travel Time	219,906	175,156	44,750
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>NET NON-BUSINESS BENEFITS: OTHER</b>	219,906 (1b)	175,156	44,750
Business			
User Benefits			
Travel Time	527,731	74,675	453,056
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>Subtotal</b>	527,731 (2)	74,675	453,056
Private Sector Provider Impacts			
Revenue			
Operating Costs			
TOC Profit	0		0
Investment Costs	0		0
Grant/Subsidy Payments			
Revenue Transfer	0		0
<b>Subtotal</b>	0 (3)	0	0
Other Business Impacts			
Developer Contributions	0 (4)	0	0
<b>NET BUSINESS IMPACT</b>	527,731 (5) = (2) + (3) + (4)		
<b>TOTAL</b>			
Present Value of Transport Economic Efficiency Benefits (TEE)	894,729 (6) = (1a) + (1b) + (5)		

Notes: Benefits appear as positive numbers, while costs appear as negative numbers

Table 2: Public Accounts

Local Government Funding			
	ALL MODES TOTAL	ROAD	RAIL
Revenue	0	0	0
Operating Costs	0	0	0
Investment Costs	0	0	0
Developer and Other Contributions	0	0	0
Grant/Subsidy Payments	0	0	0
<b>NET IMPACT</b>	0 (7)	0	0
Central Government Funding: Transport			
Revenue	0	0	0
Operating costs			
Investment Costs			
Developer and Other Contributions	0	0	0
Grant/Subsidy Payments			
Revenue Transfer	0	0	0
<b>NET IMPACT</b>			
Central Government Funding: Non-Transport			
Indirect Tax Revenues	161,629 (9)	42,621	119,008
<b>TOTALS</b>			
<b>Broad Transport Budget</b>	21,047 (10) = (7) + (8)		
<b>Wider Public Finances</b>	161,629 (11) = (9)		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.  
All entries are discounted present values in 2010 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	2,767 (12)	
Local Air Quality	2,401 (13)	
Greenhouse Gases	59,915 (14)	
Journey Quality	279,247 (15)	
Physical Activity	0 (16)	
Accidents	35,246 (17)	
Economic Efficiency: Consumer Users (Commuting)	147,092 (1a)	
Economic Efficiency: Consumer Users (Other)	219,906 (1b)	
Economic Efficiency: Business Users and Providers	527,731 (5)	
Wider Public Finances (Indirect Taxation Revenues)	-161,629 (11) - sign changed from PA table, as PA table represents costs, not benefits	
Present Value of Benefits (see notes) (PVB)	1,112,676 (PVB) = (12) + (13) + (14) + (15) + (16) + (1a) + (1b) + (5) + (17) - (11)	
Broad Transport Budget	21,047 (10)	
Present Value of Costs (see notes) (PVC)	21,047 (PVC) = (10)	
<b>OVERALL IMPACTS</b>		
<b>Net Present Value (NPV)</b>	1,091,629 NPV=PVB-PVC	
<b>Benefit to Cost Ratio (BCR)</b>	52.87 BCR=PVB/PVC	

Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

## D.2. Timetable Scenario 2

Table 1: Economic Efficiency of the Transport System (TEE)

Non-business: Commuting			
User Benefits	ALL MODES TOTAL	ROAD	RAIL
Travel Time	175,432	139,342	36,090
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>NET NON-BUSINESS BENEFITS: COMMUTING</b>	<b>175,432</b> (1a)	<b>139,342</b>	<b>36,090</b>
Non-business: Other			
User Benefits	ALL MODES TOTAL	ROAD	RAIL
Travel Time	203,200	155,782	47,419
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>NET NON-BUSINESS BENEFITS: OTHER</b>	<b>203,200</b> (1b)	<b>155,782</b>	<b>47,419</b>
Business			
User Benefits			
Travel Time	461,990	66,416	395,574
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>Subtotal</b>	<b>461,990</b> (2)	<b>66,416</b>	<b>395,574</b>
Private Sector Provider Impacts			
Revenue			
Operating Costs			
TOC Profit	0		0
Investment Costs	0		0
Grant/Subsidy Payments			
Revenue Transfer	0	0	0
<b>Subtotal</b>	<b>0</b> (3)	<b>0</b>	<b>0</b>
Other Business Impacts			
Developer Contributions	0	0	0
<b>NET BUSINESS IMPACT</b>	<b>461,990</b> (5) = (2) + (3) + (4)		
<b>TOTAL</b>			
Present Value of Transport Economic Efficiency Benefits (TEE)	<b>840,622</b> (6) = (1a) + (1b) + (5)		

Notes: Benefits appear as positive numbers, while costs appear as negative numbers

Table 2: Public Accounts

Local Government Funding			
	ALL MODES TOTAL	ROAD	RAIL
Revenue	0	0	0
Operating Costs	0	0	0
Investment Costs	0	0	0
Developer and Other Contributions	0	0	0
Grant/Subsidy Payments	0	0	0
<b>NET IMPACT</b>	<b>0</b> (7)	<b>0</b>	<b>0</b>
Central Government Funding: Transport			
Revenue	0	0	0
Operating costs			
Investment Costs			
Developer and Other Contributions	0	0	0
Grant/Subsidy Payments			
Revenue Transfer	0	0	0
<b>NET IMPACT</b>	<b></b> (8)	<b></b>	<b></b>
Central Government Funding: Non-Transport			
Indirect Tax Revenues	152,236	38,765	113,471
<b>TOTALS</b>			
<b>Broad Transport Budget</b>	<b>155,005</b> (10) = (7) + (8)		
<b>Wider Public Finances</b>	<b>152,236</b> (11) = (9)		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers. All entries are discounted present values in 2010 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	2,459	(12)
Local Air Quality	2,401	(13)
Greenhouse Gases	58,433	(14)
Journey Quality	282,265	(15)
Physical Activity	0	(16)
Accidents	31,621	(17)
Economic Efficiency: Consumer Users (Commuting)	175,432	(1a)
Economic Efficiency: Consumer Users (Other)	203,200	(1b)
Economic Efficiency: Business Users and Providers	461,990	(5)
Wider Public Finances (Indirect Taxation Revenues)	-152,236	-(11) - sign changed from PA table, as PA table represents costs, not benefits
Present Value of Benefits (see notes) (PVB)	1,065,566	(PVB) = (12) + (13) + (14) + (15) + (16) + (1a) + (1b) + (5) + (17) - (11)
Broad Transport Budget	155,005	(10)
Present Value of Costs (see notes) (PVC)	155,005	(PVC) = (10)
<b>OVERALL IMPACTS</b>		
<b>Net Present Value (NPV)</b>	<b>910,561</b>	NPV=PVB-PVC
<b>Benefit to Cost Ratio (BCR)</b>	<b>6.87</b>	BCR=PVB/PVC

Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

## D.3. Timetable Scenario 1

Table 1: Economic Efficiency of the Transport System (TEE)

Non-business: Commuting			
User Benefits	ALL MODES TOTAL	ROAD	RAIL
Travel Time	73,322	106,795	-33,474
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>NET NON-BUSINESS BENEFITS: COMMUTING</b>	<b>73,322</b> (1a)	<b>106,795</b>	<b>-33,474</b>
Non-business: Other			
User Benefits	ALL MODES TOTAL	ROAD	RAIL
Travel Time	116,951	119,395	-2,444
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>NET NON-BUSINESS BENEFITS: OTHER</b>	<b>116,951</b> (1b)	<b>119,395</b>	<b>-2,444</b>
Business			
User Benefits			
Travel Time	232,100	50,903	181,198
Vehicle Operating Costs	0		
User Charges	0		
During Construction & Maintenance	0		
<b>Subtotal</b>	<b>232,100</b> (2)	<b>50,903</b>	<b>181,198</b>
Private Sector Provider Impacts			
Revenue			
Operating Costs			
TOC Profit	0		0
Investment Costs	0		0
Grant/Subsidy Payments			
Revenue Transfer	0		0
<b>Subtotal</b>	<b>0</b> (3)	<b>0</b>	<b>0</b>
Other Business Impacts			
Developer Contributions	0	0	0
<b>NET BUSINESS IMPACT</b>	<b>232,100</b> (5) = (2) + (3) + (4)		
<b>TOTAL</b>			
Present Value of Transport Economic Efficiency Benefits (TEE)	<b>422,373</b> (6) = (1a) + (1b) + (5)		

Notes: Benefits appear as positive numbers, while costs appear as negative numbers

Table 2: Public Accounts

Local Government Funding			
	ALL MODES TOTAL	ROAD	RAIL
Revenue	0	0	0
Operating Costs	0	0	0
Investment Costs	0	0	0
Developer and Other Contributions	0	0	0
Grant/Subsidy Payments	0	0	0
<b>NET IMPACT</b>	<b>0</b> (7)	<b>0</b>	<b>0</b>
Central Government Funding: Transport			
Revenue	0	0	0
Operating costs			
Investment Costs			
Developer and Other Contributions	0	0	0
Grant/Subsidy Payments			
Revenue Transfer	0	0	0
<b>NET IMPACT</b>	<b></b> (8)	<b></b>	<b></b>
Central Government Funding: Non-Transport			
Indirect Tax Revenues	115,474	29,395	86,079
<b>TOTALS</b>			
<b>Broad Transport Budget</b>	<b>399,454</b> (10) = (7) + (8)		
<b>Wider Public Finances</b>	<b>115,474</b> (11) = (9)		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.  
All entries are discounted present values in 2010 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	1,885	(12)
Local Air Quality	2,401	(13)
Greenhouse Gases	55,545	(14)
Journey Quality	282,265	(15)
Physical Activity	0	(16)
Accidents	24,136	(17)
Economic Efficiency: Consumer Users (Commuting)	73,322	(1a)
Economic Efficiency: Consumer Users (Other)	116,951	(1b)
Economic Efficiency: Business Users and Providers	232,100	(5)
Wider Public Finances (Indirect Taxation Revenues)	-115,474	-(11) - sign changed from PA table, as PA table represents costs, not benefits
Present Value of Benefits (see notes) (PVB)	673,131	(PVB) = (12) + (13) + (14) + (15) + (16) + (1a) + (1b) + (5) + (17) - (11)
Broad Transport Budget	399,454	(10)
Present Value of Costs (see notes) (PVC)	399,454	(PVC) = (10)
<b>OVERALL IMPACTS</b>		
<b>Net Present Value (NPV)</b>	<b>273,678</b>	NPV=PVB-PVC
<b>Benefit to Cost Ratio (BCR)</b>	<b>1.69</b>	BCR=PVB/PVC

Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

# Appendix E. Timetable Development Assumptions

## E.1. Do Minimum

Assumption	Comments
Planning rules	Unless stated otherwise below, the 2018 Timetable Planning Rules were used.
Infrastructure	<p>Existing infrastructure was assumed.</p> <p>At Derby, the timetable was constructed assuming Derby remodelling had been completed, then the SRTs in the Derby area were altered back to the existing values. i.e. the new Derby layout was assumed, with the existing Derby SRTs.</p> <p><u>Derby remodelling</u></p> <p>13-NE-0050/1 v5.1</p> <p>13-NE-0050/2 v5.1</p> <p>13-NE-0050/3 v5.1</p> <p>13-NE-0050/4 v5.1</p> <p>Planning rules for Derby were taken from Appendix C of NR's MML2019 KO1 Timetable Analysis Remit Draft Version 0.4</p>
Impact of linespeed enhancements	none
Class 222 and HST SRTs	<p>Existing SRTs were used, except:</p> <ul style="list-style-type: none"> <li>Where updated by TRIP values, set out in Appendix B of NR's MML2019 KO1 Timetable Analysis Remit Draft Version 0.4</li> </ul>
Class 222 and HST dwell times	Minimum dwell times shown in the 2018 Timetable Planning Rules were used, except at Leicester. Although the minimum off-peak dwell time at Leicester is 1½ minutes, 2 minute dwells are consistently provided in the existing timetable and this was replicated in the KO1 timetable as well as the Do Minimum.
Thameslink timetable	<p>Standard off-peak, AM peak and PM peak hours were taken from the Iteration 1 Thameslink timetable as of Dec 2016.</p> <p>As Iteration 1 peak timetable contains a number of non-compliances, the following changes were assumed so this timetabling work could progress (these are all based on suggestions that were put forward by NR during spring 2017)</p> <ul style="list-style-type: none"> <li>Up GTR trains shown crossing to the Fast lines at Harpenden are revised to cross to the Fast lines at Radlett. There is one instance per hour where a non-compliant headway of 2½ minutes (3 mins required) is used at Radlett Junction. This is caused by the slightly slower running times of HSTs and no solution could be found within the timescales for this project.</li> <li>Gatwick – Bedford services remain on the Down Fast after St Albans, calling at Luton Airport Parkway and Luton only before crossing to the Down Slow at Leagrave.</li> </ul>

	<ul style="list-style-type: none"> <li>Littlehampton – Bedford services omit St Albans.</li> </ul> <p>Given that Iteration 1 was constructed around a 6-path EMT timetable, further adjustments were necessary.</p> <ul style="list-style-type: none"> <li>9K85 &amp; 9S91 would cross to the Fast lines at Harpenden vice Bedford South</li> <li>9K89 would cross to the Fast lines at Luton North vice Bedford South</li> </ul> <p>The following conflicts could not be resolved in the timeframe of this commission.</p> <ul style="list-style-type: none"> <li>9T00 / 1P10 at Leagrave Jn</li> <li>9S80 / 1C93 &amp; 1B14 at Leagrave Jn</li> <li>9T08 / 1B18 at Harpenden Jn</li> </ul>
Cross Country timetable	<p>The existing Cross Country timetable was used, with the following amendments as requested by Cross Country:</p> <ul style="list-style-type: none"> <li>Acceleration of the Southampton / Reading to Newcastle service.</li> <li>Retiming of the Birmingham New Street to Nottingham service and keeping its diagrams separate from the Cardiff – Nottingham service.</li> </ul> <p>This timetabling work has necessitated some flexing of Cross Country paths. To ascertain whether these changes are achievable, this timetable work includes the Derby – Birmingham and Leicester Birmingham corridors. It has been assumed that Cross-City line services are fixed. Platform working at Birmingham New Street has not been checked and further timetabling work, as well as liaison with Cross Country, will be required to verify the suggested timings.</p>
Freight provision	<p>The following Class 66 hauled freight services via Market Harborough have been assumed (to match existing):</p> <ul style="list-style-type: none"> <li>Down: 2 x 600t</li> <li>Up: 1 x 2000t</li> </ul> <p>Freight north of Wigston was not included in this study.</p>
Newark – Matlock service	<p>This service has been completely retimed in the clockface to accommodate the Do Minimum timetable. The new timing aligns with the 2021 ECML timetable currently being developed and explored as part of the East Midlands franchising process (which has an indirect impact on Newark – Matlock through the interaction with Nottingham – Lincoln and freight using Newark Flat Crossing).</p>

## End to end journey times

Note that all times to Sheffield assume trains approach via the fastest route. Approach via the Up Loop adds up to 2 minutes to the journey time.

## Existing

Stock	222	222	HST	222	222	
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	

Journey time	2h00	1h14	1h38	1h47	1h08	
Differential	1	1	2	2	2	
Total	2h01	1h15	1h40	1h49	1h10	

Stock	222	222	HST	222	222	
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
Journey time	2h00	2h08	1h41	1h49	1h09	
Differential	2	2	1	2	1	
Total	2h02	2h10	1h42	1h51	1h10	

## Do minimum

Stock	222	222	HST	222	EMU	
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
Journey time	2h00	2h12	1h38	1h46	1h07	
Differential	1	1	2	2	2	
Total	2h01	2h13	1h40	1h48	1h09	

Stock	222	222	HST	222	EMU	
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
Journey time	2h01	2h13	1h41	1h52	1h13	
Differential	2	2	1	2	1	
Total	2h03	2h15	1h42	1h54	1h14	

Stock	222	222	HST	222	222	
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
SOBC JT	2h01	1h15	1h40	1h49	1h10	
TRIP	+2	+2	+½	+½	+½	
'clean' JT	2h01	2h11	1h39	1h48	1h09	
change	0	-4	-1	-1	-1	
KO1 JT	2h01	2h13	1h40	1h48	1h09	
change	0	+2	+1	0	0	
		This is caused by conflicts at Leicester	This is caused by conflicts at Leicester			

Stock	222	222	HST	222	EMU	
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
SOBC JT	2h02	2h10	1h42	1h51	1h10	
TRIP	+3	+3	+1	+3	+3	

'clean' JT	2h02	2h13	1h42	1h54	1h14	
change	0	+3	0	+3	+4	
KO1 JT	2h03	2h15	1h42	1h54	1h14	
change	+1	+2	0	0	0	
	This is caused by pathing at Leicester	This is caused by pathing at Leicester				

## E.2. Do Something

Assumption	Comments
Planning rules	<p>Unless stated otherwise below, the 2018 Timetable Planning Rules were used.</p> <p>The SOBC timetable development used the 2017 Timetable Planning Rules. The only notable change is the removal of the requirement for 1½ mins performance time approaching Derby. As a future operator is likely to require performance time in their schedules, this allowance was retained in both the KO1 and Do Minimum timetables, although, in some cases, it has been distributed between Trent and Sheffield to suit the timetable.</p>
Infrastructure	<p>Existing infrastructure was assumed, except where new infrastructure was detailed in the following scheme plans supplied by NR:</p> <p><u>Sharnbrook – Corby</u></p> <p>16-NE-0033/01 v2 16-NE-0033/02 v2 16-NE-0033/03 v2 16-NE-0033/04A v2 16-NE-0033/05 v2 13-NE-0075/1 vA 13-NE-0075/2 vA</p> <p>No rules are yet available for these changes. It was assumed that headways on the new / resigalled Slow lines would be the same as on the existing Fast lines, as the new Slow line signal spacing appears to match existing signal spacing on the Fast lines.</p> <p><u>Derby remodelling</u></p> <p>13-NE-0050/1 v5.1 13-NE-0050/2 v5.1 13-NE-0050/3 v5.1 13-NE-0050/4 v5.1</p> <p>Planning rules for Derby were taken from Appendix C of NR's MML2019 KO1 Timetable Analysis Remit Draft Version 0.4</p>
Impact of linespeed enhancements	<p>The following adjustments to SRTs were assumed:</p> <ul style="list-style-type: none"> <li>Market Harborough: {-½} minute for non-stop trains</li> </ul>

	<ul style="list-style-type: none"> <li>Leicester South: {-½} minute for all trains arriving and departing Leicester at the southern end.</li> <li>Derby: adjustments were taken from Appendix C of NR's MML2019 KO1 Timetable Analysis Remit Draft Version 0.4</li> </ul>
Class 222 and HST SRTs	<p>Existing SRTs were used, except:</p> <ul style="list-style-type: none"> <li>Where updated by assumed linespeed enhancements</li> <li>Where updated by TRIP values, set out in Appendix B of NR's MML2019 KO1 Timetable Analysis Remit Draft Version 0.4</li> </ul>
Class 222 and HST dwell times	<p>Minimum dwell times shown in the 2018 Timetable Planning Rules were used, except at Leicester. Although the minimum off-peak dwell time at Leicester is 1½ minutes, 2 minute dwells are consistently provided in the existing timetable and this was replicated in the both the KO1 and Do minimum timetables.</p>
100mph EMU SRTs (shown as 375 in timing load)	<p>As no comprehensive set of suitable SRTs exist for 100mph EMUs for St Pancras – Corby services, the SRTs used in this timetable analysis come from a variety of sources.</p> <p>South of Bedford, existing Class 375 SRTs were used where possible, updated by TRIP values set out in Appendix B of NR's MML2019 KO1 Timetable Analysis Remit Draft Version 0.4 where applicable.</p> <p>It was assumed that these SRTs between Flitwick and Bedford are based on trains crossing to / from the Slow lines at Bedford South Junction. Therefore, in the Down direction, ½ minute was subtracted from the Flitwick – Bedford South SRT to allow for the fact that Corby services remain on the Down fast. In the Up direction, no further adjustment was made to the Bedford South – Flitwick SRT.</p> <p>No Class 375 SRTs for trains omitting St Albans could be found; therefore, Class 222 SRTs were used.</p> <p>North of Bedford, Routerunner was used to estimate the adjustment required to Class 222 SRTs. Up trains have been timetabled to cross to the Fast lines south of Wellingborough; therefore, this adjustment takes into account the crossing move as well as the lower train performance.</p> <p>Between Wellingborough and Corby via the Slow lines, Class 222 SRTs were used as the linespeed is below 100mph.</p>
100mph EMU dwell times	<p>Historic 'DMU' dwell times were used. These previously applied to Class 170 DMUs when they were used on the MML. Like the EMUs, Class 170s have doors at approx. the 1/3 and 2/3 position. All dwell times were increased by ½ minute for peak services.</p>
Thameslink timetable	<p>Standard off-peak, AM peak and PM peak hours were taken from the Iteration 1 Thameslink timetable as of Dec 2016. It has been assumed that the entire fleet will consist of Class 700s by the time KO1 is delivered (some Class 375 timing loads are used in Iteration 1).</p> <p>As Iteration 1 peak timetable contains a number of non-compliances, the following changes were assumed so this timetabling work could progress (these are all based on suggestions that were put forward by NR during spring 2017)</p> <ul style="list-style-type: none"> <li>Up GTR trains shown crossing to the Fast lines at Harpenden are revised to cross to the Fast lines at Radlett. There is one instance per hour where a non-compliant</li> </ul>

	<p>headway of 2½ minutes (3 mins required) is used at Radlett Junction. This is caused by the slightly slower running times of HSTs and no solution could be found within the timescales for this project.</p> <ul style="list-style-type: none"> <li>Gatwick – Bedford services remain on the Down Fast after St Albans, calling at Luton Airport Parkway and Luton only before crossing to the Down Slow at Leagrave.</li> <li>Littlehampton – Bedford services omit St Albans.</li> </ul>
Cross Country timetable	<p>The existing Cross Country timetable was used, with the following amendments as requested by Cross Country:</p> <ul style="list-style-type: none"> <li>Acceleration of the Southampton / Reading to Newcastle service.</li> <li>Retiming of the Birmingham New Street to Nottingham service and keeping its diagrams separate from the Cardiff – Nottingham service.</li> </ul> <p>This timetabling work has necessitated some flexing of Cross Country paths. To ascertain whether these changes are achievable, this timetable work includes the Derby – Birmingham and Leicester Birmingham corridors. It has been assumed that Cross-City line services are fixed. Platform working at Birmingham New Street has not been checked and further timetabling work, as well as liaison with Cross Country, will be required to verify the suggested timings.</p>
Freight provision	<p>The following Class 66 hauled freight services via Market Harborough have been assumed:</p> <ul style="list-style-type: none"> <li>Down: 1 x 2200t &amp; 1 x 800t</li> <li>Up: 2 x 2200t</li> </ul> <p>Heavier Up direction freight is assumed to travel via Corby. No Class 66 + 2600t SRTs currently exist via Corby; therefore, these heavier services have not been shown.</p> <p>Freight north of Wigston was not included in this study.</p>
Newark – Matlock service	<p>This service has been completely retimed in the clockface to accommodate the KO1 timetable. The new timing aligns with the 2021 ECML timetable currently being developed and explored as part of the East Midlands franchising process (which has an indirect impact on Newark – Matlock through the interaction with Nottingham – Lincoln and freight using Newark Flat Crossing).</p>

## End to end journey times

Note that all times to Sheffield assume trains approach via the fastest route. Approach via the Up Loop adds up to 2 minutes to the journey time.

### Existing

Stock	222	222	HST	222	222	
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
Journey time	2h00	1h14	1h38	1h47	1h08	
Differential	1	1	2	2	2	
Total	2h01	1h15	1h40	1h49	1h10	

Stock	222	222	HST	222	222	
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	
Journey time	2h00	2h08	1h41	1h49	1h09	
Differential	2	2	1	2	1	
Total	2h02	2h10	1h42	1h51	1h10	

## KO1

Stock	222	222	HST	222	EMU	EMU
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
Journey time	2h00	2h05	1h40	1h36	1h10	1h10
Differential	1	1	2	2	2	2
Total	2h01	2h06	1h42	1h38	1h12	1h12

Stock	222	222	HST	222	EMU	EMU
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
Journey time	2h01	2h05	1h45	1h41	1h15	1h15
Differential	2	2	1	2	1	1
Total	2h03	2h07	1h46	1h43	1h16	1h16

## The 'clean' timetable

### End to end journey times

Stock	222	222	HST	222	EMU	EMU
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
Journey time	1h59	2h03	1h40	1h35	1h10	1h10
Differential	1	1	2	2	2	2
Total	2h01	2h05	1h42	1h37	1h12	1h12

Stock	222	222	HST	222	EMU	EMU
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
Journey time	2h01	2h05	1h44	1h37	1h15	1h15
Differential	2	2	1	2	1	1
Total	2h03	2h07	1h45	1h39	1h16	1h16

Changes since SOBC

The impact of TRIP

SRTs between St Pancras and Bedford have been revised in line with TRIP. In general, TRIP causes a net increase in running time of up to 3 minutes, depending on rolling stock and stopping pattern. However, once timetabled, the impact on end-to-end journey times is more complex. In some cases, there is no increase to end-to-end journey time: this is because the increase south of Bedford eliminates the need for pathing time either south of Bedford or elsewhere on the MML. However, in other cases, TRIP results in an end-to-end journey time increase of up to 2 minutes more than the direct impact: this is because the change in SRTs necessitates a change to the pattern of arrivals and departures across the throat at St Pancras which introduces pathing time into some arriving trains.

Stock	222	222	HST	222	EMU	EMU
From	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
To	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
SOBC JT	1h59	2h04	1h42	1h35	1h07	1h07
TRIP	+2	+2	+½	+2	n/a	n/a
'clean' JT	2h01	2h05	1h42	1h37	1h12	1h12
change	+2	+1	0	+2	+5	+5
KO1 JT	2h01	2h06	1h42	1h38	n/a	n/a
change	0	+1	0	+1	n/a	n/a
		This is caused by conflicts between Chesterfield and Sheffield		This is caused by a conflict with Leicester – Nottingham local services		

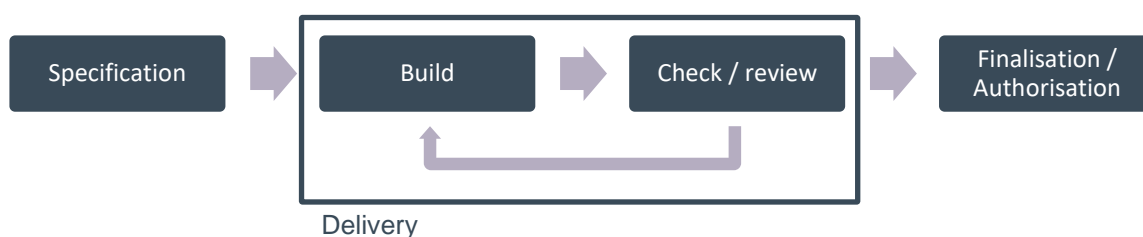
Stock	222	222	HST	222	EMU	EMU
From	Sheffield	Sheffield	Nottingham	Nottingham	Corby	Corby
To	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras	St Pancras
SOBC JT	2h00	2h02	1h42	1h34	1h08	1h08
TRIP	+3	+3	+1	+3	n/a	n/a
'clean' JT	2h03	2h07	1h45	1h39	1h16	1h16
change	+3	+4	+3	+5	+8	+8
KO1 JT	2h03	2h07	1h46	1h43	n/a	n/a
change	0	0	+1	+4	n/a	n/a
			This is caused by pathing at Leicester for the Leicester – Birmingham service	This is caused by a conflict with the Nottingham – Cardiff service which cannot be resolved through flexing alone		

## Appendix F. Quality Assurance

This appendix sets out our approach to Quality Assurance of the technical work undertaken for the MML Business Case and documents the checks undertaken as part of this process.

### Analytical Assurance Processes

The figure below illustrates the technical development environment for the modelling work undertaken to support the MML Business Case. Following agreement of a specification with the Department, technical work was then completed prior to a check stage which was focused primarily on the mechanical application i.e. checking calculations or the transfer of data. Subsequently a review stage was completed by a peer or above of the original developer. The intention of the review was to confirm the work is fit for purpose, appropriate and in line with the specification. Atkins adopts a proportional review stage based on an assessment of the criticality of analysis.



In all cases Atkins records the audit trail and outcomes of assurance activities within standalone check and review logs. These logs capture amendments or responses to review comments received internally and externally and the eventual resolution of issues. A summary of the logs compiled for this work is provided at the end of this appendix.

Atkins also understands that our internal assurance processes follow comparable principles to the DfT analytical assurance framework<sup>28</sup> including the following principles:

- Proportionality based on impact and downstream use of work;
- Approaches beyond checking i.e. the use of peer review;
- Differentiation of approaches between development and application phases.

### Modelling Framework

The modelling framework utilised in this study was based on the Comparator Model Suite developed for the East Midlands Franchise competition which was subject to external assurance in early 2017. We note that the suite itself has undergone limited change since this date, and as such consider that mechanically the suite can be categorised as having a ‘**high**’ degree of assurance from a functionality point of view. For the MML study, the focus of our assurance has therefore been on:

- By exception, areas of mechanical change to the Comparator Suite required to conduct the appraisal of the Midland Main Line Upgrade Programme;
- Checking and review of inputs to the modelling scenarios and resulting appraisal outputs.

Note that the modelling framework is designed to conform to spreadsheet modelling best practice guidance, the key principles of which are summarised as follows:

- Modularity – inputs kept separate from calculations, and calculations kept separate from outputs;

<sup>28</sup> [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/350904/qa-modelling-guidance\\_pdf.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/350904/qa-modelling-guidance_pdf.pdf)

- Consistency - through consistent formatting across all spreadsheet models, with shared cell colourings and labelling ensuring that users can quickly understand (and develop) a colleagues' work;
- Transparency – the model is simple to follow and easily understandable;
- Linearity – the model is logically laid out and 'reads like a book', i.e. from left to right and top to bottom;
- Integrity – the inclusion of error checks throughout the model, and the checking of validity of inputs; and
- Protection – prevention of errors, for example the use of the data validation feature in Excel to restrict the values that users can input into input cells.

## Framework model checks Appraisal Model

Check#	Model Name	Description	Checker	Date	ok/issue	Comments	Closed?
1	Appraisal Summary	Given the existing level of model development the first line of assurance is provided by a comparison of appraisal results breaking down components of costs and benefits at a disaggregate level. Results are compared at this level to ensure that there are no unexpected changes (and that expected changes are realised) at this level. Check – provide a second examination of this sheet raising any concerns.	■	9/08/17	Ok	(by email)	Y
1	Appraisal Model	Inputs in tab “Appraisal Assumptions”, “MEC Inputs” and “Control” are updated with match with Databook March17, and the indexes are updated in Financial Model accordingly as well.	■	14/08/17	Issue_01		Y
2	Appraisal Model	Tab “Rolling Stock Inputs” is updated following the assumptions documents and in consistency with the EMRF comparator.	■	14/08/17	Ok		Y
3	Appraisal Model	Confirm updated capex values are applied.	■	14/08/17	Issue_02		Y
4	Appraisal Model	Confirm that blended rate is applied for car diversion factor.	■	14/08/17	Issue_03		Y
5	Appraisal Model	Confirm if appraisal period of 60 years is correct.	■	14/08/17	Ok		Y
6	Appraisal Model	Check if current year of appraisal is updated to 17/18.	■	14/08/17	Ok		Y
7	Appraisal Model	NPV for capital lease cost is different than in SOBC, Check what drives changes in capital lease cost with regards to the SOBC, in relation with the new assumptions, and determine whether the change is sensible.	■	14/08/17	Ok	Approximately £28m of the difference results from PRM and 1st class reconfiguration previously applying to the base and not the option. Remainder = phasing on replacement and DM fleet size with HST replacement (e.g. 8-car vs 10-car). In original appraisal 110EMUs are not appearing until 2024/25.	Y

Check#	Model Name	Description	Checker	Date	ok/issue	Comments	Closed?
8	Appraisal Model	Value of time values are updated by pasting the hard-coded value received from DfT. (Tab "Control", E68 – E73)	■	14/08/17	Ok		Y
9	Appraisal Model	Appraisal is capable to evaluate the business case with no demand cap, this is to consistent with the forthcoming WebTAG change (November 2018). Confirm approach trending revenue and benefits with population following the cap year. Applied in <Revenue Model Extended Inputs>.	■	14/08/17	Ok		Y
10	Appraisal Model	Revenue model output is pasted into the appraisal model correctly	■	14/08/17	Issue_05		Y
11	Appraisal Model	Financial model output is pasted into appraisal model correctly	■	14/08/17	Ok		Y

## Appraisal model issue log and actions

Issue	Model	Raised By	Description	Reviewer	Actions	Follow on Check By	Follow on Check Date	Status
Issue_01	Appraisal Model / Financial Model	BW	some index are not updated in FM as per appraisal model RPI, GDP deflator, AEI	█	No action is taken RPI and GDP deflator are consistent between the financial and appraisal models, as the financial model has a functionality to choose between comparator and appraisal parameters. There is a small difference in the AEI series - the appraisal model uses the nominal growth series from WebTAG and the financial model uses the real growth series + GDP deflator, which are slightly different. A check on the results from using a consistent series has been undertaken on the central case, with a █, the BCR remaining unchanged.	BW	15/08/17	Closed
Issue_02	Appraisal Model	BW	Why we use different OB specified by WebTAG Databook for infrastructure cost?	█	OB is applied from the July 2017 version of A5.3 Rail Appraisal. Please can you confirm is this addresses comments or if this is still an issue? <a href="https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/625369/TAG_unit_a5.3_rail_appraisal_jul17.pdf">https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/625369/TAG_unit_a5.3_rail_appraisal_jul17.pdf</a>	BW	15/08/17	Closed
Issue_03	Appraisal Model	BW	Blended rate is 25%, car diversion rate is 26% in appraisal model	█	No Action is taken: A blended rate of 25% has been derived. This has not been applied within the core appraisal although impacts on the NPV by <£16m. P:\GBMRB\TP\HA\Projects\5149977 - MML Business Case - ARRA7444\5159267 MML KO1 FBC - ARRA7444\05_Technical\Revenue\OBC Timetables\Timetables\2019tt Corrections 091216\VOT Mapping	BW	15/08/17	Closed
Issue_04	Appraisal Model	BW	Revenue model output doesn't match with appraisal revenue input	█	Very minor difference. Have repasted revenue inputs. Please reconfirm revenue totals (no impact on appraisal)	BW	15/08/17	Closed

### Framework model checks on Revenue Model (Checks to updates following External Assurance)

Check#	Model Name	Description	Checker	Date	ok/issue	Comments	Closed?
1	Revenue Model	PDFH revenue forecast matched v5.02 of the revenue model	■	26/06	ok		Y
1	Revenue Model	Independent DDG2 mapping for WCP produces the same exogenous inputs	■	26/06	ok		Y
2	Revenue Model	RM results can be duplicated with a separate import of exogenous drivers	■	26/06	ok		Y
3	Revenue Model	Checks on individual driver changes.	■	26/06	ok	See <Version_Bridge> - Technical note produced due to large changes.	Y

**Table 6: Framework model checks on Financial Model (Checks to updates following External Assurance)**

Check#	Model Name	Description	Checker	Date	ok/ issue	Comments	Closed?
1	Financial Model	Checked that all relevant layers are switched on.	■	9/08/17	Issue_01	Should Option 9: For WebTAG appraisal also be set on?	Y
		Checked that model totals relate to previous version of comparator.	■		Issue_02	Unclear which version to check against	Y
		'Opt_1 - K01 (DS) cells K2863-K2893 contain text, and return errors in later calculations	■		Issue_03	Returned error #VALUE! In output tabs. But didn't impact on calculation because data related to 2013 which is outside of franchise period. Corrected anyway for good practice.	Y
2	Financial Model	Index Factor – functionality to switch between franchise comparator and MML KO1.	■		OK	This switches Option 9 on and off. Also allows different indexing dependent on whether 'Comparator' or 'MML KO1' selected. Checked that correct index is picked up in the 'Index Factor' sheet (column D from	

Check#	Model Name	Description	Checker	Date	ok/ issue	Comments	Closed?
						columns G and H) dependent on which option is selected.	
3	Financial Model	GDP Deflator: source, calculation and copy checked. Input as nominal.	■		OK	GDP deflator calculated as 0.25/0.75 split to calculate impact over a financial year.	
		DECC fuel: source, calculation and copy checked. Input as real.	■		Issue_04	Takes DECC fuel costs and TAG A1.3.7 values as separate series. Calculated as 0.25/0.75 split to calculate financial year. Uses WebTAG rather than DECC index.	Y
		DECC electricity: source, calculation and copy checked. Input as real.	■		Issue_04	Takes DECC industrial electricity costs and TAG A1.3.7 values as separate series. Calculated as 0.25/0.75 split to calculate financial year. Uses WebTAG rather than DECC index.	Y
4	Financial Model	Diesel fuel and electricity now use WebTAG rather than DECC forecasts. Staff costs use WebTAG AEI rather than OBR data.	■		OK	Use of WebTAG values is consistent with TAG Unit A5.3	
5		No capital lease costs are included when switched to MML KO1	■		OK		
6	Financial Model	Spot check - adding values to options and turning those options on. These feed through into the subsidy premium calculation.	■		OK		
7	Financial Model	Check that DMU/bi-mode has been added to rolling stock model sections. Check through 'Index Factor' tab - and spot check that change follows through into option tabs.	■		OK		

Check#	Model Name	Description	Checker	Date	ok/ issue	Comments	Closed?
8	Financial Model	<p>"Modelled values taken from here:</p> <p><a href="file:///P:/GBMRB/TP/HA/Projects/5149977%20-%20MML%20Business%20Case%20-%20ARRA7444/5159267%20MML%20KO1%20FBC%20-%20ARRA7444/00%20Enquiry/5149977%200002%20MML%20-%20FBC%20Appraisal%20Specification%20&amp;%20Assumptions_v1.xlsx">file:///P:/GBMRB/TP/HA/Projects/5149977%20-%20MML%20Business%20Case%20-%20ARRA7444/5159267%20MML%20KO1%20FBC%20-%20ARRA7444/00 Enquiry/5149977%200002 MML%20-%20FBC%20Appraisal%20Specification%20&amp;%20Assumptions_v1.xlsx</a></p> <p>EAUC - fine, diesel consumption - fine, electric consumption - fine,</p> <p>Unclear where the capital costs feed in."</p>	■		Issue_05	"Maintenance rate for Meridians - 0.80 post-2021 is correct. Query why this is different prior to 2021.	Y
9		Nothing to check					
10	Financial Model	Option 12 tab - should summarise 8-car DMU inputs. No inputs in Option 12 tab.	■		Issue_06	No inputs in Option 12. Review inputs.	Y
11		No check at this stage.					
12	Financial Model	EC4T figures seem fine. Diesel spot price confirm the figure from WCP - £/l 0.32?	■		Issue_07	Check diesel spot price from WCP	Y
13	Maintenance Calculations	"Light maintenance figures for 2016/17 don't match previous comparator RoA. Other figures seem fine. Unclear where TSA for 222/EMUs come from as these weren't included in previous RoA.	■		Issue_08	"Light maintenance doesn't match figures from previous comparator. £/mile maintenance rates not specified in options."	Y

Check#	Model Name	Description	Checker	Date	ok/ issue	Comments	Closed?
14	Base_Nom and Opt_Nom tabs of Financial Model	Numbers feed through into base option fine - options do not specify the £/mile for maintenance."	■		Issue_09	Need to review inputs of units. This doesn't seem sensible.	Y
15	Fleet Requirements	This looks wrong in the base. We end up with negative numbers of units row 1238 and 1239 in base (for PRM compliant HSTs).	■		Issue_10	Fleet requirements could benefit from commentary on where the assumptions come from and how the results are used.	Y
	Financial Model	Calculation seems fine. Unable to check the original assumptions. Little details on what these actually represent and how they are used.	■		Issue_11	Check of 'Opt_Nom' tab row 1243. This matches with 'central case' rolling stock calculation above, except for 2030/31	Y
16	Financial Model	Check of 'Opt_Nom' tab row 1243. This matches with 'central case' rolling stock calculation above, except for 2030/31	■		OK		
17	Staff Model Calc	"Assumption is fine - based on total vehicles (98 to 58) rather than units (11 to 7).	■		Issue_12	Staff calculation could benefit from commentary on where the assumptions come from and how the results are used.	Y
	Financial Model	Check of 'Opt_1 - KO1 (DS)' tab row 797. This matches with the staff calculation above, except for 2030/31.	■		Issue_13	Check of 'Opt_1 - KO1 (DS)' tab row 797. This matches with the staff calculation, except for 2030/31.	Y

## Financial model issue log and actions

Issue	Model	Raised By	Description	Reviewer	Actions	Follow on Check By	Follow on Check Date	Status
Issue_01	Financial Model	█	Should Option 9: For WebTAG appraisal also be set on?	█	█ - When Cell O29 is set as MML KO1, Cell O22 for Option 9 is automatically set on ('yes'). No action should be taken.			Closed
Issue_02	Financial Model	█	Subsidy / premium tables do not match with previous comparison versions.	█	█ Analysis undertaken in link below. P:\GBMRB\TP\HA\Projects\5149977 - MML Business Case - ARRA7444\5159267 MML KO1 FBC - ARRA7444\08_QA\Franchise Premium QA.xlsx Other charges error has no impact in results and maintenance differences can be explained due to the approach in appraisal. All other differences can be explained.			Closed
Issue_03	Financial Model	█	'Opt_1 - K01 (DS) cells K2863-K2893 contain text, and return errors in later calculations.	█	Remove text and set to zero. Sorted in checked version.			Closed
Issue_04	Financial Model	█	Query that WebTAG rather than DECC fuel and electricity costs are used in index.	█	█ - in the spreadsheet where the series were calculated, there was a comment saying that DECC would be used, but actually WebTAG had been used in the FM. No changes are suggested.			Closed
Issue_05	Financial Model	█	"Maintenance rate for Meridians - 0.80 post-2021 is correct. Query why this is different prior to 2021. Unclear where the capital costs feed in."	█	█ - Maintenance costs for Meridians are contracted through a TSA, i.e. a given per veh per annum amount. The comparator shows different rates in different years (e.g. £180k in 15/16, £192k in 16/17, etc.). The calculations to derive a per mile rate are included in the spreadsheet below. It could be argued that for consistency a constant rate of £0.80 was used for all years. P:\GBMRB\TP\HA\Projects\5149977 - MML			Closed

Issue	Model	Raised By	Description	Reviewer	Actions	Follow on Check By	Follow on Check Date	Status
					Business Case - ARRA7444\5159267 MML KO1 FBC - ARRA7444\05_Technical\Financial Model\Maintenance Calculations.xlsx Capital lease costs are dealt with directly in the appraisal model and not in the financial model			
Issue_06	Financial Model	█	No inputs in Option 12. Review inputs.	█	█ - Originally DMU and bi-mode inputs were laid out in a separate tab (Option 12), but they were later integrated in the Base Inputs tab for simplicity. No action is required.			Closed
Issue_07	Financial Model	█	Check diesel spot price from WCP	█	█ - WCP comparator has a diesel spot price of 39p per litre in 16/17 prices. The EM comparator uses 15/16 prices, therefore a conversion factor of (1/1.08) from the DECC Diesel + GDP deflator series has been used, which provides a diesel spot price of 36.2p per litre in 15/16 prices. No action is recommended.			Closed
Issue_08	Maintenance Calculations	█	Light maintenance doesn't match figures from previous comparator. £/mile maintenance rates not specified in options.	█	█ Light maintenance values were provided by █, representing figures from the LFR - █ suggested using the 16/17 to work out the cost per veh. Table 4-4 of the RoA v7.00 shows the TSA rates for 222s and EMUs and they correspond to the maintenance calculations sheet. The comparator model deals with option additively, i.e. the option scenario is the addition of the base plus all the options. Therefore rates are only to be included in the base (that's why they do not appear in the options) unless there is a change in rates, which is not the case here.			Closed

Issue	Model	Raised By	Description	Reviewer	Actions	Follow on Check By	Follow on Check Date	Status
Issue_09	Base_Nom and Opt_Nom tabs of Financial Model	█	Inputs of HST units looks wrong. Negative unit numbers in base situation (PRM compliant units).	█	█ - the way inputs are laid out in each of the tabs was originally meant to separate the different franchise interventions. For appraisal purposes the Do Minimum is the result of switching off Option 1 DS and looking at results in Option Nominal tab. It can be checked that in that tab the number of vehicles are correct.			
Issue_10	Fleet Requirements	█	Fleet requirements could benefit from commentary on where the assumptions come from and how the results are used.	█	█ - diagramming was undertaken in the SOBC stage and resulted in the fleet requirements used for the FBC. It has been assumed that no changes need to be made to the fleet establishment. Diagramming references can be found in the SOBC folder: P:\GBMRB\TP\HA\Projects\5149977 - MML Business Case - ARRA7444\05_Technical\Appraisal\Mileage Model			
Issue_11	Financial Model	█	Check of 'Opt_Nom' tab row 1243. This matches with 'central case' rolling stock calculation above, except for 2030/31. Likely to be part-year factors.	█	The outputs which are used are the 5-car scenario to represent a strengthened 5-car DMU fleet (Central Case) and the 8-car scenario to represent a uniform fleet (DMU or Bi-modes)"			
Issue_12	Financial Model	█	Staff calculation could benefit from commentary on where the assumptions come from and how the results are used.	█	█ Correct, it is due to part-year factors as used in the rolling stock business case. Assumptions that in 30/31 22% of fleet changed then 100% changed in 31/32, as explained in row 10 of the 'Bridge' tab.			

Issue	Model	Raised By	Description	Reviewer	Actions	Follow on Check By	Follow on Check Date	Status
Issue_13	Financial Model	■	Check of 'Opt_1 - KO1 (DS)' tab row 797. This matches with the staff calculation, except for 2030/31. Likely to be part-year factors.	■	■ - Results are used from tab 'Estimate with Mileage'. Dec-20 with current formation is used since introduction of EMU until 2030, where Dec-20 with 5-car strengthened is used. For the sensitivity with an 8-car fleet, Dec-20 with 8-car fleet is used, likewise for the HS2 sensitivity.			

#### Ad hoc issue log and actions

Issue	Model	Raised By	Description	Reviewer	Actions	Follow on Check By	Follow on Check Date	Status
Issue_01	CAPEX	■	Query on COWD (email ■■■■■ ■■■■■ 15/08/17 11:49)	■■■■■	Confirmation of COWD received by email ■■■■■ ■■■■■ 15/08/17 12:46)	-	15/08/17	Closed
Issue_02	HS2 Sensitivity	■	Issue relating to factoring of user benefits on HS2 scenario identified following detailed check of appraisal model results	■	Alterations to the factoring of user benefits following the introduction of HS2. (As per email from ■■■■■: 15/08/17: 09:16.	-	15/08/17	Closed

[REDACTED]

[REDACTED]

[REDACTED]