Midland Main Line Upgrade Programme

KO1A OBC Economic Case

Department for Transport

04 June 2018

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Introduction

This document presents analysis undertaken by Atkins on behalf of the Department for Transport (DfT) on the economic case for a package of infrastructure works, termed KO1A, that would be required for a fleet of new bi-mode rolling stock to operate at up to 125mph in electric mode on the Midland Main Line (MML) south of Kettering. The package of infrastructure works would be required to upgrade existing Overhead Line Equipment (OHLE) south of Bedford and to increase the power supply through a new connection to the National Grid north of Kettering. These works build upon the existing committed works to be delivered through MML Upgrade KO1, which includes OHLE extending north from Bedford to Kettering and Corby and previously formed part of the scope of works for KO2 (electrification to Sheffield and Nottingham)

Scope of Economic Case

The economic case takes the approved KO1 position as a starting point with the 6tph MML timetable assumed to operate from December 2020 in both the Do-Minimum and Do-Something scenarios. In each scenario Corby services will be operated by 100mph EMUs. Otherwise:

- In the Do-Minimum the Nottingham and Sheffield services continue to be served by the existing class 222 and HST fleets, until their assumed replacement at the end of the next franchise period in December 2030. One of the hourly Nottingham services is timed for and assumed to be operated by HSTs, incurring a journey time penalty relative to Class 222 operation due to their slower acceleration characteristics.
  - Prior to the replacement of the existing fleet it has been assumed that there is a refitting of the Class 222 and HST fleet to address an imbalance in the First/Standard class seat provision particularly for 7-car 222s. This is consistent with the MML KO1 Full Business Case (FBC).
- In the Do-Something it is assumed that KO1A infrastructure works are fully completed by December 2023. In this scenario, the existing fleet is replaced by a fleet of 5-car Bi-mode intercity rolling stock. Bi-modes have been assumed to be capable of meeting Class 222 sectional running times (SRT) in both diesel and electric mode.

The table below summarises the timeline and change points throughout the appraisal period.

Timeline	Do-Minimum (KO1)	Do-Something (KO1A)
December 2019	. Fleet size is assumed to be the same as that required to resource the May 2018 timetable. HSTs are assumed to be made fully-compliant with PRM-TSI . This assumes no derogation is allowed regardless of requirements for the future timetable	
December 2020 (Introduction of 6tph Timetable)	Cascaded 4-car 100EMUs[1] procured by the new franchisee for Corby services.	
December 2023	-	Assumed replacement of Class 222 and HSTs with new-build 5-car Bi-Modes (initial train in service December 2022, full fleet in place by end of 23/24 rail year[2]). Bi-modes capable of matching Class 222 SRTs in both diesel and electric mode.
2030/31	Assumed replacement of Class 222 and HST fleets with new-build 5-car 125mph DMUs	
2045/46	Replacement of 100mph EMUs (Assuming 379s built in 2010/11)	
2052/53	-	Replacement of Bi-Modes
2060/61	Replacement of 125mph DMUs	-
2082/83	End of 63-year appraisal period	

The core appraisal has considered four options for infrastructure investment. 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. Capital investment options included:

- **Option 1:** Electrification to Kettering North Junction as per KO1, with a cable to the planned feeder at Braybrooke;
- **Option 2:** OHLE extended to Braybrooke from Kettering North Junction;
- **Option 3:** OHLE extended to Market Harborough from Kettering North Junction; and
- **Option 4**: OHLE extended to 'south of Leicester' from Kettering North Junction.

It has been assumed that the Bi-Mode trains will be required to switch between traction modes on the move at full line-speed, based upon similar operation on the GWML with the Hitachi Bi-Mode fleets.

Key cost assumptions of an MML Bi-mode fleet and for a fleet of new 125mph DMUs, which would ultimately replace the existing fleet in the Do-Minimum, are shown in the table below. Rates are in a 2016/17 price base unless otherwise stated.

1 Electric-capable trains that will operate at least at 100 mph. Timetable development will use previous 100mph SRTs for the Corby Class 379s 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.
2 In revenue modelling terms, this will be reflected by a December 2023 timetable change.

	New 125mph DMU		New 125mph Bi-Mode	
Cost Item	**Rate**	**Source**	**Rate**	**Source**
Capital lease charge (£ per vehicle per year, 2020/21)	[redacted] (2020/21)	EMRF Rolling Stock Business Case (RSBC)	[redacted] (2020/21)	EMRF RSBC - [redacted] build cost with a financing rate of [redacted] per £m
TSA rate (£ per vehicle mile)	[redacted]	DfT Rail Analysis	[redacted]	DfT Rail Analysis
VTAC rate (pence per vehicle mile)	[redacted]	As per Class 222	[redacted]	[redacted]
Diesel fuel consumption rate (litres per vehicle mile)	[redacted]	DfT Rail Analysis	[redacted]	EMRF RSBC (Based upon Class 800/AT300 consumption rates. [redacted])
Electric consumption rate (KwH per vehicle mile)	-	-	[redacted]	Based upon Class 800/AT300 rates

Timetable Development

This business case has been undertaken using the timetables currently contained in the East Midlands Rail Franchise (EMRF) Comparator model.

It should be noted that there is still considerable uncertainty around the final status of the MML Thameslink timetable, particularly surrounding journey times and calling patterns for East Midlands (EM) services and associated impacts on EM revenue and costs. The May 2018 Thameslink timetable will not be finalised until December 2017 whilst the industry will continue to develop and refine the timetable for the December 2018 timetable (finalised after the issue of the EM Invitation to Tender (ITT)). The resultant timetables may result in significant changes to overall EMRF franchise premiums. However, future timetable development should have only a limited impact on the business case presented in this document as the only difference between Do-Minimum and Do-Something timetables are due to the earlier replacement of HSTs with the procurement of a Bi-mode fleet. This journey time saving is subject to sensitivity testing investigating bidder strategies to provide the same journey time saving over the next franchise period.

Results of Business Case Analysis

Timetable Scenario (Extent of Electrification)	Option 1 (74 miles 20 chains)	Option 2 (80 miles 3 chains)	Option 3 (83 miles 10 chains)	Option 4 (-)
PVB	166	179	186	tbc
Investment Costs	179	170	176	tbc
Operating Costs	29	18	13	tbc
Revenue	-52	-52	-52	tbc
PVC	156	137	137	tbc
Resulting Net Present Value	**10**	**42**	**49**	**tbc**
BCR	**1.07**	**1.31**	**1.36**	**tbc**
Impact on financial premium over 8-year franchise (£, nominal)	*-60*	*-58*	*-56*	-

The results of the business case analysis suggest that OHLE extensions provide superior value for money than cabling, due to the latter having a greater cost per mile in this instance. OHLE options are projected to deliver Low Value for Money. Examination of the monetised benefits calculations suggest that each additional mile of electrification beyond the appraisal presented will deliver a benefit to cost ratio (BCR) of 2.0 or greater under Bi-mode operation, so long at capital investment costs are below £2.9m per mile (2010 prices and values). This value broadly translates into an Anticipated Final Cost (AFC) of £2.5m excluding QRA for schemes at GRIP 1 & 2[3].

The procurement of a Bi-mode fleet is projected to reduce East Midlands franchise premium over an 8-year franchise by approximately [redacted]. This is largely as a result of higher capital lease costs on Bi-modes compared to the existing fleet (particularly for the HSTs). Following the replacement of this fleet in the Do-Something scenario the premium would be forecast to be higher with the Bi-mode fleet, as a result of net fuel savings across electric and diesel operation. (The actual premium is influenced by the capital lease costs with different phasing in the Do-Minimum and Do-Something scenarios).

Sensitivity Testing

A number of sensitivity tests have been examined around the 'Capital Investment Option 3' (NPV 49, BCR 1.36). These have been undertaken to assess the resilience of the business case to exogenous uncertainty, increases in capital cost, and variances in the assumed rates and operating characteristics of new build stock which does not currently exist. In summary these sensitivities show the business case for the KO1A\Bi-mode package is:

- Improved to a BCR of 1.49 (NPV £69m) when considering capital costs consistent with the final financial case. This reduced the nominal cost of the scheme, inclusive of risk from to £249,344 in the central case to £233,466k.
- Relatively insensitive to changes in passenger demand forecasts because the core benefits are not driven by change in passenger revenue or user benefits.
- Highly sensitive to variations in diesel prices over the appraisal period. DECCs high diesel price scenario (which is more comparable to diesel prices experienced between 2010-14) increases the NPV by £48m, raising the BCR to 2.08. The low DECC forecast results in a downturn of comparable magnitude.
- Transformed if considering higher damage costs for NOx emissions from DfT's Supplementary Guidance on Environmental Appraisal (WebTAG Unit A3, March 2017). This would increase the monetary valuation of reduced emissions by £304m. However, it should be noted that current supplementary guidance considers that where tests are carried our using interim NOx values, the results should be reported in the 'Qualitative' column of the 'Air Quality' row of the Appraisal Summary Table, but should not be included in the 'Monetary £(NPV)' column.
    - Updated interim NOx damage values provided by the Department in February 2018 present NOx damage values which are currently around 80% lower than the 2015 interim ones. These values are subject to change although would reduce the valuations of NOx savings down to £88.6m; still a significant uplift from the £13.7m included in the central case appraisal.
- Highly sensitive to changes in assumptions relating to the cost rates or operating characteristics of new rolling stock. For example:
    - A 1-minute change in end-end journey time on Nottingham and Sheffield services has an annual impact on EMRF revenues of [redacted] (2016/17). This difference in journey, for instance due to different rolling stock characteristics, would have an impact of >£100m on the NPV over a 60-year appraisal period.
    - A Bi-mode fleet with a diesel consumption rate 9% higher than an existing Class 222, rather than 18% higher, would increase the NPV of the package from £49m to £88m, delivering a BCR of 1.79 (Medium VfM).
    - Assuming Bi-mode trains have capital lease cost 9% higher than, rather than identical to, new 125mph DMUs would decrease the NPV to £1m and the BCR to 1.01.
    - Assuming no inherent passenger preference for Bi-mode trains over new 125DMUs would decrease the NPV to -£12m, and the BCR to 0.93. Doubling the current valuation of 0.25% would raise the NPV to £97m and the BCR to 1.82).

Rolling Stock Fleet and Configuration

A number of sensitivities have also been conducted around rolling stock configuration and the composition of the fleet in each scenario. The results of these sensitivity tests show that:

[3] It should be noted that this figure only holds were a 4tph service operates on the MML and where Bi-modes can operate on the full additional length in electric mode. Nor does this value hold true to the total extent of electrification in the original appraisal due to the unchanged elements with additional electrification (e.g. capital lease costs).

- In a scenario where all Nottingham \ Sheffield services operated with Class222 sectional running times over the next franchise period (rather than on replacement of the existing fleet in 2030/31) the BCR of the existing package would fall to 1.21.
- If Bi-mode trains could only be procured in 8-car fixed formation the BCR of the scheme would be projected to fall to 0.39 due to the extra operating costs associated with resultant increases in vehicle mileage. (This sensitivity test was undertaken to assess the implications if Bi-mode trains could only meet Class 222 SRTs in longer formations).

High Speed 2

A sensitivity test has investigated the impact of HS2 on the KO1A package. Benefits of the package, enabling 125mph operation of Bi-mode trains south of Kettering (and up to Leicester in some options) are primarily related to environmental impacts, particularly the monetised value of reduced carbon emissions. This is particularly true with relation to the scheme following the opening of HS2, when the existing fleet will have been replaced in each scenario. The introduction of HS2 would be forecast to result in a BCR of between 1.27-1.35 for the package (compared to the central case of 1.36). The business case is not highly sensitive to the introduction of HS2 as the same timetable is taken to operate in the Do-Minimum and Do-Something scenario by the opening date of 2033. A small reduction in benefits results from the reduced number of passengers on the MML (reducing the number of passenger who perceive and ambiance uplift from Bimode trains).

Full Electrification

A sensitivity test has re-examined the business case for full electrification of the MML to Nottingham and Sheffield alongside the introduction of new 125mph EMUs. With a capital cost of £979m (2010 prices and values) the scheme would be forecast to have a BCR of 1.17. Sensitivities suggest the BCR would:

- Increase to 1.59 (Medium VfM) under a high diesel cost scenario;
- Increase to 1.67 (Medium VfM) if 125EMUs were to deliver an additional minute’s journey time saving to Nottingham and Sheffield)
- Decrease to 0.78 if considered alongside the introduction of HS2 in 2033. Whilst marginal on the KO1A business case the introduction of HS2 would damage the KO2 business case. This is because:
  - The benefits of small journey time savings with electrification are reduced as long-distance London passengers are abstracted by HS2; and
  - Curtailing one Sheffield service at Derby post HS2 would lower the benefits of running 125 mph EMUs, rather than the diesel fleet assumed in the Do-Minimum, due to reduced vehicle mileage.

The business case for electrification would also significantly benefit if considering higher damage costs for NOx emissions from DfT’s Supplementary Guidance on Environmental Appraisal (WebTAG Unit A3).

This BCR of Full Electrification is sensitive changes to capital costs. For use in this sensitivity test these costs taken from the original business case in £m2010NPV (September 2016) in 2010NPV and have not been re-evaluated as part of this work.

Caveats and Limitations on Analysis

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

- This business case uses cost estimates and specifications for new bi-mode trains, it should be noted that no such trains with the required capability exist and given the bespoke requirements the likely costs of such vehicles are not known and subject to high level of risk and uncertainty, as reported in the sensitivity testing this can have a significant impact on the results.
- 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.
- There is still considerable uncertainty around the final status of the MML Thameslink timetable, particularly surrounding journey times and calling patterns for EM services and associated impacts on EM revenue and costs. The May 2018 Thameslink timetable will not be finalised until December 2017 whilst the industry will continue to develop and refine the timetable for the December 2018 timetable (finalised after the issue of the EM ITT). The continued evolution of these timetables may have a

significant impact on franchise premiums. However, with regards to the appraisal undertaken in this document changes should only have a limited impact as each scenario runs an identical timetable following the replacement of the existing fleet in 2030/31.

- The GTR timetable originally supplied to enable timetable development did not include a specific counter-peak direction timetable. At this time Atkins were not able to timetable ECS moves into and out of Cricklewood depot in the peak and shoulder peak periods. However, it was agreed with GTR at a workshop held on 20th July 2016 that it would be reasonable to assume up to 2 ECS paths per hour between St Pancras and Cricklewood.
- Revenue transfer from crowding relief is subject to the methodological application of the PDFH approach which does not reallocate demand between trains or operators. With regards to this business case this is of highest significance when forecasting different rolling stock configurations on Corby services (e.g. the Homogenous fleet sensitivity test)
- Analysis in this report has been produced in advance of December 2017 updated to WebTAG.

1. Introduction

1.1. Background

In order for new bi-mode rolling stock to operate up to 125mph in electric mode on the Midland Main Line (MML) south of Kettering, a package of infrastructure works is required to upgrade existing Overhead Line Equipment (OHLE) south of Bedford and to increase the power supply as required north of Kettering. These works, termed KO1A, build upon the existing committed works to be delivered through MML Upgrade KO1 which includes OHLE extending north from Bedford to Kettering and Corby, and are required in order for new bi-modes to operate in electric mode on the MML.

In November 2017 the Department for Transport commissioned Atkins to prepare an outline business case for the programme of works detailed above. This scope-of-work is of relevance to two contracts on which Atkins have been appointed by the Department:

- 'PPRO 04101016: Rail Group Procurement of Economic Advisors, Work Package B'. The contract commenced on 1st April 2016, for an initial 24-month period, primarily to update economic analysis for the Midland Main Line (MML) Upgrade Programme to support key decision points relating to the infrastructure works; and
- 'PS582 RM4441 The Provision of Technical Advisers for the DfT Rail Franchising Programme – Work Package A – East Midlands' as the means to approve and procure a fleet for the franchise.

The remainder of this document develops and presents the results of the outline business case for KO1A infrastructure approvals alongside the approvals process for the procurement of Bi-Mode trains to be specified through the East Midlands franchise competition. The appraisal has conducted using the modelling suite developed, and used consistently, across the two contracts above.

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 results of sensitivity testing are presented 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 appraisal assesses the incremental impact of delivering the Bi-Mode package including KO1A on top of the committed KO1 works.

- The 'Do Minimum' adopts the 6tph MML timetable change in December 2020 enabled by the KO1 investment. In this scenario Corby services would be operated by 100mph EMUs[4], with existing Class 222 and HST fleets deployed on Sheffield and Nottingham services (this essentially adopts the Do-Something position from the KO1 appraisal).
- The Do Something (KO1A) enables the operation of the southern end of this timetable with 125mph electric running for up to 6tph in each direction between St Pancras and Kettering.

The 6 train per hour service pattern operating in both the Do-Minimum and Do-Something is presented in Table 2-1 below:

Table 2-1 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 Bi-Modes	Chesterfield, Derby, Long Eaton, Loughborough, Leicester	60 min interval
Sheffield (fast)	St Pancras	MML long distance	All day	125mph Bi-Modes	Chesterfield, Derby, East Midlands Parkway, Leicester	60 min interval
Nottingham (fast)	St Pancras	MML long distance	All day	125mph Bi-Modes	East Mids Parkway, Leicester, Market Harborough, Kettering	60 min interval
Nottingham (fast)	St Pancras	MML long distance	All day	125mph Bi-Modes	Beeston, Loughborough, Leicester, Market Harborough	60 min interval
Corby (semi-fast)	St Pancras	MML outer	All day	100mph EMU	Kettering, Wellingborough, Bedford and Luton	60 min interval
Corby (semi-fast)	St Pancras	MML outer	All day	100mph EMU	Kettering, Wellingborough, Bedford and Luton Airport Parkway	60 min interval

Assumptions regarding the replacement of rolling stock during the appraisal period are summarised as follows:

- In both the Do-Minimum and Do-Something scenarios the 6tph MML timetable will operate from December 2020. As above Corby services will be operated by 100mph EMUs, with existing Class 222 and HST fleets deployed on Sheffield and Nottingham services. One of the hourly Nottingham services will be timed for and operated by HSTs, incurring a journey time penalty relative to Class 222 operation.

[4] Electric-capable trains that will operate at least at 100 mph. Timetable development will use previous 100mph SRTs for the Corby Class 379s 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.

- Consistent with the Do-Something position from the KO1 business case, the Do-Minimum assumes that the above fleet will operate until 2030/31. This fleet is then assumed to be replaced by a 5-car 125DMU fleet capable of meeting Class 222 sectional running time (SRTs).
  - Prior to the replacement of the existing fleet it has been assumed that there is a refitting of the Class 222 and HST fleet to address an imbalance in the First/Standard class seat provision particularly for 7-car 222s. This is consistent with the MML KO1 FBC.
- In the Do-Something it is assumed that KO1A infrastructure works are fully completed by December 2023. In this scenario, the existing fleet is replaced by a fleet of 5-car Bi-mode intercity rolling stock. Bi-modes have been assumed to be capable of meeting Class 222 SRTs in both diesel and electric mode.
  - Prior to the replacement of the existing fleet it is assumed that the refitting of the Class 222 and HST fleet does not occur due to the earlier replacement (as above). Because of the different assumptions prior to the completion of the KO1 infrastructure investment this scheme has been appraised over a 63-year appraisal period; 60-years from the completion of the KO1A infrastructure, and 3-years prior to this point accounting for the different internal configurations of the existing fleet.

Assumptions regarding the wider replacement of rolling stock during the appraisal period are be based on the guidance in TAG Unit A5.3. This advises that new diesel multiple units (DMU) should be assumed to have a minimum lifespan of 30 years, and new electric multiple units and electric locomotives should be assumed to have a minimum lifespan of 35 years. Table 2-2 below shows central case assumptions relating to rolling stock; this assumes replacement at the minimum lifespan taken as 30 years for Bi-Modes.

Table 2-2 Timeline and Change Points

Timeline	Do-Minimum (KO1)	Do-Something (KO1A)
December 2019	A PRM-compliant HST fleet required in service to operate the 5tph May-18 MML timetable. Fleet size is assumed to be the same as that required to resource the May-18 timetable. This assumes no derogation is allowed regardless of requirements for the future timetable	
December 2020 (Introduction of 6tph Timetable)	Cascaded 4-car 100EMUs[5] procured for Corby services.	
December 2023	-	Assumed replacement of Class 222 and HSTs with new-build 5-car 125 Bi-Modes (initial train in service December 2022, full fleet in place by end of 23/24 rail year[6])
2030/31	Assumed replacement of Class 222 and HSTs with new-build 5-car 125DMU	
2045/46	Replacement of 100mph EMUs (Assuming 379s built in 2010/11)	
2052/53	-	Replacement of 125 Bi-Modes
2060/61	Replacement of 125DMUs	-
2082/83	End of 63-year appraisal period	

2.2.1. Capital Investment Scenarios

The business case examines four separate infrastructure options to deliver 125mph electric running for up to 6tph in each direction between St Pancras and Kettering. These infrastructure options are summarised in Table 2-3 below.

[5] Electric-capable trains that will operate at least at 100 mph. Timetable development will use previous 100mph SRTs for the Corby Class 379s 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.
6 In revenue modelling terms, this will be reflected by a December 2023 timetable change.

Table 2-3 Capital investment options

Option	Description	Electrification Mileage
1	Electrification to Kettering North Junction as per KO1, with a cable to the planned feeder at Braybrooke;	74 miles 20 chains
2	OHLE extended to Braybrooke from Kettering North Junction	80 miles 3 chains
3	OHLE extended to Market Harborough from Kettering North Junction	83 miles 10 chains
4	OHLE extended south of Leicester (Kilby Bridge Junction) from Kettering North Junction	93 miles 40 chains

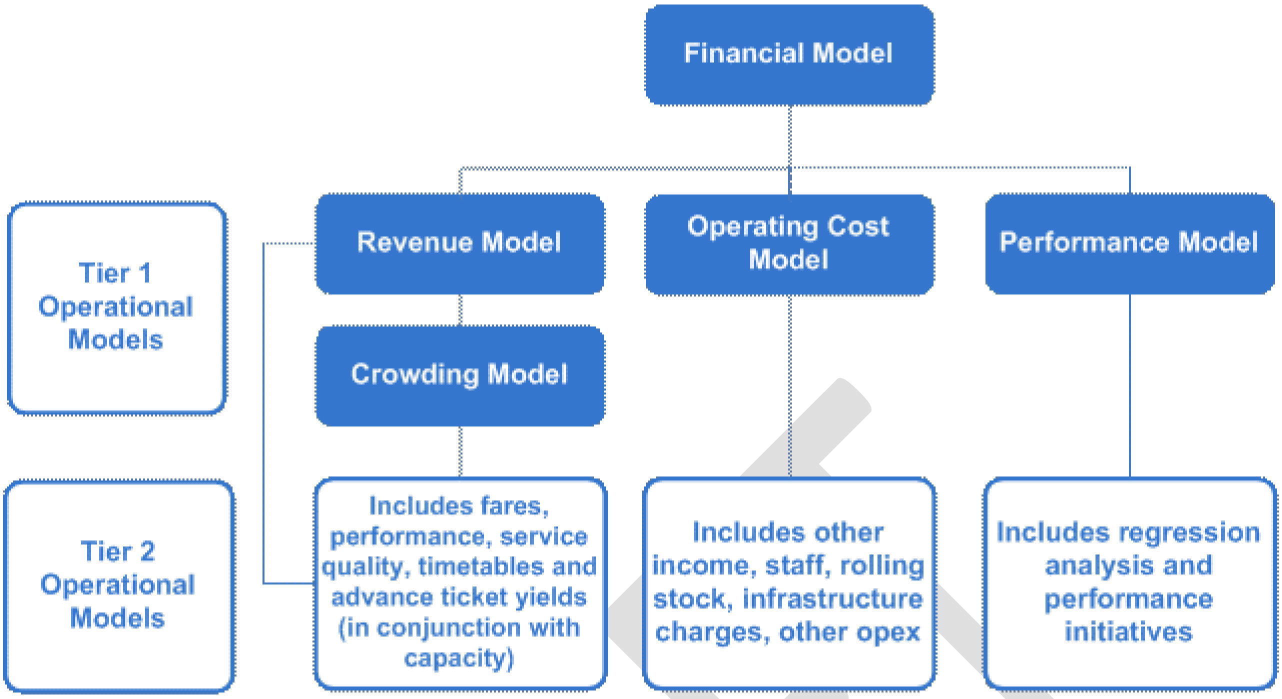
As the SRT of Bi-modes is taken to match existing Class 222s in both diesel and electric mode, each option has been appraised using a single timetable. Capital investment options are appraised by offsetting capital infrastructure costs against the proportion of the timetable that is operated in diesel and electric modes. For simplicity in modelling it has been assumed that Bi-Modes will switch seamlessly at speed to diesel operation at the extent of electrification.

It is assumed that the modelled KO1 FBC service pattern is retained in each scenario including OHLE south of Leicester. Electrification south of Leicester would open the possibility of running a fifth service each hour to Leicester, replacing one of the hourly Corby services. Previous sensitivity tests have suggested that this is not economically positive; benefits have been limited in existing timetabling work due to this service being ‘overtaken’ prior to arriving at London St Pancras. However, from a strategic perspective this option offers benefits of partially reinstating north-south connectivity across Kettering and merits further investigation considering the responses received in the public consultation undertaken for the East Midlands refranchising process.

2.2.2. Modelling Approach

To be consistent with the KO1 full business case presented in August 2017 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 forecasts and has accounted for outturn demand and revenue for the 2016/17 financial year. For this study exogenous forecasts provided by the DfT in the format of the July 2017 Demand Driver Generators are used. 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. Figure 2-1 below provides an overview of the East Midlands Franchise Comparator Suite.

Figure 2-1 East Midlands Franchise Comparator Model Suite



3. Timetable Development

There is still considerable uncertainty around the final status of the MML Thameslink timetable, particularly surrounding journey times and calling patterns for EM services and associated impacts on EM revenue and costs. The May 2018 Thameslink timetable will not be finalised until December 2017 whilst the industry will continue to develop and refine the timetable for the December 2018 timetable (finalised after the issue of the EM ITT).

In light of ongoing uncertainty around the December 2018 timetable this business case has been undertaken using the timetables currently contained in the EMRF Comparator model. This assumes that:

- The May 2018 timetable will operate as bid by East Midlands Trains/Govia Thameslink Railway in August 2017[7]; and
- The KO1 timetable is the KO1 full business case development version of the December 2020 timetable currently used in the EMRF Comparator. With regards to this timetable it should be noted that:
  - The comparator timetable for December 2020 was developed using the version of TRIPS available at the time, recent revisions to TRIPS have reduced the number of SRT increases.
  - Network Rail timetable development work (developed using the same version of TRIPS) following the production of the timetable above have provided faster journey times on Corby services as a result of updated assumptions on SRTs. As a consequence, the journey times on these services could be reduced by up to 5 minutes.

With regards to the December 2020 timetable it should be noted that the developments highlighted above are likely to provide an uplift on the return on the December 2020 timetable. With regards to the EMRF it is proposed that these changes should be incorporated with revised economic forecasts in early 2018.

With regards to the appraisal undertaken in this document the above changes would have a minimal impact as the appraisal assumes that both new 125DMUs and a new Bi-mode fleet would be capable of meeting Class 222 sectional running times. As a result, the only impact that timetable development has on the KO1A business case is during the period from December 2023 to December 2030 due to the earlier replacement of HSTs in the Do-Something. This results in a time saving in the Do-Something as sectional running times of the HSTs requires an additional 8-minutes relative to Class 222 operation.

This time saving is subject to sensitivity testing through examining the impact of delivering identical journey time savings in the Do-Minimum for the period between December 2023 and December 2030. This assumes that the use of shortened HSTs (in 2+6 formation rather than 2+8) could match Class 222 journey times and therefore realise the journey time and revenue uplifts identified with Bi-Modes.

[7] Requiring three additional HST sets leased (ex-Grand Central) as per ROSCO terms provided.

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. Due to the similarity in the timetables operated it should be noted that the primary benefits of the scheme assessed over a 63-year appraisal period do not result from demand and revenue changes. The primary benefits of the package result from monetised environmental benefits and operational savings as a result of the rolling stock characteristics.

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 advice given in DfT's Transport Analysis Guidance (TAG) Unit M4 (November 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[8] 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; and
- 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 MML 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 as follows:

[8] LENNON is a database that stores ticket sale data from all purchased rail tickets in the UK rail network.

- Timetable impacts which are modelled using MOIRA1[9] – with both 'Generalised Journey Time' and 'ORCATS'[10] 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 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[11] 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 of 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 [(crowded + uncrowded mins) / 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.

Table 4-1 below shows the factors included in the demand and revenue forecasts and the assumptions with relation to the inputs and elasticities:

[9] MOIRA 1 is a piece of software used to forecast the impact of timetables on passenger demand and revenue.
[10] 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.
[11] 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
Exogenous Drivers		
GDP or employment	Input: EDGE[12], 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
Endogenous Drivers		
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[13]	PDFH5.0 Table B6.2
Train Loadings	MOIRA: OR55	
Crowding: average journey time elasticities	Average derived for EMRF LDHS services [redacted] Average derived for EMRF 'other' services [redacted]	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

[12] Exogenous Growth Demand Estimation (EDGE) inputs provided by the DfT (Forecasting Source: July 2017)
[13] 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'.

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 of current loading and by the balance of seating of proposed rolling stock. As a result, the 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. Rebalancing is not applied in the Do-Something due to the earlier replacement of the existing fleet.

Table 4-2 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 and Bi-Mode 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

	Current Rolling Stock Capacity			Appraisal Rolling Stock Capacity		
Rolling Stock	Standard Seats	Standard Class Standing Capacity m²	1st Class Seats	Standard Seats	Standard Class Standing Capacity m²	1st Class Seats
HST	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
222 4-car	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
222 5-car	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
222 7-car	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
125 mph DMU 5-car				[redacted]	[redacted]	[redacted]
125mph Bi-Modes 5-car				[redacted]	[redacted]	[redacted]
125mph Bi-Modes 8-car				[redacted]	[redacted]	[redacted]
100 mph EMU 4-car				[redacted]	[redacted]	[redacted]

4.3. Appraisal of Benefits

The Revenue Model developed for the East Midlands franchise competition is used to forecast 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).

[14] This appraisal has not made any alterations to seating or standing capacities on HSTs resulting from modifications relating to PRM TSI requirements.

- **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 Table 4-3 below:

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.
- **Rolling stock ambience:** Is calculated as a weighted in-vehicle time, making the following assumptions with relation to rolling stock:
  - A new 125mph DMU will deliver an in-vehicle ambience which is equivalent to existing Class 222s or HSTs
  - A new 125mph Bi-mode will deliver a 0.25% reduction in in-vehicle time relative to an existing Class 222 or HST, resulting from an improved ride quality when operating under the wires.
  - 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 of in-vehicle ambience resulting from the replacement of high quality inter-city rolling stock with suburban style EMUs on services to Corby 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.
- **Nitrous Dioxide Emissions**. The monetary value of proposed electrification on Nitrous Dioxide emissions has been calculated in accordance with TAG Unit A3 Environment Impact Appraisal. Previous appraisal has assumed that NOx emissions from diesel trains can be taken to be in the order of 80 grams per kilometre per train (TAG Unit A3) with no NOx emissions from electrical rolling stock. Recognising the different diesel consumption rates between new build 125mph BMUs and Bi-modes, this appraisal has assumed that replacement stock shall meet the upper limit for Nitrous Dioxide emissions according to Stage 5 Rail Traction Standards from the non-road mobile machinery (NRMM) directives; limiting emissions to 2.0 g NOx/kwh for auxiliary engines used in railcars. This derives emission rates of:
  - 5-car 125DMU: 62g grams per kilometre per train
  - 5-car Bi-Mode: 73g grams per kilometre per train (whilst operating in diesel mode)
- **Performance:** Performance forecasting for the EMRF has forecast scenarios both retaining and replacing HSTs. These forecasts have been used within the appraisal for the KO1A investment assuming that HSTs are replaced in 2023/24 in the Do-Something and not until 2030/31 in the Do-Minimum.

4.4. Forecasting Results

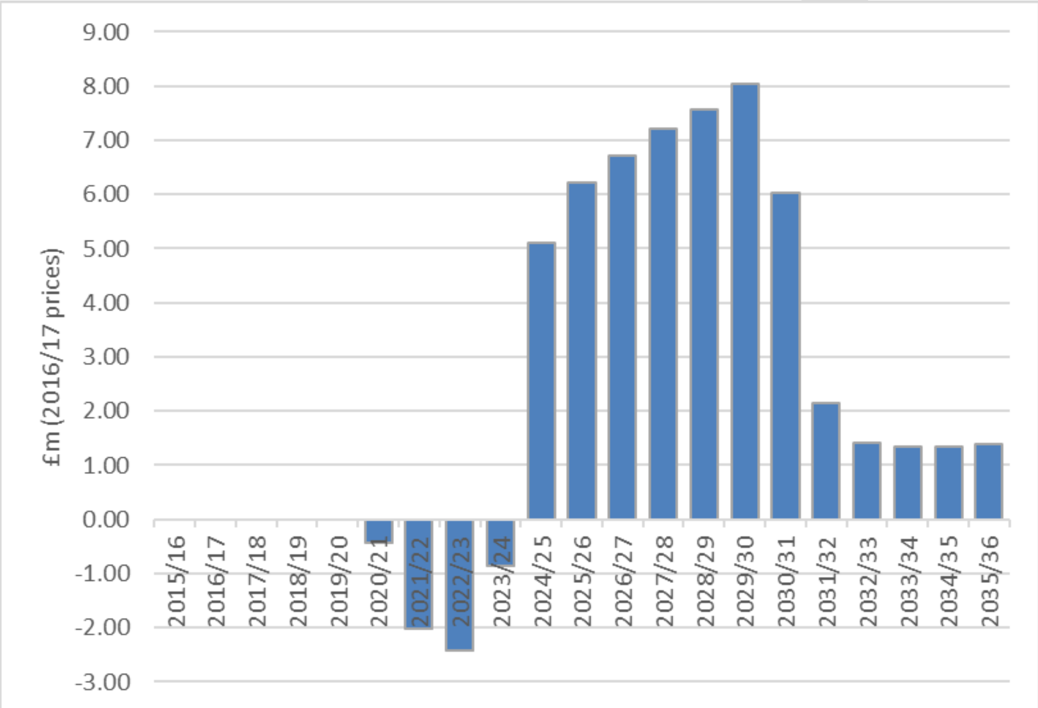
4.4.1. Introduction

This section presents the results of the demand and revenue forecasting exercise and examining the changes in demand and revenue forecasts between Do-Minimum and Do-Something scenarios. It also present a build-up of wider appraisal benefits.

4.4.2. Growth in Demand over the Appraisal Period

Figure 4-1 below shows the difference in annual national rail revenues resulting from the implementation of the Do-Something scenairo:

Figure 4-1 Revenue difference between Do-Something and Do-Minimum scenarios



The revenue changes shown in the chart above are result of:

- Prior to the procurement of the Bi-mode fleet national rail revenues are reduced in the Do-Something scenario. This is due to reconfiguration of First\Standard class seating throughout the existing Class222\HST fleet in the Do-Minimum resulting in reduced levels of crowding. Given the estimated cost of £28m this reconfiguration is not implemented in the Do-Something appraisal scenario due to the earlier replacement of the fleet.
- With the introduction of the Bi-mode fleet revenue benefits in the Do-Something ramp-up from £5m per annum to £8m per annum this is due to:
  - The replacement of existing HSTs, which results in an 8-minute reduction in journey time between London and Nottingham, due to reduced sectional running times;
  - Performance benefits from replacing the HSTs;
  - Crowding benefits from the new 5-car fleet with peak strengthening; and
  - Ambience benefits assumed to result from a new fleet of Bi-modes operating under the wires to Kettering (or beyond). A new 125mph Bi-mode is assumed to deliver a 0.25% reduction in in-vehicle time relative to an existing Class 222 or HST.
- Following the assumed replacement of Class 222 and HSTs with new-build 5-car 125DMU in 2030/31 the revenue improvements in the Do-Something scenario are reduced to approximately £1.25m per

annum. With the introduction of a new fleet of 5-car 125mph DMUs all benefits above are equalled out except for ambience improvements.

4.4.3. Growth in Demand over the Appraisal Period

Figure 4-2 below shows the accumulation of benefits over the appraisal period. This is presented for Option 3: OHLE extended to Market Harborough from Kettering North Junction. The chart 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); and
- The cumulative appraisal benefits accrued over the appraisal period – as the shaded area of the chart. (Note: for appraisal purposes the increased revenue is essentially treated as a reduction in costs).

Figure 4-2 Growth in Demand and Benefits Over the Appraisal Period

[redacted]

Key points to note from Figure 4-2 are that:

- The majority of benefits are derived from air quality benefits, which relate to different emissions between Bi-modes and 125DMUs, particularly as a result of running under the wires; and
- With the exception of air quality, benefits tail off after 2030/31. From this point, onwards a new fleet of 125DMUs is assumed to achieve the same journey times and deliver the same capacity as Bimodes. The only passenger benefits that remain following this point are as a result of an 0.25% perceived saving in in-vehicle time which represent the relative ambience benefits of running in electric mode, as opposed to diesel running, as far as Kettering\Market Harborough.

5. Rolling Stock

5.1. Introduction

As described in Section 2 the 6tph MML timetable change is adopted in December 2020 in both the Do-Minimum and Do-Something scenarios. It is assumed that:

- In the Do-Minimum Corby services will be operated by 100mph EMUs[15], with existing Class 222 and HST fleets deployed on Sheffield and Nottingham services until 2030/31 when they are replaced by a fleet of 125mph 5-car DMUs; and
- In the Do-Something Corby services will be operated by 100mph EMUs[16] (the option would enable some marginal benefits of 110mph running although this is not considered critical to this appraisal); there is an earlier replacement of the existing Class 222 and HST fleets with 5-car Bi-modes in 2023/24.

The rest of this chapter:

- Sets out the baseline fleet assumptions used in the appraisal prior to, and following, the replacement of the existing Class 222/HST fleet.
- 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.

5.2. Existing Fleet

The baseline fleet is based on East Midlands Trains current inter-city rolling stock fleet. [redacted] The size of the current fleet is detailed in Table 5-1 below.

Table 5-1 Existing Fleet

Rolling Stock	Length	No. of Sets	No. of Vehicles
Class 222	[redacted]	[redacted]	[redacted]
Class 222	[redacted]	[redacted]	[redacted]
Class 222	[redacted]	[redacted]	[redacted]
HST (Power Car + Mk3 Coaches)	[redacted]	[redacted]	[redacted]

[redacted].

Source: East Midlands Comparator Suite

5.3. Establishment of Rolling Stock Fleet for Modelled Options

Estimated fleet sizes have been retained from the earlier KO1 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.

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[15] Electric-capable trains that will operate at least at 100 mph. Timetable development will use previous 100mph SRTs for the Corby Class 379s 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.

Following the assumed 2030/31 Do-Minimum replacement of Class 222 and HSTs fleet sizes are consistent between Do-Minimum and Do-Something scenarios. The only difference is that 5-car 125mph DMUs operate in the Do-Minimum instead of the Do-Something Bimode fleet.

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/Bimode	5-car 125mph DMU/Bimode	7-car 125mph DMU/Bimode	HST (2+8 cars)	4-car 100mph EMU
KO1 6tph: Existing Class 222 and HST fleets (with strengthening)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
KO1 6tph: 5-car 125mph DMU replacement fleet for Meridians and HSTs (without strengthening)	[redacted]				
KO1A 6tph: 5-car Bi-mode replacement fleet for Meridians and HSTs (without strengthening)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

**[redacted] complete HST sets, plus some spares, i.e. [redacted] powercars and [redacted] coaches. Reduces requirement from the current fleet due to the introduction of the electric fleet on the Corby services).*

5.3.2. Peak Strengthening

The approach to peak strengthening is 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.

Table 5-3 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/Bimode	**5-car 125mph DMU/Bimode**	**7-car 125mph DMU/Bimode**	**HST (2+8 cars)**	**4-car 100mph EMU**
KO1 6tph: 5-car 125mph DMU replacement fleet for Meridians and HSTs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
KO1A 6tph: 5-car Bi-mode replacement fleet for Meridians and HSTs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

5.3.3. Total Estimated Fleet Requirements

Table 5-4 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/Bimode	5-car 125mph DMU/Bimode	7-car 125mph DMU/Bimode	HST (2+8 cars)	4-car 100mph EMU
KO1 6tph: 5-car 125mph DMU replacement fleet for Meridians and HSTs	-	39	-	-	20
KO1A 6tph: 5-car Bi-mode replacement fleet for Meridians and HSTs	-	39	-	-	20

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.

6. Operating Costs

6.1. Introduction

Operating costs are modelled using the Comparator Suite developed for the East Midlands franchise competition. For the purposes of this appraisal this model forecasts costs and benefits of the six train per hour timetable with the evolving fleet as detailed above.

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^{th} 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 in Table 6-1.

Table 6-1 Annual Train and Vehicle Mileages

Annual Mileage		4-car 125mph DMU/Bimode	5-car 125mph DMU/Bimode	7-car 125mph DMU/Bimode	HST (2+8 cars)	4-car 100mph EMU	Total
KO1 6tph (Existing Fleet)	Train mileage	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Vehicle mileage	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
KO1/A 6tph (5-car Bi-mode\DMU)	Train mileage		[redacted]		[redacted]	[redacted]	[redacted]
	Vehicle mileage		[redacted]		[redacted]	[redacted]	[redacted]

Table 6-1 shows that vehicle mileage under the KO1 6tph timetable remains similar with both the existing fleet and with a replacement 5-car fleet in the latter scenario. (Further analysis suggest that mileage is better matched to demand in the latter).

6.3. Infrastructure Cost Inputs

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

- Capacity charges;
- Variable track access charges (VUC); 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, differentiated by 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 Table 6-2.

Table 6-2 Capacity Charge Rates

Service Group	Price Year	Weekday Rate (£ per train mile)	Weekend Rate (£ per train mile)
EM1500: STP - Sheffield/Leeds	2016/17	2.047	1.372
EM1520: STP – Derby/Sheffield	2016/17	2.306	1.545
EM1530: STP – Nottingham Fast	2016/17	1.968	1.319
EM1540: STP – Nottingham Slow	2016/17	2.235	1.498
EM1560: STP – Kettering/Corby	2016/17	2.225	1.491

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 2016/17 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 Train 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. Rates on the replacement Bi-mode trains are taken to be 12% higher to reflect greater weight per vehicle.

VTAC rates are in 2016/17 prices and in the model are assumed to grow in line with RPI over the appraisal period. Rates are shown in Table 6-3.

Table 6-3 Variable Track Access Charge Rates

Rolling Stock	Price Year	Source	VTAC Rate (pence per vehicle mile)
Class 222 Meridian	2016/17	East Midlands Comparator Model Suite	11.96
HST	2016/17	East Midlands Comparator Model Suite	13.73
100 mph 4-car EMU	2016/17	East Midlands Comparator Model Suite	7.22
DMU (replacement for Meridians and HSTs)	2016/17	Assumption	11.96
Bi-mode (replacement for Meridians and HSTs)	2016/17	12% higher than Class 222 rate to reflect greater weight per vehicle	13.40

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, overhead wires. Therefore, this is only charged to electric trains and is based on vehicle mileage. Note that for bi-mode vehicles the EAUC is only levied on electrified sections of route. Electrification asset usage charge rates applied to electric vehicles in the opex model are listed in Table 6-4. This is based on the rate provided in NR's CP5 price list. The EAUC rate is given in 2016/17 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	2016/17	NR CP5 Price List	1.75
Bi-mode (replacement for Meridians and HSTs)	2016/17	NR CP5 Price List	1.75

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 Table 6-5 below. Based upon Class 800/AT300 consumption rates diesel consumption on Bi-mode trains is taken as 18% higher than an existing Class 222 (or replacement 125DMU)

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	[redacted]
2+8 HST	litres per vehicle mile	East Midlands Comparator Model Suite	[redacted]
DMU (replacement for Meridians and HSTs)	litres per vehicle mile	East Midlands Comparator Model Suite	[redacted]
Bi-mode (replacement for Meridians and HSTs)	litres per vehicle mile	EMRF RSBC (Based upon Class 800/AT300 consumption rates. 18% higher than a Class 222)	[redacted]

6.4.2. Diesel Fuel Prices

A current spot price of 36.3p per litre excluding VAT and Duty (October 2017) is taken to represent the 2017/18 diesel price (in 2016/17 prices). Fuel duty is applied at 11.1p per litre.

Diesel price growth is based on the values for Gas Oil (resource cost) and Gas Oil (Duty) and provided in Table A1.3.7 of the WebTAG databook (March 2017). 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. In agreement with the DfT the March 2017 databook is used reflecting a closer representation of the current spot price than the updated July 2017 series.

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 Table 6-6 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
Bi-mode (replacement for Meridians and HSTs)	kWh per vehicle mile	Based upon Class 800/AT300 rates	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 Comparator Model Suite, of 9.91p per kWh (in 2016/17 prices), to which the real growth to electricity prices was applied.

[17] Per vehicle mile of a total set (10)

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.

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 Table 6-7.

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	[redacted]
Class 43 HST	2015/16	East Midlands Comparator Model Suite	£ per veh per annum	[redacted]
Mk3	2015/16	East Midlands Comparator Model Suite	£ per veh per annum	[redacted]
100 mph Suburban EMU – 4 car	2020/21	Atkins Assumption	£ per veh per annum	[redacted]
DMU (replacement for Meridians and HSTs)	2020/21	DfT Rail Analysis	£ per veh per annum	[redacted]
Bi-mode (replacement for Meridians and HSTs)	2020/21	DfT Rail Analysis	£ per veh per annum	[redacted]

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. (capex of £[redacted] per vehicle, financed through the capital lease at a rate of £[redacted] per million.

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 controlled emission toilets (c [redacted] per vehicle). These costs are based upon a financing rate of [redacted], 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 all 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, where applicable, costs are 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.

Mileage based rates are shown in Table 6-8 below.

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	[redacted]
HSTs	2015/16	East Midlands Direct Award TSA	£ per vehicle mile	[redacted]
100mph EMU – 4 car	2015/16	DfT Rail Analysis	£ per vehicle mile	[redacted]
DMU (replacement for Meridians and HSTs)	2015/16	DfT Rail Analysis	£ per vehicle mile	[redacted]
Bi-mode (replacement for Meridians and HSTs)	2015/16	DfT Rail Analysis	£ per vehicle mile	[redacted]

** 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 mileage rates have been forecast at £0.80 per vehicle mile.*

[1] *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 sixth path delivered by the scheme facilitates an additional hourly service to Corby. This 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. A 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.

It has been estimated that from the introduction of the electric fleet until the replacement of the Class 222s and HSTs in 2030/31, 9 full time equivalent (FTE) on-train staff would no longer be necessary, as remaining staff 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-train 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 operated, in which case it is assumed that two on-train staff would be required.

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 costs removed following HST replacement.

6.8. Operating Costs

Total operating costs (in nominal, undiscounted values) calculated for the 63-year appraisal period are shown for each the Do Minimum and Do Something scenarios in the Table below. With the exception of capital lease costs, costs are presented for the EMRF franchise.

Table 6-9 Total Operating Costs (63 years, £bn, nominal undiscounted)

	Baseline	Option 1	Option 2	Option 3	Option 4
Staff Costs	36.04	36.03	36.03	36.03	-
Rolling Stock Capital Lease Costs	5.84	5.62	5.62	5.62	-
Rolling Stock Fixed Maintenance Costs	1.60	1.59	1.59	1.59	-
Capacity Charge	3.69	3.69	3.69	3.69	-
VTAC	1.46	1.58	1.58	1.58	-
EC4T	1.22	2.83	2.96	3.02	-
EAUC	0.05	0.12	0.13	0.13	-
FTAC	5.70	5.70	5.70	5.70	-
Other Charges (Stations, Depots, etc.)	19.92	19.92	19.92	19.92	-
Diesel	6.13	4.30	4.09	3.98	-
Variable Maintenance Costs (Calc. on a per mile basis)	8.53	8.62	8.62	8.62	-
Materials Costs for Maintenance	1.28	1.24	1.24	1.24	-
Total	**91.46**	**91.24**	**91.15**	**91.11**	**-**
Total: Option - Base		**-0.22**	**-0.31**	**-0.35**	

7. Scheme Capital Costs

7.1. Introduction

Capital cost estimates for the infrastructure upgrade were supplied by the DfT sponsor based on information received from Network Rail reflecting each of the four capital investment scenarios below. Capital cost estimates reflect the four core capital investment scenarios: Please note that these costs were not reviewed, checked or audited as part of this work.

- **Option 1**: Electrification to Kettering North Junction as per KO1, with a cable to the planned feeder at Braybrooke;
- **Option 2:** OHLE extended to Braybrooke from Kettering North Junction;
- **Option 3:** OHLE extended to Market Harborough from Kettering North Junction; and
- **Option 4:** OHLE extended south of Leicester from Kettering North Junction.

7.2. Capital Cost Estimates

The costs supplied by DfT are presented in Table 7-1 below. Each element of the scheme included an overlay showing the GRIP stage and existing allowances for risk and contingency. 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). A summary of the scheme cost estimates received for each investment option is shown in Table 7-1.

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

Option #	Scheme	GRIP	Total AFC	COWD	Contracted Commitments	P80 value (shown for GRIP1/2)
1	Option 1: Cable Back Feed Braybrooke	1	[redacted]	[redacted]	[redacted]	[redacted]
	Power/Neutral sections/signalling South of Bedford	3	[redacted]	[redacted]	[redacted]	[redacted]
	OLE 125 mph	3	[redacted]	[redacted]	[redacted]	[redacted]
	Option 1: Total	**various**	[redacted]	[redacted]	[redacted]	[redacted]
2	Option 2: OLE Kettering North – Braybrooke	2	[redacted]	[redacted]	[redacted]	[redacted]
	Power/Neutral sections/signalling South of Bedford	3	[redacted]	[redacted]	[redacted]	[redacted]
	OLE 125 mph	3	[redacted]	[redacted]	[redacted]	[redacted]
	Option 2: Total	**various**	[redacted]	[redacted]	[redacted]	[redacted]
3	Option 3: OLE Kettering North - Market Harborough	2	[redacted]	[redacted]	[redacted]	[redacted]
	Power/Neutral sections/signalling South of Bedford	3	[redacted]	[redacted]	[redacted]	[redacted]
	OLE 125 mph	3	[redacted]	[redacted]	[redacted]	[redacted]
	Option 3: Total	**various**	[redacted]	[redacted]	[redacted]	[redacted]
4	Option 4: OHLE extended south of Leicester from Kettering North Junction	2	[redacted]	[redacted]	[redacted]	[redacted]
	Power/Neutral sections/signalling South of Bedford	3	[redacted]	[redacted]	[redacted]	[redacted]
	OLE 125 mph	3	[redacted]	[redacted]	[redacted]	[redacted]
	Option 4: Total	**various**	[redacted]	[redacted]	[redacted]	[redacted]

8. Economic Appraisal

8.1. Introduction

This chapter presents the results of the economic appraisal for the KO1A infrastructure approvals alongside the procurement of Bi-Mode trains to be specified through the East Midlands franchise competition. It 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; and
- 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.

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 focus on the guidance for appraisal of rail schemes provided in TAG Unit A5.3. Standard assumptions used in the appraisal are set out in Table 8-1 below.

Table 8-1 Core Appraisal Assumptions

Item	Assumption
Appraisal period	63 years
First year of appraisal	2019/20
Last year of appraisal	2082/83
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 Chapter 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 accompanied by 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 cost as advised in WebTAG. Where there is evidence a particular scheme is riskier than these levels of optimism suggest, alternative higher values may be used. Based on independent analysis conducted by Oxford Global Projects 'Reference Class Forecasting' (RCF) analysis has been applied to the KO1A programme. Traditional assessment of cost and timeframes in projects in based on 'bottom up' inside view of what is required which is nearly always too optimistic about costs and timescales and overestimates benefits. The Reference Class Forecasting method says that the best predictor of performance in a planned project is actual performance in a class of completed comparable projects and provides a benchmark comparison against nearly 180 similar Western European rail upgrade programmes. Using the RCF method the Department have advised that a

£60m project reserve should be added to the scheme capital costs. 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 with risks identified where costed.
- 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
- Addition of the 'project reserve'
- 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	GRIP	AFC	COWD Removed	Risk and Contingency Removed (GRIP 1/2)	Optimism Bias Included	RFC Project Reserve	Appraisal (£k, 2010 prices, discount.)
1	Option 1: Cable Back Feed Braybrooke	1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Power/Neutral sections/signalling South of Bedford	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	OLE 125 mph	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Option 1: Total	**various**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2	Option 2: OLE Kettering North – Braybrooke	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Power/Neutral sections/signalling South of Bedford	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	OLE 125 mph	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Option 2: Total	**various**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3	Option 3: OLE Kettering North - Market Harborough	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Power/Neutral sections/signalling South of Bedford	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	OLE 125 mph	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Option 3: Total	**various**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
4	Option 4: OHLE extended south of Leicester from Kettering North Junction	tbc	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Power/Neutral sections/signalling South of Bedford	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	OLE 125 mph	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Option 4: Total	**various**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Subsequent to wider option testing the finalisation of the financial case has identified the need for total funding of [redacted] for the delivery of the KO1A elements of programme. This includes a project reserve of [redacted] applied to the AFC in isolation from any additional optimism bias. With the removal of COWD this translates to a PVC of [redacted] in 2010 prices and values. This revision to the capital cost estimate is presented as a separate sensitivity test within Section 9.3 of this report.

[18] This total does not include COWD on KO2 schemes incorporate under KO1A which do not form part of scheme appraisal.

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, 63 years)

Capital Investment Option	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)
Option 1: Cable Back Feed Braybrooke	[redacted]	[redacted]	[redacted]	[redacted]
Option 2: OLE Kettering North - Braybrooke	[redacted]	[redacted]	[redacted]	[redacted]
Option 3: OLE Kettering North - Market Harborough	[redacted]	[redacted]	[redacted]	[redacted]
Option 4: OHLE extended south of Leicester from Kettering North Junction	[redacted]	[redacted]	[redacted]	[redacted]

8.3. Derivation of Scheme Benefits

The primary source of benefits resulting from the scheme are through reduced greenhouse gas emissions and improvements in air quality as a result of reduced diesel mileage on the rail network. These benefits have been estimated in accordance with the methodology described in Chapter 4 using the methodology provided in WebTAG Unit A3 – Environmental Impact Appraisal. In addition, the appraisal has also estimated user benefits resulting from journey time savings and the resulting decongestion benefits 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 drivers as a result of changes in the distance travelled by rail passengers.

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.

8.4. Economic Appraisal Results

8.4.1. Summary

Summary economic statistics for each timetable scenario are presented below in Table 8-4. Full Transport Economic Efficiency (TEE) tables are provided for each option in Appendix A. Department for Transport Value for Money (VfM) Guidance identifies the following categories for defining the VfM of a scheme[19]:

- 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

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- Very High VfM if the BCR is greater than 4.0

Present Value of Costs (PVC) is comprised of investment costs, changes to operating costs and revenue transfer. Where a scheme generates significant revenue, the latter can offset the former with a scheme becoming financially positive. Where schemes are not financially positive but where revenue transfer offsets a significant proportion of costs benefit to cost ratios (BCRs) can become particularly sensitive to additional changes in costs/revenues. As a result, the three major contributing factors to PVC are shown in Table 8-4 below.

Alongside the economic appraisal the table shows the increment each option would have on the franchise premium over an 8-year franchise period from August 2019. Changes to the franchise premium are presented in nominal prices as opposed to 2010 prices and values used for the economic appraisal.

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

Timetable Scenario (Extent of Electrification)	Option 1 (Cable to Braybrooke) (74 miles 20 chains)	Option 2 (OHLE to Braybrooke) (80 miles 3 chains)	Option 3 (OHLE to Market Harborough (83 miles 10 chains)	Option 4 (tbc)
PVB	166	179	186	tbc
Investment Costs	179	170	176	tbc
Operating Costs	29	18	13	tbc
Revenue	-52	-52	-52	tbc
PVC	156	137	137	tbc
Resulting Net Present Value	**10**	**42**	**49**	**tbc**
BCR	**1.07**	**1.31**	**1.36**	**tbc**
Impact on financial premium over 8-year franchise (£, nominal)	*-60*	*-58*	*-56*	*tbc*

Based on the results presented in Table 8-4, and supporting analysis, the appraisal of the KO1A\Bi-mode investment options can be summarised as follows:

- Under Option 1, Electrification to Kettering North Junction, with a cable to the planned feeder at Braybrooke, which offers the shortest extent of electrification at the highest capital cost, would be forecast to deliver a BCR of 1.07 (Low VfM).
- With the reduced capital cost under Option 2 the BCR of the scheme increases to 1.31. The additional length of electrification adds to scheme benefits through reducing diesel mileage with bi-mode trains.
- The VfM of the scheme improves further with onwards electrification from Braybrooke (Option 2) to Market Harborough (Option 3). This is partly due to the relatively low cost of electrification equating to £2.3m (nominal) per route mile for this stretch of network. Changes to this cost per mile rate would directly influence this conclusion.
- To date capital costs have not been provided for Option 4. Analysis shows that with Bi-mode operation over the 60-year appraisal period projects that each extra mile of electrification would deliver:
    - A reduction in PVC of: £1.7m (net savings through a switch from diesel to electric)
    - An increase in PVB of: £2.3 (£3.1m saving through reduced greenhouse gas emissions and marginal external costs partially offset by a loss in indirect tax revenues of £0.8m)
    - From the above is can be derived that each additional mile of electrification will deliver a BCR of 2.0 or greater so long as capital investment costs are below £2.9m per route mile (2010 prices and

values). This value broadly translates into an Anticipated Final Cost (AFC) of £2.5m excluding QRA for schemes at GRIP 1 & 2[20].

The options are shown to reduce the franchise premium over an 8-year term by between £56-58m. The reduced premium is primarily as a result of the higher capital lease cost on new Bi-modes compared to the existing fleet of Class 222s and HSTs. Beyond the next franchise period, with the replacement of the existing fleet, like-for-like operating costs are slightly lower in the Do-Something scenario, due to lower net fuel costs. (This varies over given periods different phasing impacting on capital lease costs between the Do-Minimum and Do-Something scenarios).

8.4.2. Disaggregation of User Benefits

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

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

Timetable Scenario	Option 1	Option 2	Option 3	Scenario 4
Noise	0	0	0	-
Local Air Quality	12	13	14	-
Greenhouse Gases	146	162	171	-
Journey Quality	32	32	32	-
Physical Activity	0	0	0	-
Accidents	1	1	1	-
Rail Economic Efficiency (Commuting)	1	1	1	-
Rail Economic Efficiency (Other)	1	1	1	-
Rail Economic Efficiency (Business)	6	6	6	-
Road Economic Efficiency (Commuting)	6	6	6	-
Road Economic Efficiency (Other)	6	6	6	-
Road Economic Efficiency (Business)	3	3	3	-
Wider Public Finances (Indirect Taxation Revenues)	-49	-54	-56	-
PVB	**166**	**179**	**186**	**-**

As can be seen from the table above:

- In each scenario, the majority of benefits come from reduced greenhouse gas emissions, these benefits increase with investment options which increase the extent of electrification.
- Only a minority of user benefits result from user time savings as following replacement of the existing fleet in the Do-Minimum in 2030/31 journey times are assumed to be equal between scenarios.

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 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 23% of the economic benefits from the scheme.

[20] It should be noted that this figure only holds were a 4tph service operates on the MML and where Bi-modes can operate on the full additional length in electric mode. Nor does this value hold true to the total extend of electrification in the original appraisal due to the unchanged elements with additional electrification (e.g. capital lease costs).

9. Sensitivity Tests

9.1. Introduction

A number of sensitivity tests have been undertaken; these have been split into categories as below:

- **Exogenous Uncertainty.** These sensitivities examine the resilience of the business case to exogenous uncertainty. Sensitivities present different scenarios for future growth in rail demand and in diesel prices. This set of tests also examines the impact of higher damage costs for NOx emissions as defined in TAG Unit A3 air quality guidance, forthcoming changes (March 2017).
- **Capital Costs.** These sensitivities examine the resilience of the business case to increases in capital investment costs.
- **Rolling Stock (Operating costs and performance).** These tests relating to the performance and operating costs of the future fleet reflecting uncertainty around the characteristics of replacement rolling stock and the BI-mode fleet.
- **Rolling Stock (Fleet).** Whereas the above tests reflect changes to the operating costs and performance of the fleet assumed within the central case these tests examine the impact of changes in the composition of the fleet or phasing of changes. Test include:
  - Shortening of HSTs in the Do-Minimum (to reduce end-end journey times);
  - Operation of the Do-Something with a uniform 8-car Bi-mode fleet (rather than a 5-car fleet with strengthening in peak hours);
  - Operation of the Do-Something with a homogenous fleet with Bi-mode trains also operating on Corby services
- **High Speed 2.** This sensitivity test investigates the impact of HS2, currently expected to be opened in 2033, on the business case for KO1A.
- **Full Electrification.** This sensitivity test presents a high-level reassessment for the full electrification of the MML.

All sensitivities have been undertaken around Option 3: OHLE extended to Market Harborough from Kettering North Junction. Each sensitivity test presents the headline results from the appraisal (PVB, PVC, NPV, BCR) alongside the incremental impact of the scenario on 8-year franchise premiums (nominal) with the introduction of a Bi-mode fleet.

9.2. Exogenous uncertainty

9.2.1. Introduction

The sensitivity tests below examine the resilience of the business case to exogenous uncertainty tests include an assessment of;

- High and low rail growth scenarios;
- High and low diesel price scenarios;
- Higher damage costs for NOx emissions in-line with new guidance published in September 2015 by the Department for Environment, Food & Rural Affairs (Defra) and incorporated as sensitivity test in TAG (December 2017).

9.2.2. Rail Demand Growth Scenarios

High and Low growth scenarios have been examined as defined in TAG Unit M4 Forecasting and Uncertainty Section 4.2. This section also assesses the impact of switching to demand forecasting using the current (September 2017) draft version of the PDFH6.0 forecasting framework (applied with no continuation of the ‘GJT Trend’ in future years). The results of different growth scenarios for rail demand are presented in the Table 9-1 below.

Table 9-1 Sensitivity Tests: Rail Demand Growth (£m, 2010 present values, unless stated)

Scenario	PVB	PVC	NPV	BCR	∆ 8yr Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
High Growth	189	134	55	1.41	-55
Low Growth	183	141	43	1.30	-58
PDFH6.0	185	138	48	1.35	-54

With high growth the BCR of the KO1A\Bi-mode package increases from 1.36 to 1.41, whilst low growth reduces this to 1.30. The minor impact on NPV +- £6m (NPV) is due to the relatively small contribution or revenue and user time savings to the overall scheme benefits. Scheme benefits are primarily through reduced greenhouse gas emissions and are therefore not sensitive to demand growth.

Similarly, although revised growth forecasts would heavily impact upon the franchise premium, they would have little impact on the additional change as a result of introducing a bi-mode fleet. The incremental cost of introducing the Bi-mode fleet stays relatively constant at a cost of £56m over the 8-year franchise regardless of growth scenarios.

9.2.3. High and Low Diesel Prices

Figure 9-1 below presents the pence per mile of diesel and electric fuel costs assuming:

- Low\Central\High estimates of industrial electric and oil prices from DECC 2016, providing outturn to 2015 and forecasts thereafter.
- Assumed consumption rates of 0.94 litres per vehicle mile (125DMU) and of 3.47kwh per vehicle mile (Bi-mode)

Figure 9-1 Historical and forecast fuel cost for rail opeartion (Electric & Diesel)

[redacted]

Figure 9-1 shows that:

- Diesel operating costs (excluding VAT and Duty) were in excess of 50p per mile between 2010 and 2014 and were in excess of 60p per vehicle mile between 2011 and 2013. Each vehicle mile under electrical operation cost between 25-30p over the same time period.
    - Between February 2011 to April 2014 and Gas Oil\Rail Diesel prices gradually fell from over 50 pence per litre to a low point of 21 pence per litre in February 2016. (This downturn was largely un-forecast in earlier TAG data and appraisals of electrification before this point would have resulted in a higher net saving from changes in fuel costs).
- With the current comparator spot prices of 36.3 pence\litre (excluding VAT and Duty) and 9.91 pence per KwH the fuel costs for each mile of diesel and electrical operation are approximately equal at 34 pence per vehicle mile (given the consumption rates above). The inclusion of fuel duty at 11.4 pence\litre increases diesel operating cost by approximately 10.7 pence per mile. (However, for appraisal purposes with reduced diesel mileage this result in a loss of indirect tax revenues to central government offsetting operational cost savings.)
- Uncertainty around future diesel costs is much greater than around electricity costs. High diesel cost scenarios improve the business case for Bi-modes whilst low cost scenarios have the opposite effect.

The sensitivity tests summarised in Table 9-2 below examine the impact of high and low diesel cost scenarios on the business case. This applies high and low DECC profiles to the existing diesel spot price as an alternative to the central forecast.

Table 9-2 Sensitivity Tests: High\Low Diesel Price Scenarios (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ 8yr Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
High Diesel	186	90	97	2.08	-52
Low Diesel	186	200	-13	0.93	-76

As would be anticipated the sensitivity test above show that the business case is highly sensitive to future changes in diesel prices. The high diesel cost scenario increases the NPV of the scheme by £48m raising the BCR to 2.08. The low diesel cost scenario reduces the NPV of the scheme by £62m reducing the BCR to 0.93. The high degree of sensitivity to diesel prices is a function of the nature of the scheme; less than half of Bi-mode mileage is under diesel operation with electrification to Market Harborough.

9.2.4. Higher Air Quality Benefits

In September 2015 the Department for Environment, Food & Rural Affairs (Defra) published new guidance for valuing air quality impacts on a damage cost basis. The values from this guidance are captured in TAG Unit A3 air quality guidance, forthcoming changes (March 2017). A sensitivity test using these higher damage costs for NOx emissions has been undertaken as defined in the forthcoming changes document above. This guidance proposes a higher damage cost for NOx emissions, with a transport average NOx damage cost of £25,252 (per tonne, 2015 prices).

- As of February 2018, the Department has provided Atkins with interim (updated, unpublished) damage costs. These Feb'18 damage costs are currently around 80% lower than the 2015 interim figures. As advised by the Department a separate sensitivity test has been conducted applying a rail NOx damage cost of £3,420 (per tonne, 2015 prices). This value is grown at 2% per annum to account for increasing willingness to pay for healthcare

Table 9-3 below present the results of the sensitivity tests with revised damage cost for NOx emissions:

Table 9-3 Sensitivity Test: High Air Quality Benefits (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ 8yr Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
STB3 Higher Air Quality Benefits (March 2017 Forthcoming Changes)	*491*	*137*	*353*	*3.57*	-56
February 2018 Interim Values	*261*	*137*	*124*	*1.90*	-56

Monetising NOx emissions as set out in TAG Unit A3 Environmental Impact Appraisal (December 2015) the central case appraisal contains £13.7m of benefits from reduced NOx emissions.

- The March 2017 values for air quality benefits increases the monetary valuation of reduced emissions by £304m; new interim values of NOx inflate the damage values by a factor of more than 20 times, valuing the damage resulting from NOx emissions per litre of diesel higher than carbon dioxide emissions and more than doubling scheme benefits. Although the table above presents the summary of changes in terms of NPV it should be noted sensitivity tests using this guidance 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.

- This value is downturned to £88.6m when using the (updated, unpublished) damage costs provided by the Department in February 2018. It is noted this test is based on interim values which are subject to change.

9.3. Capital Investment Costs

The sensitivity test in Table 9-4 below examines the resilience of the business case to changes in capital costs in increments of £25m. The £25m increments are treated as a nominal cost inclusive of optimism bias and translate to increments of £17.7m in 2010 prices and values. These increments are applied relative to the £249.3 (nominal) cost estimate shown presented in Table 8-2.

In addition to these incremental sensitivity tests around capital costs two specific sensitivity tests are undertaken around capital investment costs:

- The first adjusts capital investment costs in-line with those used following the finalisation of the financial case. This identifies the need for total funding of [redacted] for the delivery of the KO1A elements of programme as opposed to £[redacted] applied within the central case.
- The second removes the ‘project reserve’ from the appraisal applying only optimism bias adjusted cost as advised in WebTAG to the AFC.

Table 9-4 Sensitivity Tests: Capital Investment Costs (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ 8yr Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
-£50m	Tbc	tbc	tbc	tbc	-56
-£25m	Tbc	tbc	tbc	tbc	-56
+£25m	186	155	31	1.20	-56
+£50m	186	173	14	1.08	-56
+£75m	186	190	-4	0.98	-56
+£100m	186	208	-22	0.90	-56
KO1A Funding (Financial Case)	**186**	**125**	**62**	**1.49**	**-56**
WebTAG Optimism Bias	186	95	91	1.96	-56

9.4. Rolling Stock Operating Costs and Performance

9.4.1. Introduction

This business case uses cost estimates and specifications for new bi-mode trains, it should be noted that no such trains with the required capability exist and given the bespoke requirements the likely costs of such vehicles are not known and subject to high level of risk and uncertainty. The following sensitivity tests examine variances in the performance and operating costs of the future fleet to reflect uncertainty around the rolling stock characteristics of the new bi-mode fleet. The sensitivity tests examine:

- A 10% improvement in efficiency on both fuels (this sensitivity shall be applied to all new 125DMUs and Bi-Modes;
- A 25% improvement in efficiency on both fuels (this sensitivity shall be applied to all new 125DMUs and Bi-Modes);

- An assumption that diesel consumption rates for Bi-modes will only be 9% higher than a Class 222 (rather than the 18% sourced from existing rates on of Class 800/AT300 diesel consumption);
- The impact of revised capital lease costs on the business case; and
- The impact of both removing and doubling the assumed 0.25% reduction in in-vehicle time relative to an existing Class 222 or HST.

9.4.2. Fuel Consumption Rates

As a high-level representation of future improvements in fuel consumption Table 9-5 below presents the results of tests of assuming 10% and 25% improvements across both diesel and electric consumption on both new built 125mph DMUs and Bi-modes. This is presented alongside a sensitivity test assuming a lower 'premium' on diesel consumption with heavier Bi-mode trains.

Table 9-5 Sensitivity Tests: Fuel Consumption Rates (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ 8yr Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
10% fuel efficiency	174	127	47	1.37	-41
25% fuel efficiency	156	112	44	1.40	-18
Reduced Bi-mode Diesel Consumption	199	112	88	1.79	-49

The sensitivity tests examining improvements to fuel efficiency on all new build stock show a small improvement to the business case. Improved fuel efficiency results in lower carbon benefits (due to assumed diesel efficiency in the Do-Minimum). This is offset by net fuel savings, this impact if primarily due to the earlier replacement of the existing fleet in the Do-Something scenario.

The sensitivity decreasing the 'premium' in diesel consumption rates of a Bi-mode relative to a Class 222 from +18% to +9% result in a marked improvement to the business case adding £39m to the NPV. Although this is a hypothetical sensitivity around the sourced increase from a Class 800/AT300 it highlights the importance of the final rolling stock specification to the overall value for money of the KO1A/Bi-mode package.

9.4.3. Capital Lease Costs

To reflecting uncertainty around rolling stock manufacturing costs and finance rates high and low capital lease cost sensitivities have been assessed. High and low capital lease cost sensitivities are applied to both Bi-mode and new 125DMUs; An additional test has assessed a scenario with higher capital lease costs only on Bi-modes. Capital cost scenarios are as below:

- Central case: [redacted] (2020/21 prices). Based on a capital cost of [redacted] and a financing rate of [redacted]
- High capital lease costs Bi-modes and 125DMUs. [redacted] 2020/21 prices). Based on a capital cost of [redacted] and a financing rate of [redacted].
- Low capital lease costs Bi-modes and 125DMU. [redacted] (2020/21 prices) Based on a capital cost of [redacted] and a financing rate of [redacted]
- High Bi-mode capital lease cost. [redacted]. Assuming the capital cost increases to [redacted] but that the financing rate would be unchanged from the central case (e.g. identical to that for 125DMUs).

The results of this sensitivity test are summarised in Table 9-6.

Table 9-6 Sensitivity Tests: Capital Lease Costs (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	△ 8yr Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
High Bi-mode & 125DMU	186	166	20	1.12	-100
Low Bi-MOde&125DMU	186	112	75	1.67	-17
High Bi-mode	186	185	1	1.01	-72

The results of the sensitivity test show that

- A scenario with high capital lease costs on both new Bi-modes and 125mphh DMUs reduces the NPV of the business case. This is primarily as a result of the additional costs incurred with the earlier replacement of the existing fleet earlier in the Do-Something scenario. For the same reasons, the sensitivity test would be forecasts to reduce the franchise premium by a further [redacted].
- Conversely lower capital lease costs would increase the NPV of the business case and would reduce the impact of implementing KO1A and bi-modes on franchise premium.
- The scenario with higher capital lease costs on bi-modes only (assumed to be approximately 9% higher than on new build 125mph DMUs) would lower the NPV by £48m reducing the BCR to 1.01.

9.4.4. Rolling Stock Ambience

The Central Case assumes a perceived 0.25% reduction in in-vehicle time as a result of Bi-mode operation relative to either the existing Class 222 \ HST fleet or a new fleet of 125mph DMUs. The rational for this saving is as a result of improved ride quality when running under the wires. Due to the subjective nature of this valuation sensitivity tests examine both the removal and doubling of this valuation.

The results of this sensitivity test are shown in Table 9-7.

Table 9-7 Sensitivity Tests: Rolling Stock Ambience (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	△ 8yr Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
Higher Ambience	216	119	97	1.82	-
No Ambience Improvement	154	166	-12	0.93	-

The tests above show that assumptions relating to rolling stock quality can have a significant impact on the business case. Assuming passengers have no inherent preference for either Bi-modes or DMUs would reduce the NPV of the package by £61m reducing the BCR to 0.93. A doubling of this valuation would increase the BCR to 1.82.

9.5. Rolling Stock Fleet

9.5.1. Introduction

The following tests examine the impact of changes in the composition of the fleet in either the Do-Minimum or Do-Something scenarios

9.5.2. Replacement of Full Length HSTs

The central case assumes an earlier replacement of HSTs in the event of infrastructure investments for KO1A. This results in journey time savings in the period between December 2023 and 2030/31 compared to the Do-Minimum where HSTs (with slower journey times) are assumed to operate until 2030/31. This sensitivity test effectively considers a revised Do-Minimum to examine a scenario where these journey time savings are delivered at the same time in both the Do-Minimum and Do-Something; representing potential bidder strategies over the next franchise. This scenario assumes that shortened HSTs (in 2+6 formation rather than 2+8) could match Class 222 journey times and therefore realise the journey time revenue uplifts identified with Bi-Modes. Sheffield and Nottingham services would operate with the existing fleet of Class 222s and HSTs, supplemented by the three additional HST sets leased (ex-Grand Central) to run the May 2018 timetable. The results of this sensitivity test are presented in Table 9-8 below.

Table 9-8 Sensitivity Tests: Replacement of Full Length HSTs (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
Sensitivity Test	178	147	31	1.21	-67

The enhanced journey times in the Do-Minimum above remove £18m from the NPV of the KO1A\Bi-mode package reducing the BCR from 1.36 to 1.21.

9.5.3. 8-car Bi-mode

The sensitivity test examines a scenario where Bi-modes are only capable of meeting Class 222 SRTs in diesel mode. The test presented below present the results of a Do-Minimum consistent with the central case but with Bi-modes operating in fixed 8-car formation in the Do-Something. Results are summarised in Table 9-9 below.

Table 9-9 Sensitivity Test: 8-car Bi-mode Fleet (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
Sensitivity Test	141	358	-217	0.39	-110

The results of this scenario suggest that If Bi-mode trains could only be procured in 8-car fixed formation (tested to assess the implications if bi-mode trains could only meet Class 222 SRTs in longer formations) the BCR of the scheme would be projected to fall to 0.39 due to the extra operating costs associated with resultant increases in vehicle mileage.

9.5.4. Homogenous Fleet

This sensitivity assesses the economic benefits of procuring a homogenous fleet across EMT MML services. The revised Do-Something phasing assumes:

- The 6tph timetable operated from December 2020. Cascaded 4-car 100EMUs will operate on Corby services in the short term;
- Assumed replacement of Class 222, HST and 100EMUs with new-build 5-car 125 Bi-Modes from December 2022.
  - This will require re-timetabling of Corby services with 125mph Bi-Mode stock (on which a view has already been developed from earlier work).

Results are summarised in Table 9-10.

Table 9-10 Sensitivity Test: Homogenous Fleet (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
Homogenous Fleet	92	283	-191	0.33	-103

The results of the sensitivity test suggest that a homogenous fleet would significantly reduce the BCR of the package, and that 100EMUs would deliver better value for money on Corby services. This is primarily because:

- The Corby services are forecast to have strong peak demand which can be better met by strengthening 4-car 100EMUs into 12-car sets than with doubling of 5-car bi-modes.
- The replacement of 100mph EMUs with Bi-modes increases operating costs primarily due to higher maintenance rates but also higher capital lease charge per vehicle.

9.6. HS2 Sensitivity

A sensitivity has been undertaken to investigate the impact of HS2 of the business case for KO1A. HS2 is currently expected to be opened in 2033. By this date the same KO1 timetable would be served by an identical feet of either:

- 5 car 125DMUs in the Do-Minimum; and
- 5-car 125mph Bi-Modes in the Do-Something.

Therefore, the only differences resulting from the opening of HS2 on the business case will result from changes in vehicle mileages as a result of:

- Reduced mileage in the Alternative MML TSS as a result of curtailing one of the existing Sheffield services at Derby; and
- Potential additional benefits and opex savings for Bi-modes through HS2's planned electrification between Clay Cross and Sheffield Midland station. (Currently unfunded the HS2 sensitivity test is undertaken both with and without this 'free good').

Results of this sensitivity test are shown in Table 9-11 below.

Table 9-11 Sensitivity Test: HS2 (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
HS2 (with Clay Cross electrification)	188	139	49	1.35	-56
HS2 (minus Clay Cross electrification)	182	143	39	1.27	-56

The business case is not highly sensitive to the introduction of HS2 as the same timetable is taken to operate in the Do-Minimum and Do-Something scenario by the opening date of 2033. A small reduction in benefits results from the reduced number of passengers on the MML (reducing the number of passenger who perceive and ambiance uplift from Bimode trains). However, these changes are largely offset by:

- Electrification between Clay Cross and Sheffield Midland station which would improve the business case through increasing electric mileage of the bi-mode fleet.

- Curtailing one Sheffield service at Derby which would also improve the business case as running in diesel mode for this section Bi-modes would be less efficient than the 125DMUs operating in the Do-Minimum.

9.7. Full Electrification

A sensitivity test has been undertaken to provide a high-level reassessment for the full electrification of the MML. With regards to benefits this assumes that:

- The SRTs of 125mph EMUs save 1-minute over Class 222s on end-end journeys to Nottingham and Sheffield. (Consistent with the KO2 SOBC);
- A new 125mph Bi-mode will deliver a 0.25% reduction in in-vehicle time relative to an existing Class 222 or HST, due to improved ride quality when operating under the wires.

Assumptions relating to operating costs are presented in Table 9-12 below.

Table 9-12 125 EMU Key Cost Assumptions

	New 125 Bi-Mode		New 125 EMU	
Cost Item	**Rate**	**Source**	**Rate**	**Source**
Capital lease charge (£ per vehicle per year)	[redacted] (2020/21)	EMRF RSBC - [redacted] build cost with a financing rate of [redacted]	[redacted] (2020/21)	Consistent with the assumption that capital lease costs on 125DMUs will be 15.8% higher than 125EMUs as presented in the electrification business case from September 2016.
TSA rate (£ per vehicle mile)	0.80	DfT Rail Analysis	0.60	DfT Rail Analysis
VTAC rate (pence per vehicle mile)	[redacted]	12% higher than Class 222 rate to reflect greater weight per vehicle	[redacted]	DfT Rail Analysis
Diesel fuel consumption rate (£ litres per vehicle mile)	[redacted]	EMRF RSBC (Based upon Class 800/AT300 consumption rates. 18% higher than a Class 222)	[redacted]	-
Electric consumption rate (KwH per vehicle mile)	3.47	Based upon Class 800/AT300 rates	3.38	DfT Rail Analysis

NOTE; In the absence of revised capital investment schemes for the full electrification programme this sensitivity test takes the capital investment cost for this scheme from the Midland Main Line Upgrade Programme Economic Case (September 2016) estimating the incremental cost between KO1 and KO2 at £979m in 2010 prices and values.

The results of the sensitivity test are presented in Table 9-13 below.

Table 9-13 Sensitivity Test: KO2 Full Electrification (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ Franchise Premium (£m, nominal)
Central Case	**186**	**137**	**49**	**1.36**	**-56**
KO2: Electrification	466	399	67	1.17	49

Given the assumptions above the full electrification of the MML would deliver an NPV of £67m with a BCR of 1.17. (Please Note: this number would be sensitive to alterations to capital cost estimates which have neither been reassessed since 2016 or subject to change in WebTAG relating to the treatment of capital costs).

The poorer economic return is largely due to the additional capital cost incurred. Unlike the Bi-mode scenario the introduction of 125EMUs over the 8-year franchise would increase the franchise premium. This is due to lower capital lease costs and lower TSA rates on 125EMUs along with additional fuel savings and the fact that capital expenditure on infrastructure would not directly affect franchise finances.

The 'full electrification' business case has been subject to three separate sensitivity tests examining:

- A high diesel cost scenario;
- A scenario where 125EMUs save 2-minutes over a Class 222 as opposed to the 1-minute assumed above; and
- The impact of HS2 on the business case for KO2

The results of these tests are summarised in Table 9-14.

Table 9-14 Sensitivity Test: KO2 Full Electrification Sensitivities (£m, 2010 present values)

Scenario	PVB	PVC	NPV	BCR	∆ Franchise Premium (£m, nominal)
KO2: Electrification	**466**	**399**	**67**	**1.17**	**49**
High diesel costs	466	293	173	1.59	83
SRT saves 2-minutes	553	331	223	1.67	62
KO2: Electrification (HS2)	379	485	-106	0.78	49

The sensitivity tests show that:

- The business case for electrification is significantly improved with a 'high diesel' cost scenario (where the difference in operating costs between diesel and electric running are closer to those realised with historic oil prices between 2010-2014).
- The business case for electrification is significantly improved assuming a 2-minute, rather than 1-minute journey time saving relative to a Class222 (The net 'value-of-a-minute' of £105m over the appraisal period is not dissimilar to that presented in earlier analysis from September 2016)
- Whilst marginal on the KO1A business case the introduction of HS2 would significantly damage the KO2 business case. This is because:
  - The benefits of the SRT saving of 1-minute over Class 222s on end-end journeys to Nottingham and Sheffield is reduced as long-distance London passengers shift to HS2; and
  - Curtailing one Sheffield service at Derby would reduce overall benefits derived from running 125 mph EMUs vice DMUs assumed in the Do-Minimum.

The case for full electrification would also be markedly improved if considering the higher damage costs for NOx emissions has been undertaken as defined in TAG Unit A3 air quality guidance, forthcoming changes (March 2017).

10. Summary & Conclusions

This business case has considered the following four capital infrastructure options to enable a fleet of new bi-mode rolling stock to operate at up to 125mph in electric mode on the Midland Main Line (MML) south of Kettering or beyond.

Option	Description	Electrification Mileage
1	Electrification to Kettering North Junction as per KO1, with a cable to the planned feeder at Braybrooke;	74 miles 20 chains
2	OHLE extended to Braybrooke from Kettering North Junction	80 miles 3 chains
3	OHLE extended to Market Harborough from Kettering North Junction	83 miles 10 chains
4	OHLE extended south of Leicester (Kilby Bridge Junction) from Kettering North Junction	93 miles 40 chains

The results of each capital infrastructure option are presented below:

Timetable Scenario (Extent of Electrification)	Option 1 (74 miles 20 chains)	Option 2 (80 miles 3 chains)	Option 3 (83 miles 10 chains)	Option 4 (-)
PVB	166	179	186	tbc
Investment Costs	179	170	176	tbc
Operating Costs	29	18	13	tbc
Revenue	-52	-52	-52	tbc
PVC	156	137	137	tbc
Resulting Net Present Value	**10**	**42**	**49**	**tbc**
BCR	**1.07**	**1.31**	**1.36**	**tbc**
Impact on financial premium over 8-year franchise (£, nominal)	*-60*	*-58*	*-56*	-

The results of the business case analysis suggest that OHLE extensions provide superior value for money than cabling, due to the latter having a greater cost per mile in this instance. OHLE options are projected to deliver Low Value for Money. Examination of the monetised benefits calculations suggest that each additional mile of electrification beyond the appraisal presented will deliver a benefit to cost ratio (BCR) of 2.0 or greater under Bi-mode operation, so long at capital investment costs are below £2.9m per mile (2010 prices and values). This value broadly translates into an Anticipated Final Cost (AFC) of £2.5m excluding QRA for schemes at GRIP 1 & 2[21].

The procurement of a Bi-mode fleet is projected to reduce East Midlands franchise premium over an 8-year franchise by approximately [redacted]. This is largely as a result of higher capital lease costs on Bi-modes compared to the existing fleet (particularly for the HSTs). Following the replacement of this fleet in the Do-Something scenario the premium would be forecast to be higher with the Bi-mode fleet, as a result of net fuel

[21] It should be noted that this figure only holds were a 4tph service operates on the MML and where Bi-modes can operate on the full additional length in electric mode. Nor does this value hold true to the total extend of electrification in the original appraisal due to the unchanged elements with additional electrification (e.g. capital lease costs).

savings across electric and diesel operation. (The actual premium is influenced by the capital lease costs with different phasing in the Do-Minimum and Do-Something scenarios).

Sensitivity Testing

A number of sensitivity tests have been examined around the 'Capital Investment Option 3' (NPV 49, BCR 1.36). These have been undertaken to assess the resilience of the business case to exogenous uncertainty, increases in capital cost, and variances in the assumed rates and operating characteristics of new build stock which does not currently exist. In summary these sensitivities show the business case for the KO1A\Bi-mode package is:

- Improved to a BCR of 1.49 (NPV £69m) when considering capital costs consistent with the final financial case. This reduced the nominal cost of the scheme, inclusive of risk from to [redacted] in the central case to [redacted]
- Relatively insensitive to changes in passenger demand forecasts because the core benefits are not driven by change in passenger revenue or user benefits.
- Highly sensitive to variations in diesel prices over the appraisal period. DECCs high diesel price scenario (which is more comparable to diesel prices experienced between 2010-14) increases the NPV by £48m, raising the BCR to 2.08. The low DECC forecast results in a downturn of comparable magnitude.
- Transformed if considering higher damage costs for NOx emissions from DfT's Supplementary Guidance on Environmental Appraisal (WebTAG Unit A3, March 2017). This would increase the monetary valuation of reduced emissions by £304m. However, it should be noted that current supplementary guidance considers that where tests are carried our using interim NOx values, the results should be reported in the 'Qualitative' column of the 'Air Quality' row of the Appraisal Summary Table, but should not be included in the 'Monetary £(NPV)' column.
  - Updated interim NOx damage values provided by the Department in February 2018 present NOx damage values which are currently around 80% lower than the 2015 interim ones. These values are subject to change although would reduce the valuations of NOx savings down to £88.6m; still a significant uplift from the £13.7m included in the central case appraisal.
- Highly sensitive to changes in assumptions relating to the cost rates or operating characteristics of new rolling stock. For example:
  - A 1-minute change in end-end journey time on Nottingham and Sheffield services has an annual impact on EMRF revenues of [redacted] (2016/17). This difference in journey, for instance due to different rolling stock characteristics, would have an impact of [redacted] on the NPV over a 60-year appraisal period.
  - A Bi-mode fleet with a diesel consumption rate 9% higher than an existing Class 222, rather than 18% higher, would increase the NPV of the package from £49m to £88m, delivering a BCR of 1.79 (Medium VfM).
  - Assuming Bi-mode trains have capital lease cost 9% higher than, rather than identical to, new 125mph DMUs would decrease the NPV to £1m and the BCR to 1.01.
  - Assuming no inherent passenger preference for Bi-mode trains over new 125DMUs would decrease the NPV to -£12m, and the BCR to 0.93. Doubling the current valuation of 0.25% would raise the NPV to £97m and the BCR to 1.82).

Rolling Stock Fleet and Configuration

A number of sensitivities have also been conducted around rolling stock configuration and the composition of the fleet in each scenario. The results of this sensitivity test show that:

- In a scenario where all Nottingham \ Sheffield services operated with Class222 sectional running times over the next franchise period (rather than on replacement of the existing fleet in 2030/31) the BCR of the existing package would fall to 1.21.
- If Bi-mode trains could only be procured in 8-car fixed formation the BCR of the scheme would be projected to fall to 0.39 due to the extra operating costs associated with resultant increases in vehicle mileage. (This sensitivity test was undertaken to assess the implications if Bi-mode trains could only meet Class 222 SRTs in longer formations).

High Speed 2

A sensitivity test has investigated the impact of HS2 on the KO1A package. Benefits of the package, enabling 125mph operation of Bi-mode trains south of Kettering (and up to Leicester in some options) are primarily related to environmental impacts, particularly the monetised value of reduced carbon emissions.

This is particularly true with relation to the scheme following the opening of HS2, when the existing fleet will have been replaced in each scenario. The introduction of HS2 would be forecast to result in a BCR of between 1.27-1.35 for the package (compared to the central case of 1.36). The business case is not highly sensitive to the introduction of HS2 as the same timetable is taken to operate in the Do-Minimum and Do-Something scenario by the opening date of 2033. A small reduction in benefits results from the reduced number of passengers on the MML (reducing the number of passenger who perceive and ambiance uplift from Bimode trains).

Full Electrification

A sensitivity test has re-examined the business case for full electrification of the MML to Nottingham and Sheffield alongside the introduction of new 125mph EMUs. With a capital cost of [redacted] (2010 prices and values) the scheme would be forecast to have a BCR of 1.17. Sensitivities suggest the BCR would:

- Increase to 1.59 (Medium VfM) under a high diesel cost scenario;
- Increase to 1.67 (Medium VfM) if 125EMUs were to deliver an additional minute's journey time saving to Nottingham and Sheffield)
- Decrease to 0.78 if considered alongside the introduction of HS2 in 2033. Whilst marginal on the KO1A business case the introduction of HS2 would damage the KO2 business case. This is because:
  - The benefits of small journey time savings with electrification are reduced as long-distance London passengers are abstracted by HS2; and
  - Curtailing one Sheffield service at Derby post HS2 would lower the benefits of running 125 mph EMUs, rather than the diesel fleet assumed in the Do-Minimum, due to reduced vehicle mileage.

The business case for electrification would also significantly benefit if considering higher damage costs for NOx emissions from DfT's Supplementary Guidance on Environmental Appraisal (WebTAG Unit A3).

This BCR of Full Electrification is sensitive changes to capital costs. For use in this sensitivity test these costs taken from the original business case in £m2010NPV (September 2016) in 2010NPV and have not been re-evaluated as part of this work.

Caveats and Limitations on Analysis

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

- This business case uses cost estimates and specifications for new bi-mode trains, it should be noted that no such trains with the required capability exist and given the bespoke requirements the likely costs of such vehicles are not known and subject to high level of risk and uncertainty, as reported in the sensitivity testing this can have a significant impact on the results.
- 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.
- There is still considerable uncertainty around the final status of the MML Thameslink timetable, particularly surrounding journey times and calling patterns for EM services and associated impacts on EM revenue and costs. The May 2018 Thameslink timetable will not be finalised until December 2017 whilst the industry will continue to develop and refine the timetable for the December 2018 timetable (finalised after the issue of the EM ITT). The continued evolution of these timetables may have a significant impact on franchise premiums. However, with regards to the appraisal undertaken in this document changes should only have a limited impact as each scenario runs an identical timetable following the replacement of the existing fleet in 2030/31.
- The GTR timetable originally supplied to enable timetable development did not include a specific counter-peak direction timetable. At this time Atkins were not able to timetable ECS moves into and out of Cricklewood depot in the peak and shoulder peak periods. However, it was agreed with GTR at a workshop held on 20th July 2016 that it would be reasonable to assume up to 2 ECS paths per hour between St Pancras and Cricklewood.

- Revenue transfer from crowding relief is subject to the methodological application of the PDFH approach which does not reallocate demand between trains or operators. With regards to this business case this is of highest significance when forecasting different rolling stock configurations on Corby services (e.g. the Homogenous fleet sensitivity test)
- Analysis in this report has been produced in advance of December 2017 updated to WebTAG.

Appendix A. TEE Table

A.1. Option 3: OLE Kettering North - Market Harborough

MML Electrification Business Case (£k, 2010 prices discounted to 2010)

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

	ALL MODES TOTAL		ROAD	RAIL
Non-business: Commuting				
User Benefits				
Travel Time	6,660		5,751	909
Vehicle Operating Costs	0			
User Charges	0			
During Construction & Maintenance	0			
NET NON-BUSINESS BENEFITS: COMMUTING	6,660	(1a)	5,751	909
Non-business: Other				
User Benefits				
Travel Time	7,850		6,429	1,421
Vehicle Operating Costs	0			
User Charges	0			
During Construction & Maintenance	0			
NET NON-BUSINESS BENEFITS: OTHER	7,850	(1b)	6,429	1,421
Business				
User Benefits				
Travel Time	9,148		2,741	6,407
Vehicle Operating Costs	0			
User Charges	0			
During Construction & Maintenance	0			
Subtotal	9,148	(2)	2,741	6,407
Private Sector Provider Impacts				
Revenue	[redacted]			[redacted]
Operating Costs	[redacted]			
TOC Profit	[redacted]			
Investment Costs	[redacted]			[redacted]
Grant/Subsidy Payments	[redacted]			
Revenue Transfer	[redacted]			[redacted]
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	9,148	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits (TEE)	23,659	(6) = (1a) + (1b) + (5)		

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

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
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
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	-75		-75	0
Investment Costs	176,268		0	176,268
Developer and Other Contributions	0		0	0
Grant/(Subsidy) Payments	-38,751		0	-38,751
Revenue Transfer	0		0	0
NET IMPACT	137,442	*(8)*	-75	137,517
Central Government Funding: Non-Transport				
Indirect Tax Revenues	56,319	*(9)*	1,912	54,407
TOTALS				
Broad Transport Budget	137,442	*(10) = (7) + (8)*		
Wider Public Finances	56,319	*(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	103	*(12)*
Local Air Quality	13,748	*(13)*
Greenhouse Gases	171,483	*(14)*
Journey Quality	32,212	*(15)*
Physical Activity	0	*(16)*
Accidents	1,473	*(17)*
Economic Efficiency: Consumer Users (Commuting)	6,660	*(1a)*
Economic Efficiency: Consumer Users (Other)	7,850	*(1b)*
Economic Efficiency: Business Users and Providers	9,148	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	-56,319	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Present Value of Benefits (see notes) (PVB)	186,359	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1a) + (1b) + (5) + (17) - (11)*
Broad Transport Budget	137,442	*(10)*
Present Value of Costs (see notes) (PVC)	137,442	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	48,917	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	1.36	BCR=PVB/PVC

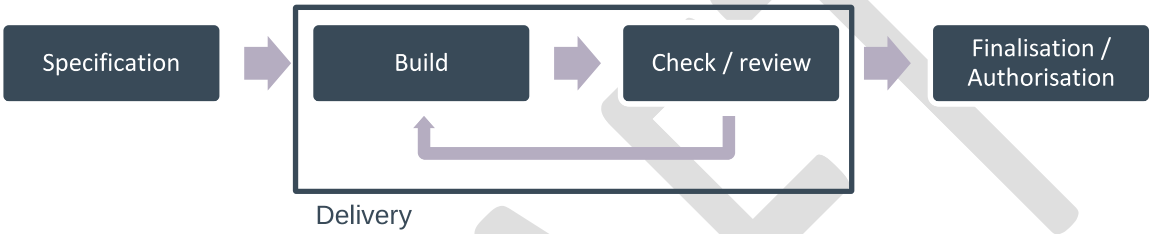
Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where 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 B. 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[22] 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 single 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;

[22] 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

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.	[redacted]	Various (ongoing)	Ok		
2	Appraisal Model	<Appraisal_Assumps> check indices are consistent with July 2016 DataBook	[redacted]	22/11/2107	issue01, 02, 03		Y
3	Appraisal Model	<Capex Input> confirm inputs are as sourced from sheet	[redacted]	22/11/2107	Ok		
4	Appraisal Model	<FM Model Inputs> confirm inputs are as sourced from sheet	[redacted]	22/11/2107	Ok		
5	Appraisal Model	<Rolling Stock Inputs> confirm inputs are as sourced from sheet	[redacted]	22/11/2107	issue04,07		Y
6	Appraisal Model	<Revenue Model Inputs> confirm inputs are as sourced from sheet	[redacted]	22/11/2107	issue08		Y
7	Appraisal Model	<Carbon Inputs> confirm inputs are as sourced from sheet (noting separate inputs for carbon & NoX	[redacted]	22/11/2107	yes		
8	Appraisal Model		[redacted]	22/11/2107	Ok		
9	Appraisal Model	<Carbon Inputs> For NOx input check rational for calculation of NOx emissions	[redacted]	22/11/2107	Ok	tag-workbook-air-quality-valuation-jul16_C1.xlsx <Inputs>, K17-L22, how / where the numbers are derived?	
10	Appraisal Model	<Carbon Inputs> Confirm appraisal timescales are consistent with the core appraisal model	[redacted]	22/11/2107	Ok		
11	Appraisal Model	<MECs Inputs> not yet updated to July2017. Check if values require updating from March 2017 version of the DataBook (please update if necessary recording the impact on the appraisal)	[redacted]	22/11/2107	Ok	MEC is updated in Jul17, updated appraisal for MEC-Jul17 is v0.12, impact of the results is changing BCR from 1,52 to 1.51	
12	Appraisal Model						
13	CAPEX	<CAPEX> : check if calculations are correct.	[redacted]	22/11/2107	issue06		Y
14	CAPEX	Ad hoc	[redacted]	22/11/2107	issue09/10		Y
15	MOIRA	Confirm 1 minute time saving applied for 'full electrification' timetable	[redacted]	23/11/07	Ok		
16	Specific copy\paste checks between models:						

Check#	Model Name	Description	Checker	Date	ok/issue	Comments	Closed?
16.1	- 5134744 MML KO1 FBC Appraisal v0.10 KO1A_C2_COMPARATOR.xlsx		[redacted]	22/11/2107	Issue 7		Y
16.2	- 5134744 MML KO1 FBC Appraisal v0.10 KO1A_C3_COMPARATOR.xlsx		[redacted]	22/11/2107			
16.3	- 5134744 MML KO1 FBC Appraisal v0.10 KO1A_C3_COMPARATOR_SHORTHST.xlsx		[redacted]	22/11/2107			
16.4	- 5134744 MML KO1 FBC Appraisal v0.10 KO1A_C3_COMPARATOR_HOMOGENOUS.xlsx		[redacted]	22/11/2107			
16.5	- 5134744 MML KO1 FBC Appraisal v0.10 KO1A_C3_COMPARATOR_8CAR BIMODE.xlsx		[redacted]	22/11/2107			
16.6	- 5134744 MML KO1 FBC Appraisal v0.10 KO1A_C3_COMPARATOR_125EMU.xlsx		[redacted]	22/11/2107			

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	[redacted]	<Appraisal Assump>, row 98-105, currently numbers are from Jul17 WebTAG, should them be changed to Mar17 WebTAG in order to be consistent?	[redacted]	Highway fuel resource costs do not impact on the appraisal. These are included in the sheet as an original alternative calculation for the impact of alterations in highway miles on indirect tax. These are now calculation via MEC. (Values not active in the model, March 2017 values retained to maintain consistency with rail diesel prices (following a return to the March 2017 Databook indices)	[redacted]	15/08/17	Closed
Issue_02	Appraisal Model	[redacted]	<Appraisal Assump>, row 100, numbers are from WebTAG road electricity, should it be changed to Rail electricity?	[redacted]	This line relates to electric car use and should not change to rail electricity (As per Issue 1 above these values are not active within the appraisal model.	[redacted]	15/08/17	Closed
Issue_03	Appraisal Model	[redacted]	<Appraisal Assump>, row 34-36, currently numbers are from Jul17 WebTAG, should them be changed to Mar17 WebTAG in order to be consistent? (this has no impact on appraisal result, numbers are not used in the model)	[redacted]	Values are not active in the appraisal. Replacement would be presentational only	[redacted]		Closed

Issue	Model	Raised By	Description	Reviewer	Actions	Follow on Check By	Follow on Check Date	Status
Issue_04	Appraisal Model	[redacted]	<Rolling Stock Input> source file is blank (D13)	[redacted]	Rolling stock allocation is internally sourced to reflect the Do-Minimum and Do-Something scenario. (Rolling stock allocation has been revised to be identical to phasing in the comparator).	[redacted]		Closed
Issue_05	Appraisal Model	[redacted]	<MECs_Inputs>, MECs values are not updated for Jul-17 databook.	[redacted]	All are updated for July2017 databook	[redacted]		Closed
Issue_06	CAPEX	[redacted]	KO1A_CAPEX_141117_v0,01.xlsx are all the numbers in column G,H real or nominal? I think we at least should convert the number before copying into appraisal model in nominal	[redacted]	CAPEX is carried over to the appraisal model in nominal prices, excluding QRA. Optimism bias, discounting, deflation and conversion to market prices are all carried out in the appraisal model (although are also applied separately in this sheet, with the final results in column 'T' providing a check against the values derived in the appraisal model.)	[redacted]		Closed
Issue_07	Appraisal Model	[redacted]	<Rolling Stock Input>, RS numbers at phase in/out year do not match with FM (AE53-70, X80-97)	[redacted]	Rolling stock phasing has been revised to match that in the comparator model.	[redacted]		Closed
Issue_08	Appraisal Model	[redacted]	Appraisal models: Rev are labelled in 15/16, this should be changed to 16/17 (especially in tab <Ben_Rev_Appraisal>, F35-F45	[redacted]	Values updated in Appraisal models.	[redacted]		Closed
Issue_09	Appraisal Model	[redacted]	Appraisal models: currently appraisal model doesn't take into partial year effect, so the starting date 08/12/22 is now treated as it starts from 01/04/22	[redacted]	Modelling assumption maintained (Non-material over a 60-year appraisal)	[redacted]		Closed
Issue_10	Appraisal Model	[redacted]	Appraisal models: <Ben_Rev_Appraisal>, row203-211, format should be copied until col CE.	[redacted]	Amended	[redacted]		Closed

[redacted]

[redacted]