High Speed Two (HS2) Phase Two

Economic case advice for the Department for Transport

July 2017

CS866_A

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Department for Transport

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1 Preface

1.1 Coverage of this Economic Case

1.1.1 This document presents High Speed Two (HS2) Ltd's advice to Government on the Economic Case for the HS2 network.

1.1.2 The aim of this document is to set out the costs and benefits of building the full HS2 network, and the Phase 2a and Phase 2b sections of the route. It provides an appraisal of the costs and benefits of:

- The full HS2 network;
- Phase 2a, as an increment on Phase One, alongside publication of the Phase 2a hybrid Bill; and
- Phase 2b, as an increment on Phase One and Phase 2a, following the consultation on route refinements launched in November 2016, and subsequent Government decision on the route.

1.1.3 A further chapter in this document also provides an initial value for money assessment of potential options to connect HS2 services with a new regional transport hub in the north-west ('Crewe Hub'). This analysis supports the current consultation led by the Department for Transport (DfT) on these potential options.

1.1.4 As with all previous appraisals, our economic analysis has been carried out in accordance with HM Treasury's Green Book and the DfT's Web Based Transport Analysis Guidance (WebTAG). In line with that guidance, our analytical framework continues to be based on a social cost benefit analysis, which attempts to place a monetary value on as many impacts as possible. As with previous Economic Cases, we also consider the impact of changing key appraisal variables on the value for money assessment of the scheme.

1.2 Previous Economic Cases

1.1.1 In 2016, HS2 Ltd published two Economic Cases for the Phase Two increments. This Economic Case builds on those previous Economic Cases. The previous Economic Cases set out the case for:

- Phase 2a Strategic Outline Business Case – accelerating the building of the HS2 route from the West Midlands to Crewe six years earlier than planned, operating from 2027[1]; and

[1] HS2 Phase Two, West Midlands to Crewe Economic Case, January 2016, available on gov.uk, https://www.gov.uk/government/organisations/high-speed-two-limited

- Phase 2b Strategic Outline Business Case – building the Phase 2b route from Crewe to Manchester and East Midlands to Leeds, operating from 2033[2].

[2] High Speed Two Phase 2b, Crewe to Manchester - West Midlands to Leeds Economic Case, November 2016, available on gov.uk, https://www.gov.uk/government/organisations/high-speed-two-limited

2 Executive summary

2.1 Overview

2.1.1 Phase One of HS2, due to open in 2026, will see a new high-speed line constructed from London to the West Midlands where it will join the existing West Coast Main Line (WCML) at Handsacre.

2.1.2 Current plans are for a second phase delivered in two parts:

- Phase 2a will extend the line from the West Midlands to Crewe in 2027, bringing benefits to the North West earlier; and
- Phase 2b will extend the line north from Crewe to Manchester and join the WCML south of Wigan. It will also deliver a new eastern leg, which will stop in the East Midlands, South Yorkshire, and Leeds, and connect to the East Coast Main Line (ECML) near York.

2.1.3 This document presents the HS2 Ltd Economic Case both for building the full HS2 network and the Phase Two increments that will deliver that network.

2.1.4 In addition to the core scheme, we consider a number of different options that assess the impact of making adjustments to the HS2 train service specification (TSS) for services stopping at Crewe (the 'Crewe Hub') that may enable greater benefits to be delivered by the HS2 scheme.

2.2 Phase 2b Preferred Route Decision

2.2.1 Following the publication of the Phase 2b Strategic Outline Business Case, the DfT launched a consultation on seven proposed changes to the Phase 2b route. The DfT has published a Phase 2b Route Decision setting out the Secretary of State's decision on the areas covered by the consultation[3].

2.2.2 A key change for the purposes of appraising the costs and benefits of the HS2 scheme is the eastern leg route between Derbyshire and West Yorkshire (the M18/Eastern Route). In our previous appraisal of the Phase 2b route, we assessed the impact on the costs and benefits of the HS2 scheme of adopting the M18/Eastern Route[4].

2.2.3 The TSS modelled in this Economic Case adopts the decisions set out in the Phase 2b Route Decision on the M18/Eastern Route – namely that HS2 Ltd will:

- Build a 9.4km southern spur at Stonebroom off the HS2 mainline, enabling HS2 trains to run into Sheffield city centre along the existing rail network;

[3] High Speed Two Phase 2b, West Midlands to Crewe – West Midlands to Leeds and Beyond, Phase 2b Route Decision, July 2017, available on Gov.uk, https://www.gov.uk/government/organisations/high-speed-two-limited

[4] High Speed Two Phase 2b, Crewe to Manchester & West Midlands to Leeds: Economic Case, November 2016, available on gov.uk, https://www.gov.uk/government/organisations/high-speed-two-limited

- Move the main north-south route alignment to follow a more easterly alignment between Derbyshire and East Yorkshire; and
- Create a connection back onto the HS2 mainline north of Sheffield through a northern junction at Clayton.

2.2.4 The M18/Eastern Route also introduces a change to the TSS originally modelled for the Meadowhall Route. The M18/Eastern Route utilises an additional train path to deliver the TSS set out in Appendix 1b. Two Birmingham to Leeds services are also modelled as being re-routed from the M18/Eastern Route to travel via Sheffield Midland using the southern spur and northern junction described above.

2.2.5 In order to operate services between Sheffield Midland and Leeds, via the northern junction, improvements will be needed to the existing rail line, including: electrification of Midland Mainline (MML) south of Sheffield to the southern spur; and the electrification of the railway north of Sheffield to the northern junction.

2.2.6 The benefits of the electrification of the MML on conventional journey times have been incorporated into the 'without HS2' baseline (also referred to as the 'do minimum') for the purposes of our appraisal of the HS2 scheme. This assumes the electrification of the MML between Clay Cross and Sheffield Midland is completed before 2033, and that electrification of the existing railway from Sheffield to Clayton (and any signalling renewal at Sheffield) is taken forward as part of Transport for North's (TfN) work and future Network Rail investment plans.

2.3 Economic Appraisal

2.3.1 We continue to apply standard guidance on how to assess the costs and benefits of transport infrastructure projects, as set out in the DfT's WebTAG[5] guidance. As part of this analysis, the costs and benefits are compared against each other to generate the Benefit Cost Ratio (BCR). The BCR is a measure of the value of benefits (including WebTAG compliant wider economic benefits), that would result from every £1 that the scheme costs.

2.3.2 This assessment captures the costs, benefits and changes in revenues for the whole of the rail network, not just those directly associated with the HS2 infrastructure. It includes the costs of both constructing and operating the railway. The benefits include lower levels of crowding on both HS2 and standard rail services, and the impact of quicker, more frequent and reliable journeys for passengers.

2.3.3 We capture all of these benefits and changes in revenue using a detailed model of rail passenger flows, the product of over six years of detailed development (the PLANET Framework Model). The model forecasts the likely behaviour of rail passengers taking real world information on how people make choices into account, such as what trains to get and which train station is best to use for particular journeys. It forecasts the

[5] WebTAG – The Department for Transport's Web Based Transport Analysis Guidance: https://www.gov.uk/guidance/transport-analysis-guidance-webtag

anticipated levels of demand we expect to see using the HS2 and conventional rail networks.

2.3.4 HS2 is a large undertaking, with significant upfront capital investment, but with benefits that will accrue for generations to come. The sheer size of the project, and longevity of its impacts, magnify the opportunities for transformational impacts, while also being a source of risk for the investment. It is not possible to forecast far into the future without a degree of uncertainty, and we therefore continue to give attention in our economic analysis to understanding the range of possible outcomes, as well as providing a central BCR estimated along Government appraisal guidelines.

2.3.5 During 2017, we have applied a number of important updates to our PLANET Framework Model. The most significant update is the application of an updated DfT forecast of gross domestic product (GDP). This forecast is based on the new short-term macro-economic forecast and long run determinants published by the Office for Budget Responsibility (OBR) alongside the 2016 Autumn Statement, which followed the June 2016 referendum on the UK's membership of the EU.

2.3.6 We have also updated the rail demand data contained within the model, taking into account observed growth in rail demand between the model base year (2015) and the present, as recorded by the Office for Road and Rail (ORR).

2.4 Case for Phase 2a

2.4.1 Phase 2a will extend the line from the West Midlands to Crewe in 2027, bringing additional benefits to the North West shortly after Phase One becomes operational. Phase 2a will allow HS2 trains to continue at high-speed beyond Birmingham and up to Crewe. In this Economic Case, we assess the value for money of the Phase 2a as an incremental investment decision in its own right given the proposal to build it earlier than the rest of Phase Two. We have assessed the costs and benefits of Phase 2a as an additional phase following the construction of Phase One, and assuming that Phase 2b *is not built*. Its overall value, however, should be seen in the context of being an essential component of the value for money of Phase Two as a whole.

Applying the standard DfT approach to transport appraisal, the Phase 2a increment generates a BCR with a point estimate of 1.9 including WebTAG compliant Wider Economic Impacts. Risk analysis shows that the case for the Phase 2a increment is robust to a variety of potential changes to both scheme and cost assumptions. The majority of the sensitivities tested – including variations in construction costs, fares and GDP – provide over a two-thirds chance of the scheme providing medium, or higher, value for money.

2.5 Case for Phase 2b

2.5.1 Phase 2b will extend the line north from Crewe to Manchester and join the WCML south of Wigan. It will also deliver a new eastern leg, which will stop in the East Midlands, South Yorkshire, and Leeds, and connect to the ECML near York.

2.5.2 Phase 2b generates, as an increment on Phase One and 2a, a BCR with a point estimate of 2.6 including WebTAG compliant Wider Economic Impacts. Risk analysis shows that the case for the Phase 2b increment is robust to a variety of potential changes to both scheme and cost assumptions. The majority of the six sensitivities tested – including variations in construction costs, fares and GDP – provide around a 75% (or higher) chance of the scheme providing medium, or higher, value for money.

2.6 Case for the full HS2 network

2.6.1 The full HS2 network will become operational in 2033. It will combine the incremental elements of Phase One, Phase 2a and Phase 2b to deliver a network that will provide a high-speed rail service between London and major cities in the Midlands and the North of England.

2.6.2 Applying the standard DfT approach to transport appraisal, the full HS2 network generates a BCR with a point estimate of 2.3 including WebTAG compliant Wider Economic Impacts. Risk analysis shows that the case for the full HS2 network is robust to a variety of potential changes to both scheme and cost assumptions. All six sensitivities tested – covering variations in construction costs, fares, GDP and network reliability - provide a 70% (or higher) chance of the scheme providing medium, or higher, value for money.

2.6.3 Our assessment follows the latest WebTAG guidance on rail appraisal by the DfT. There are, however, a number of elements in the business case that are not currently assessed as part of the primary BCR measure. Some of these elements – such as the potential for land use change and the value of commercial development around the stations – have the potential to add significantly to the measured benefits of the scheme. We therefore regard it likely the BCR measures will prove conservative, given the potential for wider transformative impacts over the life of the project that are not fully captured in the measure.

3 Introduction

3.1 Scope and purpose of this document

3.1.1 This document sets out HS2 Ltd's advice to Government on the Economic Case for the full HS2 network and the Phase Two increments that will deliver that network by 2033.

3.2 Document structure

3.2.1 This document is structured as follows:

- Chapter 4 provides an overview of the HS2 scheme, the route and HS2 train service specification we are appraising in this Economic Case;
- Chapter 5 gives an overview of our approach to the economic appraisal of the HS2 scheme;
- Chapter 6 summarises what has been updated in the modelling framework since the last HS2 Economic Case was published in November 2016;
- Chapter 7 summarises the economic appraisal for the Phase 2a increment;
- Chapter 8 summarises the economic appraisal for the Phase 2b increment;
- Chapter 9 summarises the economic appraisal for the full HS2 network;
- Chapter 10 sets out the benefits for a number of options for making potential changes to the core HS2 train service specification for services stopping at Crewe (the 'Crewe Hub') to support the consultation by the DfT;
- Chapter 11 outlines some of the costs and benefits, which may be important to the scheme but are not currently included in the primary benefit cost ratio;
- Appendix 1 sets out the scheme service patterns that have been assumed for modelling purposes;
- Appendix 2 has more detail on the cost assumptions that have been incorporated into the appraisal;
- Appendix 3 sets out more detail on benefits and how we calculate the benefit cost ratio;
- Appendix 4 reports transport impacts for the full HS2 network and the incremental phases;
- Appendix 5 reports the regional benefits for the full HS2 network and the incremental phases;
- Appendix 6 reports the benefit cost ratios for the full HS2 network and the incremental phases;

- Appendix 7 reports the costs and benefits for the Crewe Hub options assessed in Chapter 10;
- Appendix 8 reports the median spot point BCR estimates, as generated by our risk analysis; and
- Appendix 9 sets out examples of the journey times modelled in this Economic Case.

3.3 Supporting documentation

3.3.1 For more information on certain aspects of the analysis, this Economic Case should be read in conjunction with other reports. These include:

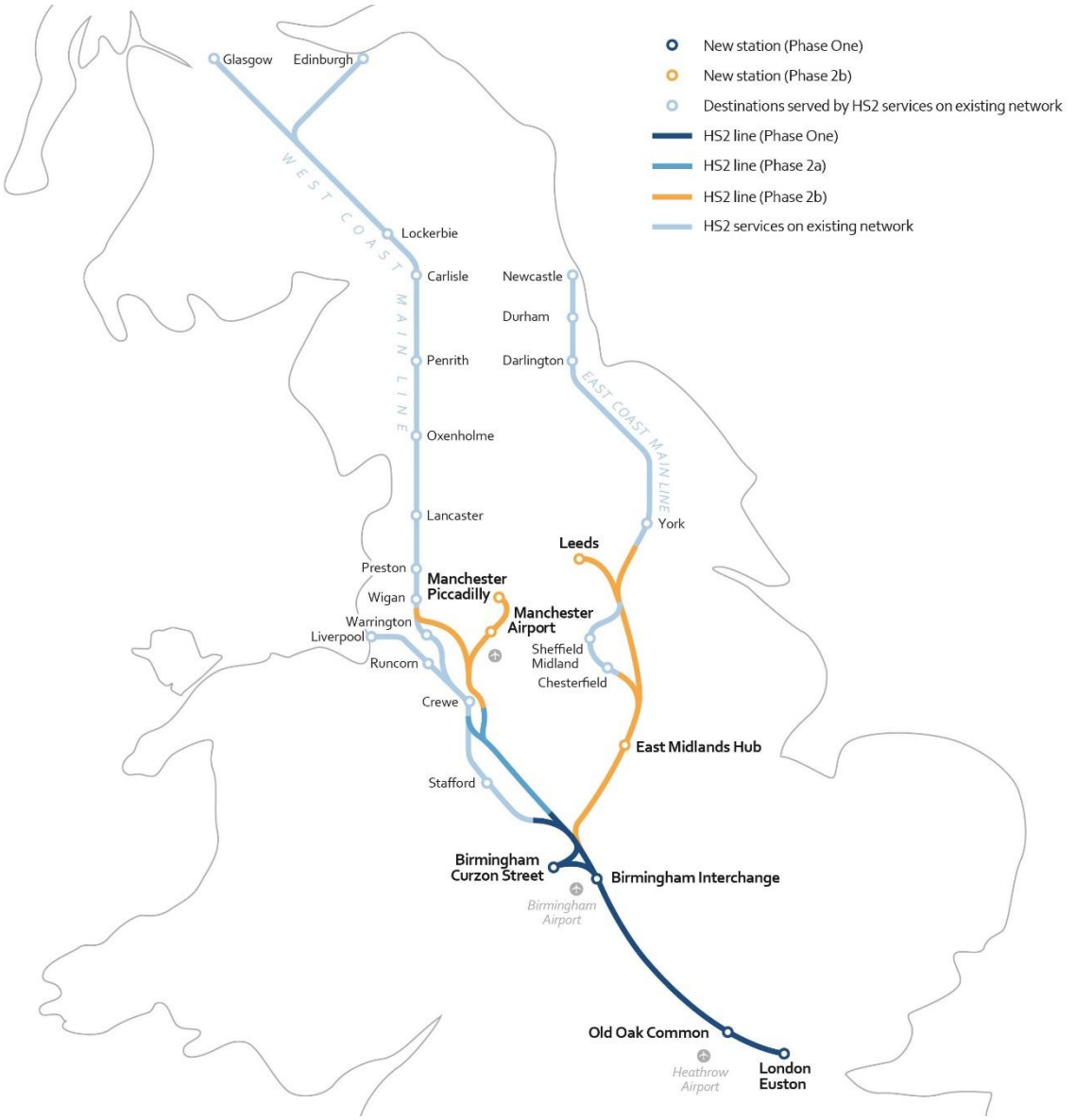
- PLANET Framework Model (PFM V7.1) – Model Description;
- PLANET Framework Model Version V7.1 Assumptions Report;
- PLANET Framework Model Version V7.1 Demand forecasting report;
- PFM V7.1 Step-through report. Summary of key changes to the modelling assumptions between PFM 6.1c and PFM v7.1;
- Audit of the development of PLANET Framework Model version 7.1;
- Risk analysis for the HS2 Economic Case – Technical documentation;
- High Speed Two Phase Two Economic Case; and
- High Speed Two Phase Two Financial Case.

4 The HS2 network

4.1 Full network

4.1.1 HS2 is a new high-speed rail network for the UK, connecting London with major cities in the Midlands and the North of England. It will be delivered in several phases. Trains will also run beyond the high-speed network to serve places such as Liverpool, Preston, Newcastle and Scotland. Figure 1 shows the proposed full HS2 network.

Figure 1: The full HS2 network



4.1.2 Phase One of HS2 will see a new high-speed line constructed from Euston to just north of Birmingham, where it will join the existing WCML, allowing fast, direct services to destinations including Manchester, Liverpool, Crewe, Preston and Glasgow. New high-speed trains will also serve Birmingham city centre via a dedicated high-speed line and a new station at Curzon Street, with an interchange station

designed to serve the wider West Midlands and Birmingham International Airport. A new interchange will be built at Old Oak Common in West London, connecting HS2 with Crossrail and the Great Western Main Line. The parliamentary bill for Phase One of HS2 received Royal Assent on 23 February 2017.

4.1.3 The full Phase Two proposal is to extend the line north-west to Manchester with connections onto the WCML, and extend the line north-east to Leeds with a connection onto the ECML. There will be stations in Manchester and Leeds, with intermediate stations in the East Midlands and South Yorkshire, as well as a Manchester Airport High Speed station (depending on third party funding). Phase Two is planned to be delivered in two phases:

- Phase 2a will bring forward the benefits of Phase Two by accelerating the delivery of the high-speed line from the West Midlands to Crewe; and
- Phase 2b will extend high-speed lines from the West Midlands to Leeds and from Crewe to Manchester, with intermediate stations at Manchester Airport and the East Midlands, and with connections onto the WCML and ECML. It will also include connections onto the existing network north and south of Sheffield at Clayton and Clay Cross.

4.2 Assessing the benefits of the HS2 network

4.2.1 The HS2 scheme brings a number of key benefits to the UK. This includes increased capacity between key city destinations, faster and more reliable journey times bringing cities closer together, and the release of capacity on the conventional network, allowing the conventional network to refocus on serving shorter distance markets. Importantly, released capacity on the conventional network also creates options for the future to respond to changes in passenger demand and freight travel.

Journey times

4.2.2 The full HS2 network provides a number of significant reduced journey times. For example, journey times for:

- London to Manchester will reduce from 2 hours 7 minutes to 1 hour 8 minutes;
- London to Leeds will reduce from 2 hours 10 minutes to 1 hour 21 minutes; and
- Birmingham to Manchester will reduce from 1 hour 28 mins (Birmingham New Street) to 41 minutes (Birmingham Curzon Street).

4.2.3 Appendix 9 provides more detail on the journey times that we have used to model the benefits of the HS2 network.

Increased capacity between key city destinations and on the conventional network

4.2.4 The HS2 network will provide trains that are much longer than possible on the current rail network (except HS1), with 400m trains serving the key city stations providing significantly more capacity on a single train than available today.

4.2.5 Alongside the increase in capacity, the potential to revise services on the conventional network will allow both a mix of additional capacity to intermediate stations from the transfer of long distance passengers to HS2, and services of new markets. For example, once HS2 arrives, it would be possible to revise the type and makeup of services on the WCML into and out of Euston to provide significantly more commuter seats.

5 Our approach to economic appraisal of the HS2 scheme

5.1 Overview

5.1.1 At HS2 Ltd, we continue to review and update our appraisal methodology in line with updated guidance from the DfT, and develop our modelling framework, in order to enhance our ability to assess the impact of HS2. This chapter gives brief details of our approach to economic appraisal of the scheme.

5.2 Appraisal of the HS2 Scheme

PLANET Framework Model (PFM)

5.2.1 As with previous Economic Cases, we appraise the value for money of the HS2 scheme using a detailed model of long-distance travel in Great Britain called the PLANET Framework Model (PFM), which has been developed over a number of years.

5.2.2 The PFM looks to understand and provide forecasts of demand for travel and the changes in travel behaviour across rail, air and road that would result from building HS2. It provides a strategic view of the rail, road and air markets and networks, while also drawing on detailed information on passenger travel from ticket sales and other data.

5.2.3 The PFM is a framework of a number of models, each aiming to understand different dimensions of passenger behaviour. Key components are below.

5.2.4 PLANET Long distance (PLD): the component that models the behaviour of long distance travel demand, on the rail, road and air networks, both with and without HS2. The rail data for this component comes from ticket sales data. Alongside this is a representation of how many people travel long distance on the road network, and use air travel. These data sets feed into a demand forecasting model to forecast changes in future travel markets.

5.2.5 PLD works in conjunction with the Station Choice Model (SCM): the SCM looks at how passengers choose which station to use to catch a train from, and allows passengers to consider and change their access station once a new scheme is built, based on an analysis of journey times. Hence, the model allows passengers to decide that sometimes it might be a better idea to drive slightly further to catch a quicker train from another rail station. These choices are calibrated against surveys of passenger behaviour.

5.2.6 Regional Models: there are also three regional models, which are designed to look at the local changes that can be facilitated by HS2. These specifically look at rail passengers and include the millions of commuting passengers into London, Birmingham, Manchester and Leeds and the potential benefits to those travelling into these cities from changes to the commuter service.

Transport user benefits

5.2.7 The PFM produces an assessment of the scale of likely benefits from building the HS2 network. These benefits are initially assessed in units of time before being converted to monetary values using DfT guidance. They include an assessment of the following, all using procedures in line with DfT WebTAG guidance:

- quicker journeys;
- improved performance associated with high-speed rail;
- reductions in crowding;
- reductions in congestion on the road network; and
- other impacts, such as changes in the costs of accessing the rail network; time spent waiting for a train; or the number of times a passenger has to change train on their journey.

5.2.8 The model we use is designed to capture all of these impacts, whether positive or negative and, importantly, whether they are directly related to HS2 or represent other secondary impacts. The model looks at the change in overall journeys, not simply the experience on HS2. Therefore, if someone chooses a longer journey to access an HS2 station in order to gain a faster journey time once on board the HS2 train, we would count the negative cost of the increase in access time together with the benefit of the reduction in journey time. Similarly, if any trips become disadvantaged, for example, due to changes on the conventional network, this would be captured in the model[6].

5.2.9 Our valuation of benefits uses the latest DfT values of time drawn from a recent project based on large-scale surveys of the travelling public and businesses and state-of-the-art analytic techniques. The DfT project provides a significant development to the rigour of our assessment, not least because the study surveyed business travellers and their employers, and provides values of time, which account for changes in technology and the ability to do some work on trains. The research was peer reviewed by Leeds Institute of Transport Studies, which comprises leading experts in value of time estimation and choice modelling.

5.2.10 In economic cases for HS2 prior to November 2016, we used the standard approach applied across conventional DfT rail programmes, known as the 'rule of a half', in valuing transport user benefits (see DfT's WebTAG guidance for further details). Following advice from the DfT's transport appraisal team, we have adopted the alternative statistical technique of numerical integration for calculating passenger benefits. Numerical integration is recommended for schemes such as HS2, for which there are large changes in demand or travel time. The move to numerical integration in our appraisal method has the effect of reducing estimated benefits, which lowers the BCR with WEIs by 0.5 for the full HS2 network. When comparing HS2 with other

[6] PLANET Framework Model (PFM V7.1) – Model Description, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

transport spending proposals, particularly those that drive large changes in demand or journey time, it is worth being aware of the different methods for calculating transport user benefits that may be applied across different proposals, and the effect they have on estimates of value for money.

Wider Economic Impacts

5.2.11 The benefits assessed also include the standard wider economic impacts (WEIs) as outlined in the DfT's WebTAG Guidance (Unit A2.1)[7]. They are estimated using the Wider Impacts in Transport Appraisal (WITA) software that the DfT has developed for this purpose. There are three types of wider economic impacts we calculate in our modelling:

- *Agglomeration:* arising from increased connectivity between cities and towns. This is about reducing the costs of travel between areas, creating opportunities for more intense and productive interactions between businesses and workers;
- *Imperfect competition:* reduced costs facilitate an increase in output. Companies operating in imperfectly competitive industries will be able to increase their production as a result of lower transport costs; and
- *Increased labour force participation*: transport changes can affect individual's incentives to work and therefore affect the overall level of labour supply.

5.2.12 In addition to the standard WebTAG compliant wider economic impacts there are a number of other important effects, which are not currently assessed as part of the primary BCR measure in the business case. Some of these elements – such as land use change and commercial development around the HS2 stations – have the potential to generate significant additional benefits. We highlight these appraisal issues in Chapter 11.

Rail fares

5.2.13 Our value for money assessment includes an estimate of likely fares revenues from the HS2 services, and the reference case is based on an assumption that regulated fares follow Government policy for the existing rail network and increase by RPI+0% up to 2020, and then RPI+1 between 2020 and 2037. Our risk analysis then indicates the impact of variations in fares policy on the value for money of the scheme. Our analysis is based on applying the fares policy assumptions to DfT's EDGE forecasting model, using industry-agreed PDFH elasticities to assess the likely impact on rail demand. We note that the modelling illustrates the impact of fares policy applied to all operators, and does not take into account any differential fares or potential competitive responses between HS2 and existing train operating companies.

[7] Web TAG Unit A2-1 wider impacts, available on gov.uk: https://www.gov.uk/guidance/transport-analysis-guidance-webtag

Risks and uncertainties

5.2.14 Our reference case BCR provides a central estimate of the value for money of the scheme following DfT guidance on methodology. In practice, in an infrastructure project with a potential lifespan of over 100 years, a single point-estimate fails to capture the potential upside and downside risks to returns from the investment.

5.2.15 Therefore, for the HS2 economic case, we provide a particular focus on risks around the central case. Our risk analysis provides a distribution of BCR results, using probability distributions to define a range of potential outcomes for the assumptions made when assessing the returns for transport infrastructure investment, including demand for travel, economic growth, and the costs of the scheme. Further details of the risk analysis process are explained in the risk analysis technical documentation[8].

5.2.16 Where there is good quality data on the probability distribution around an input variable, it has been included in the risk analysis. For other variables, specific scenarios detail how the risk analysis would change under different assumptions.

5.2.17 Table 1 details which variables have been considered by the risk analysis. Table 2 sets out the list of sensitivities that have been considered against the reference case.

Table 1: List of variables included in the risk analysis

Economic Variable	Benefits/Cost Impact
GDP Growth Rate	Transport User Benefits Wider Economic Impacts Capital Cost Revenue
Value of Time	Transport User Benefits
VOT Elasticity	Transport User Benefits
GDP & Fares Elasticities	Transport User Benefits Revenue
Phase One Construction Cost Risk	Capital Cost
Phase One Rolling Stock Cost Risk	Capital Cost
Phase 2b Rolling Stock Cost Risk	Capital Cost
Car and Diesel Carbon Impacts	Other quantifiable benefits

[8] Risk analysis for the Economic Case: Technical documentation, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

Table 2: Sensitivity tests considered in this Economic Case

Sensitivity Test	Assumption being tested against the reference case
Higher Growth	We assess the impact of assuming that GDP growth rates are 10% higher each year than the current GDP forecast.
Lower Growth	We assess the impact of assuming that GDP growth rates are 10% lower each year than the current GDP forecast.
Higher Optimism Bias	We assess the impact of increasing Phase 2a and 2b optimism bias on construction costs from 40% to 50%.
Lower Fares	We assess the impact of assuming that fares increase by RPI+0% per year between 2020 and 2037 rather than RPI+1%.
Higher Fares	We assess the impact of assuming that fares increase by RPI +2% per year between 2020 and 2037 rather than RPI+1%.
Without Reliability Benefits	We assess the impact of assuming that HS2 does not deliver any reliability benefits beyond those achieved by the conventional network.

Cost estimation

5.2.18 The cost estimates used for this analysis are consistent with the Spending Review 2015 allocation. The HS2 funding position is detailed in the Financial Case. The spending review set the long-term funding envelope for the HS2 scheme at £55.7bn in 2015 prices, and allocated the funding envelope across the phases as follows:

- Phase One including rolling stock (London – West Midlands) – £27.2bn;
- Phase 2a (West Midlands – Crewe) – £3.7bn; and
- Phase 2b including rolling stock (West Midlands – Manchester/Leeds) - £24.8bn

There has since been a further amendment of the cost split between Phase 2a and Phase 2b, and is explained in sections 5.2.21 and 5.2.22.

5.2.19 The Phase One and rolling stock elements of the funding envelope include a contingency requirement calculated at a level of 95% certainty that costs will not

exceed the anticipated final cost[9]. This is a conservative application of Quantified Risk Assessment (QRA) which leads to a higher cost estimate, as guidance implies it should normally be applied at a level of 50% certainty that costs will not exceed the anticipated final cost (the 'P-mean')[10].

5.2.20 The cost estimates for the Phase 2a and Phase 2b elements of the scheme (excluding rolling stock) are based upon an assumption of 40% optimism bias. This is in line with HM Treasury Green Book guidance[11]. As detailed in the Financial Case, while sufficient progress has been made to develop a risk profile for Phase 2a, the level of detail is not currently sufficient to exceed the threshold for converting from the use of optimism bias to a full QRA approach.

5.2.21 As also explained in the Financial Case, part of the Phase 2a design is a tunnel required for Phase 2b under Crewe; the southern portal of this tunnel is a handover point between Phase 2a and Phase 2b. A route refinement to extend this tunnel was proposed in November 2015, and underwent consultation in September 2016.

5.2.22 We have assumed the tunnel will be delivered in full during Phase 2b construction works, and therefore the costs of this extension (£0.24bn) are incurred within the Phase 2b budget. As a result, the SR15 budget for Phase 2a has been reduced from £3.72bn to £3.48bn, while the Phase 2b budget increases from £24.83bn to £25.07bn. This reallocation of costs does not change the overall £55.7bn funding envelope for the HS2 programme.

5.2.23 In undertaking the appraisal within this Economic Case, a number of adjustments are made to the above cost estimates to adhere to HMT Green Book and DfT WebTAG guidance for undertaking appraisal of transport schemes[12]. Significant adjustments include:

- Discounting to present value – in order to provide estimates of costs and benefits in the BCR in present values;
- Adding an estimate for higher construction cost/project specific inflation between 2017/18 and 2021/22 – a conservative assumption specific to the HS2 scheme;
- The removal of sunk costs – HM Treasury guidance specifies that these are expenditure prior to the appraisal base year (2017/18), and should not be included;
- Applying a market price uplift so all costs and benefits are gross of indirect tax; and

[9] From the June 2016 National Audit Office (NAO) report 'Progress with Preparations for High-speed 2': https://www.nao.org.uk/report/progress-with-preparations-for-high-speed-2/
[10] WebTAG: TAG unit A1-2 scheme costs, available on gov.uk: https://www.gov.uk/guidance/transport-analysis-guidance-webtag
[11] The Green Book: appraisal and evaluation in central government, available on gov.uk:https://www.gov.uk/government/organisations/hm-treasury
[12] WebTAG: TAG unit A1-2 scheme costs, available on gov.uk: https://www.gov.uk/guidance/transport-analysis-guidance-webtag

- Adding in additional costs to accommodate repair and renewal of the HS2 infrastructure over the 60-year appraisal period.

5.2.24 We note that the addition of higher construction cost/project specific inflation is an appraisal methodology specific to the HS2 scheme. It also means that the appraisal incorporated within this Economic Case is undertaken on a higher overall cost estimate than the Financial Case. This provides a further conservative assumption for appraising the value for money of the scheme. Removing higher construction inflation, and taking the assumption that the costs of HS2 increase in line with the GDP deflator, would increase the median Full Network BCR from 2.3 to 2.7.

5.2.25 In line with HM Treasury appraisal guidance, we have removed sunk costs from the calculation of the BCRs. If we were to include the sunk costs incurred up to 2017, we estimate that this would reduce the median Full Network BCR by 0.2.

6 Updates to our appraisal data and framework

6.1 Overview

6.1.1 We have updated our modelling and appraisal framework to reflect the most recent data available and the latest guidance from the DfT on how best to appraise rail schemes. This chapter details the key changes implemented for this Economic Case.

6.2 Demand Forecasts

6.2.1 The growth in rail demand between the Base Year and the Future Year models is forecast using estimates of growth in key rail demand drivers. These key rail demand drivers reflect several factors that significantly influence rail demand growth, such as GDP, population, and employment. The drivers are subject to updates as new and revised forecasts are released by national bodies such as the OBR, the DfT and HM Treasury.

6.2.2 Since the last Economic Case, the following WebTAG updates have been incorporated into our modelling[13]:

- Updated November 2016 forecast of gross domestic product (GDP) - based on the new short-term macro-economic forecast and long run determinants published by the OBR alongside the 2016 Autumn Statement; and
- Observed growth in rail demand between the model base year (2014/15) and the present, as recorded by the ORR.

6.3 Long Term Benefit Extrapolation

Overview

6.3.1 Until now, our existing approach to assessing the benefits of the HS2 scheme has been to hold benefits constant after the final forecast year, in line with DfT guidance for appraising transport schemes. The final forecast year is maintained as being 20 years from the appraisal year. Hence, the final forecast year for this Economic Case is 2037. This meant that we used our models and appraisal tools to forecast benefits up to 2037, after which, the benefits are held constant and no further growth in demand is assumed to the end of the appraisal period (2093). This approach is also known as the 'Demand Cap.'

6.3.2 Holding benefits constant also implies the number of trips per person falls after the final forecast year, as the population is forecast to continue growing. We regard an approach that caps rail demand just four years after the proposed opening of the full

[13] WebTAG: TAG forthcoming changes May 2017, available on gov.uk: https://www.gov.uk/guidance/transport-analysis-guidance-webtag

HS2 network as conservative for a transformative project such as HS2. In our previous Economic Case, we therefore included a risk analysis sensitivity showing the impact of extrapolating benefits in line with population growth to the end of the appraisal period[14], arguably also a conservative approach to assessing value for money.

Latest WebTAG guidance

6.3.3 In July 2017, the DfT issued a forthcoming change to the WebTAG Unit A5.3 guidance on rail appraisal[15]. The guidance sets out a new approach to demand and revenue forecasting within rail appraisal. Key points are that:

- A final forecast year should be applied to benefits and revenue forecasts 20 years from the appraisal year (or further into the future subject to demonstrating the robustness of the model parameters and inputs over the whole forecast period);
- A requirement to cap demand growth after 20 years has been removed; after the final forecast year, benefits and revenues should be extrapolated in line with national population projections; and
- Care should be taken where capacity constraints are likely to reduce or curtail the size of benefits over the full extrapolation period. This requires consideration of potential overcrowding on the network once the scheme is in place.

HS2 Appraisal: Adoption of revised DfT Guidance

6.3.4 When considering the updated WebTAG guidance, we looked at the capacity that Phase Two of the HS2 scheme will bring to the rail network as each incremental phase starts operation.

6.3.5 Our analysis included consideration of all day average and peak time loadings and international benchmarks. The latter (including evidence from the Shinkansen) points to a network-wide, all-day average load factor of around 70% as a stretching, but reasonable, level for a complex high-speed network such as HS2 (with a comparable figure for the peak in the mid-80%).

6.3.6 The Phase 2a increment does not, in itself, generate a significant increase in capacity; the TSS from Phase One continues into Phase 2a, but it draws on the benefits provided by accelerating the delivery of high-speed track to Crewe. Phase 2b, in contrast, brings into operation a significant increase in capacity, both in terms of destinations served and rolling stock. The risk of any capacity constraints are therefore more likely in the Phase 2a increment than for the full HS2 network.

6.3.7 We have therefore adopted the following approach in this Economic Case:

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[14] High Speed Two Phase 2b, Crewe to Manchester & West Midlands to Leeds: Economic Case, November 2016, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

[15] WebTAG: TAG unit A5.3 rail appraisal, forthcoming changes, July 2017, available on gov.uk: https://www.gov.uk/guidance/transport-analysis-guidance-webtag

- **Phase 2a increment** – we have continued the approach of capping benefits and revenues at the point of our final forecast year (2037); and
- **Phase 2b increment/the full HS2 network** – we have adopted the new guidance of extrapolating benefits and revenue from the final forecast year (2037) to the end of the appraisal period (2093). In line with the requirements of the updated WebTAG guidance we also show, as a sensitivity test comparison, what the value for money estimates would be if benefits were still capped at 2037.

6.4 Updates to the 'without HS2' baseline

6.4.1 The 'without HS2' baseline (also referred to as the 'do minimum'), against which HS2 is compared, has been updated to reflect recent changes in franchise commitments and forecast changes to conventional rail services. Conventional rail updates include:

- **London Midland** – Full recoding of the franchise based upon the specifications within the franchise Invitation to Tender (ITT) issued for the franchise competition. Final award of the franchise to the operator is expected in summer 2017;
- **Greater Anglia** – Full recoding of the franchise based on the award of the franchise and the agreements within the new franchise including new timetable and rolling stock assumptions – which also includes the remapping of some services to London Overground;
- **Midland Mainline (MML)** – Updates to the journey time and service patterns for East Midlands services to/from London following new assumptions related to the upgrade and electrification of the Midland Mainline;
- **West Coast Mainline (WCML)** – There are revised assumptions regarding the provision of WCML services. In PFMv7.1, all WCML services in the 'do something' scenario will be provided by 11-car train sets whereas previously there were some services operated by 9-car train sets; and
- **WCML/TPE** – There has been an amendment to the forecast 'do something' service pattern assumptions for WCML and TPE. Previously there was an assumption that in the 'do something' a Manchester Airport to Scotland service operated by TPE in the 'do minimum' would be removed and replaced by extending a WCML Euston-Manchester service to Scotland. However, this has now been revised to terminate the WCML service at Manchester Piccadilly, and reinstate the TPE Manchester Airport to Scotland service in the 'do something.'

6.5 HS2 service patterns

6.5.1 There have been a number of changes generated by updates to the reference case route and our modelling. The proposed HS2 stopping patterns are shown in Appendix 1. The modelled HS2 journey times are shown in Appendix 9. For this Economic Case:

- Phase One and Phase 2a – there are no changes to stopping patterns; and
- Phase 2b - the eastern leg has been updated to incorporate, within the reference case, the M18/Eastern route option via Sheffield Midland (previously known as the M18 Loop route). This route was set out in the November 2016 Economic Case[16].

6.6 Air quality

6.6.1 In appraising environmental impacts, HS2 considers the impacts of air quality in line with WebTAG guidance. In September 2015 Defra published updated interim guidance on valuing changes in emissions, as set out in the DfT March 2017 Forthcoming Change to WebTAG[17]. As part of continuing to review and update our appraisal methodology in line with updated guidance, the new evidence base for appraising NO_x emissions has been considered as a sensitivity.

6.6.2 Applying these new Marginal External Costs into our appraisal gives a benefit to the Full Network (in addition to those set out in Appendix 4a) of £52m for air quality[18]. This sensitivity has an insignificant impact on the estimate of the Full Network BCR.

[16] High Speed Two Phase 2b, Crewe to Manchester and West Midlands to Leeds: Economic Case, November 2016, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

[17] WebTAG: Forthcoming Change to WebTAG March 2017, available on gov.uk: https://www.gov.uk/guidance/transport-analysis-guidance-webtag

[18] Note that the estimated air quality impact has been calculated in 2010 prices, due to the availability of the sensitivity figures in WebTAG; the rest of our core appraisal estimates are in 2015 prices.

7 Case for Phase 2a

7.1 The scope of this assessment

7.1.1 Here we present the Economic Case for the Phase 2a increment. Phase 2a will extend the line from the West Midlands to Crewe in 2027, bringing additional benefits to the North West shortly after Phase One becomes operational. Phase 2a will allow HS2 trains to continue at high speed beyond Birmingham and up to Crewe. Services will then re-join conventional rail lines.

7.1.2 This chapter assesses the value for money of the Phase 2a increment as an investment decision in its own right, given the proposal to build it earlier than the rest of Phase Two. Its overall value, however, should also be assessed in the context of the value for money of Phase Two as a whole, and we assess the Phase 2b increment in the next chapter. Here we focus on the costs and benefits of:

a) Phase 2a as an incremental phase following the construction of Phase One; and

b) Assuming that Phase 2b *is not built*.

As set out in Section 6.3, for the Phase 2a increment we have not adopted DfT's latest WebTAG guidance on increasing benefits and revenues from our final forecast year in 2037 due to an assessment of available capacity. Rather, we have maintained a conservative approach of capping benefits and revenues at the point of our final forecast year (2037). We do, however, remove the demand cap in our assessment of Phase 2b, given the significant extra capacity it provides in terms of destinations served and rolling stock.

7.2 What has changed since the last Phase 2a Economic Case?

7.2.1 In January 2016, HS2 Ltd published an initial assessment of the Phase 2a increment[19]. Since that publication, a number of changes have been adopted. These were summarised in the more recent Economic Case for Phase 2b in November 2016[20] and in Chapters 5 and 6 of this report. The more significant changes to affect the assessment of the Phase 2a increment since the previous assessment include :

a) The January 2016 Phase 2a increment Economic Case was based on a reference case assumption that, of the three London to Manchester services, two would be routed via, but not stopping at, Crewe. A sensitivity test was undertaken, which demonstrated that routing all three services via, but not stopping at, Crewe provided additional benefits that have now been adopted into the Phase 2a increment reference case;

[19] HS2 Phase Two, West Midlands to Crewe Economic Case, January 2016, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

[20] High Speed Two Phase 2b, Crewe to Manchester & West Midlands to Leeds: Economic Case, November 2016, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

b) A sensitivity test was included in the 2016 case to show the impact of assuming HS2 incurs project specific inflation up to 2020/21 – that is, the project experiences higher price inflation than the general rate of inflation. Project-specific inflation has now been adopted within the reference case from 2017/18 to 2021/22;

c) A sensitivity test was undertaken in 2016 to show the impact of DfT-commissioned research, which generated new values of time. These new values of time, with analysis based on up-to-date large-scale surveys, used methodologies which allow for the productive use of journey time, and have now been adopted within the reference case and have been incorporated into WebTAG;

d) As set out earlier in Chapter 6, we have adopted the OBR's updated November 2016 forecast of GDP, together with observed growth in rail demand between the model base year (2015) and the present - as recorded by the Office for Road and Rail (ORR). The lower GDP forecast following the June 2016 EU referendum places downward pressure on forecasts of rail demand;

e) As set out in Chapter 6 of this Economic Case, we have capped benefits and revenue 20 years after the appraisal base year of 2017 – which is also in line with our final forecast year of 2037 (see section 6.3);

f) The assessment in January 2016 was undertaken with a price base of 2011 for costs and benefits. The price base has since been updated to 2015, which aligns with the HS2 funding envelope of £55.7bn in 2015 prices;

g) We have included a transfer of £0.24bn from Phase 2a to Phase 2b for the extension of a tunnel under Crewe, as the tunnel is expected to be completed in full during Phase 2b construction works.

7.3 Phase 2a increment – reference case result

7.3.1 Applying the latest train service specifications, and updated DfT methodologies, the Phase 2a increment generates a Benefit-Cost Ratio (BCR) with a point estimate of 1.9, including WebTAG compliant Wider Economic Impacts (WEIs). Table 3 summarises the benefits and costs for Phase 2a of the HS2 scheme. Appendix 6 presents the Phase 2a increment reference case with a further detailed breakdown of benefits and costs.

Table 3: Phase 2a increment Benefit Cost Ratio - £bn, 2015 prices, Present Value (PV)

		Phase 2a increment Reference Case
	BCR Components	**Benefits capped in 2037 Present Value (PV) £billion, 2015 prices**
1	Net Transport Benefits excluding WEIs	3.2
2	Net Benefits including WEIs	3.9
3	Total Costs	4.2
4	Revenue	2.1
5	Net Costs to Government = (3) – (4)	2.1
6	**BCR without WEIs = (1)/(5)**	**1.6**
7	**BCR with WEIs = (2)/(5)**	**1.9**

7.4 Phase 2a increment – Robustness of the Case

Overview

7.4.1 The appraisal of HS2 draws on a number of data sources and appraisal assumptions that seek to forecast the costs and benefits of the scheme over a 60-year timeframe. These assumptions are in line with the DfT's WebTAG guidance. In the case of the Phase 2a increment, this reflects 60 years from the opening of Phase 2a in 2027. A number of these variables are subject to some uncertainty (e.g. the rate of growth of demand, the level of demand, fares, costs, and optimism bias assumptions).

7.4.2 This section therefore examines the impact changes to these key variables could have on the Phase 2a increment BCR, and therefore the value for money of the scheme, using the risk analysis model explained in Chapter 5.

Risk analysis results

7.4.3 Table 4 summarises the risk analysis sensitivities we have undertaken mapping the relative probability of different levels of BCR against the DfT's value for money categories. It shows that the case for the Phase 2a increment is robust to a variety of potential changes to both scheme and cost assumptions:

- Sensitivities covering variations in fares and higher GDP growth provide over an 80% chance of the Phase 2a increment providing medium, or higher, value for money;
- Five out of the six sensitivities tested – including significant increases to construction costs and lower GDP growth assumptions – provide over a two-thirds chance of the Phase 2a increment providing medium, or higher, value for money; and
- Removing all reliability benefits significantly reduces the chance of the railway providing high value for money. This is an extreme test, which

assumes HS2 delivers no reliability benefits compared to the existing conventional network. It nonetheless delivers a BCR above 1 for the Phase 2a increment.

Table 4: Phase 2a increment Benefit Cost Ratio – Risk analysis sensitivities

Phase 2a Inc	Poor VfM (BCR <1.00)	Low VfM (BCR 1.0 - 1.5)	Medium VfM (BCR 1.5 - 2.0)	High VfM (BCR 2.0 - 4.0)	Very High VfM (BCR > 4.0)
Reference Case	0.2%	14.8%	47.4%	37.7%	0.0%
Higher GDP Growth	0.0%	5.3%	32.4%	61.5%	0.9%
Lower GDP Growth	0.3%	33.2%	52.7%	13.9%	0.0%
Higher Fares	0.0%	8.3%	40.2%	51.5%	0.1%
Lower Fares	0.2%	19.3%	50.0%	30.7%	0.0%
50% OB	0.5%	31.7%	49.9%	18.0%	0.0%
Without Reliability	7.7%	67.3%	22.8%	2.3%	0.0%

Note: Likelihoods based on 2000 simulations.

7.4.4 The following sections look at the sensitivities in more detail. The reference case risk analysis is detailed in Appendix 8.

Assessing the impact of higher/lower demand assumptions

7.4.5 Our forecast of the number of passengers expected to travel on HS2 remains a central element of the Economic Case. Our approach to forecasting rail demand growth remains unchanged from previous economic cases, and follows standard DfT guidance drawing on a range of factors – including the cost of travel, population growth, employment rates and economic growth (as measured by GDP) over time. Projections of these drivers have been updated in line with DfT guidance, with the most significant change following the OBR's November 2016 GDP forecast.

7.4.6 Figure 2 and Figure 3 show the impact on the reference case BCR if we assume that GDP growth rates are 10% higher/lower each year than the reference case GDP forecast up to the final forecast year (2037), and passenger demand held constant thereafter.

- For the assumption of higher GDP growth, 62% of modelled scenarios are within the high, or very high, value for money categories;
- With the assumption of lower GDP growth, 14% of modelled scenarios are within the high, or very high, value for money categories, and two-thirds of modelled scenarios are within the medium, or higher, value for money categories.

Figure 2: Risk analysis – Phase 2a increment with 1.1x GDP growth rate

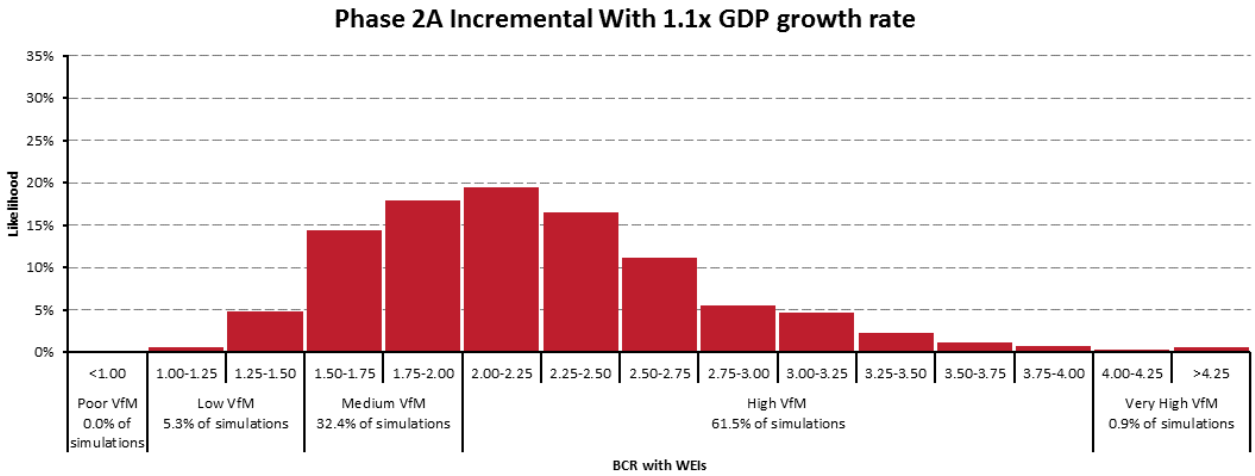
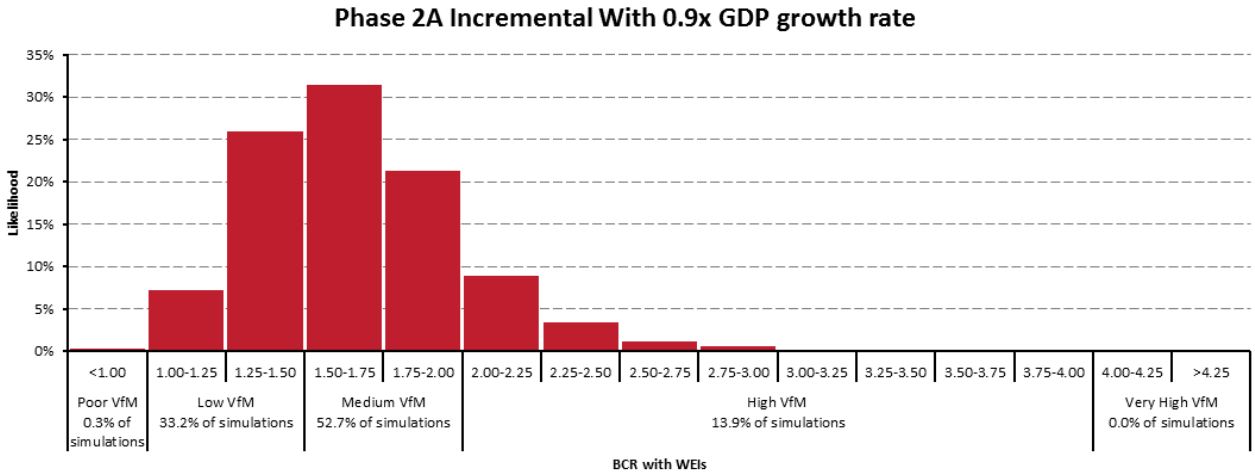


Figure 3: Risk analysis – Phase 2a increment with 0.9x GDP growth rate



Assessing the impact of higher/lower fares policy assumptions

7.4.7 The fares policy assumption is a key component of the BCR for the scheme as future rail fares policy directly feeds through to our estimates of the likely revenue returned from the scheme. For this Economic Case, we have followed the Government's policy for the existing rail network and assumed that growth in regulated rail fares will be maintained at RPI until 2020. Rail fares are then assumed to increase at RPI+1% beyond 2020 until the final forecast year (2037).

7.4.8 Our approach to modelling rail fares is set out in Chapter 5, which notes that it does not take into account any differential fares or potential competitive responses between HS2 and existing train operating companies. Using that approach, Figure 4 and Figure 5 show the impact on the reference case BCR if we were to assume that fares are higher/lower than the reference case fares assumption.

7.4.9 Increasing fares has two effects on revenue:

- The number of passengers travelling by rail falls as the cost of rail travel is higher; and
- Revenue per passenger (for remaining passengers) increases, as fares are higher.

The effect that dominates will determine whether the BCR increases or decreases.

7.4.10 In Phase 2a, the higher fares scenario increases the BCR as the effect of higher per passenger revenue dominates the reduction in numbers of passengers. The lower fares scenario conversely decreases the BCR.

7.4.11 The specific impacts on our modelled scenarios is as follows:

- For the assumption of higher fares (RPI +2% per year after 2020), 51% of modelled scenarios are within the high, or very high, value for money categories;
- With the assumption of lower fares (RPI +0% per year after 2020), 30% of modelled scenarios are within the high, or very high, value for money categories. Over 80% of modelled scenarios are in the medium, or higher, value for money categories.

Figure 4: Risk analysis – Phase 2a increment with higher fares

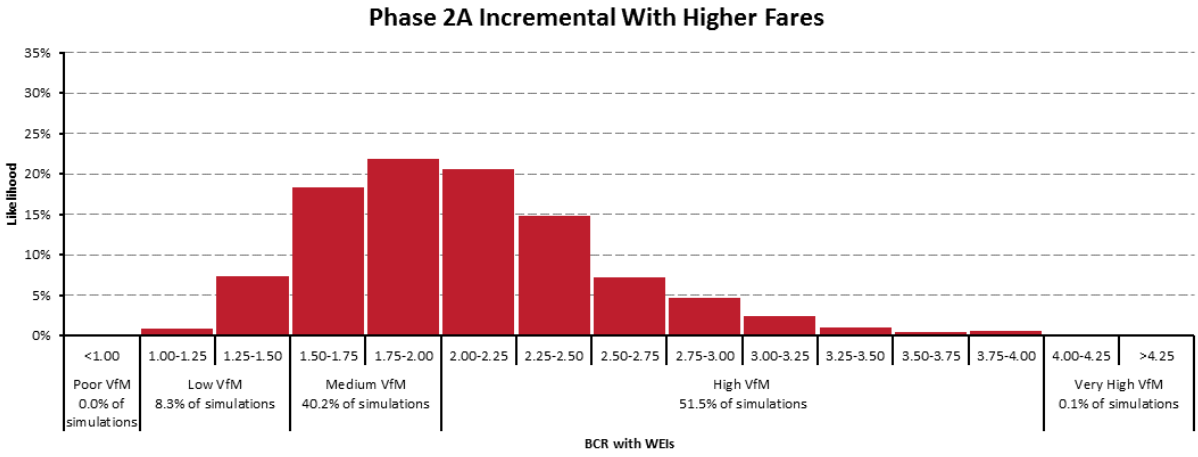
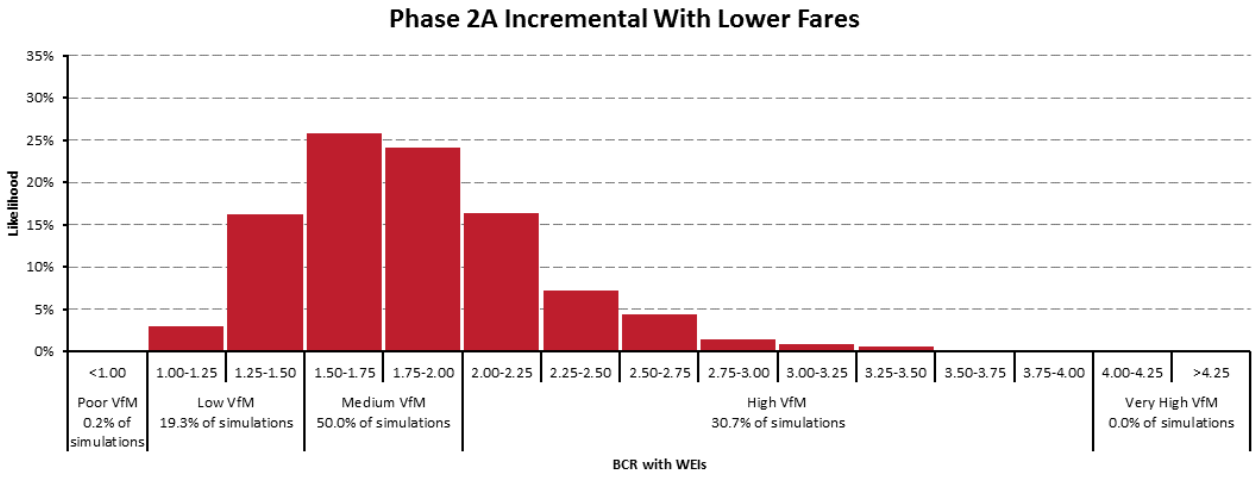


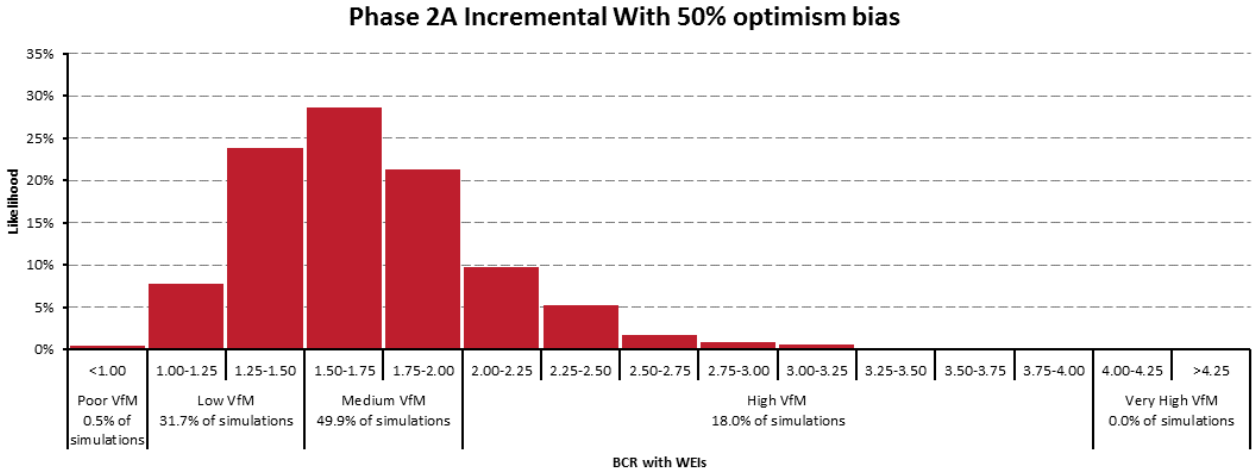
Figure 5: Risk analysis – Phase 2a increment with lower fares



Assessing the impact of higher construction costs (50% optimism bias)

7.4.12 To test the impact on the value for money of higher Phase Two construction costs, we assess the impact on the BCR of increasing Phase 2a optimism bias to 50%, i.e. an increase of 10 percentage points from our core assumption, which follows HM Treasury guidance. An assumption of 50% optimism bias was applied, in addition to higher construction inflation for the years 2017/18 to 2021/22, giving a total contingency for Phase Two of about 58%. With this assumption, 18% of modelled scenarios are within the high, or very high, value for money categories, and around two-thirds of modelled scenarios are within the medium, or higher, value for money categories (see Figure 6).

Figure 6: Risk analysis – Phase 2a increment with 50% optimism bias



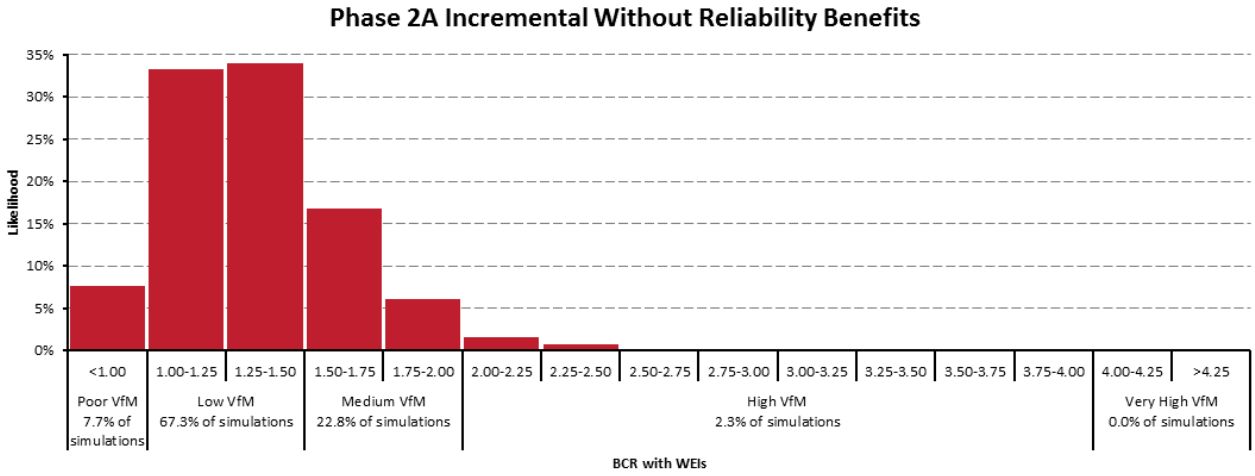
Assessing the impact of removing the assumption that the HS2 scheme will deliver improved reliability benefits.

7.4.13 A key benefit of HS2 concerns the opportunity for improved reliability in the service, which feeds through to reduced journey times for HS2 passengers, and is included within the monetised benefits for HS2. While we capture the higher reliability of high-speed services on the HS2 network in the Economic Case, our modelling does not reflect the reductions in delays that could be achieved by relieving the pressure on the rest of network.

7.4.14 Reliability benefits are subject to some uncertainty as we seek to estimate the potential improvements that an operational high-speed railway will bring. To reflect the potential impact of this uncertainty on the value for money of the scheme, we tested the impact of removing any reliability benefits from our estimated benefits for the HS2 scheme. This is an extreme test, in that it assumes the HS2 network, despite being built for purpose, is no more reliable than the existing conventional network.

7.4.15 As expected, removal of all the benefits associated with reliability reduces the value for money of the Phase 2a increment. Figure 7 shows that for the Phase 2a increment the majority of modelled scenarios are in the low value for money category, in the extreme case that all reliability benefits are removed.

Figure 7: Risk analysis – Phase 2a increment without reliability benefits



7.5 Conclusions

7.5.1 This chapter assessed the value for money of the Phase 2a increment as a stand-alone investment – that is assessing the costs and benefits of Phase 2a, as an additional investment on Phase One and assuming Phase 2b *is not built*. We continue to assess the costs and benefits applying the DfT's WebTAG guidance; using this approach, the Phase 2a increment generates a BCR with a point estimate of 1.9, including WEIs.

7.5.2 Risk analysis shows that the case for the Phase 2a increment is robust to a variety of potential changes to both scheme and cost assumptions. The majority of the

sensitivities tested – including variations in construction costs, fares and GDP – provide over a two-thirds chance of the scheme providing medium, or higher, value for money.

8 Case for Phase 2b

8.1 The scope of this assessment

8.1.1 Here we present the Economic Case for the Phase 2b increment. Phase 2b refers to the northern part of the network, notably the route from Crewe to Manchester to complete the western leg, and the eastern leg from Birmingham to Leeds. We also capture wider benefits as HS2 trains run beyond the Phase 2b track to serve places such as Liverpool, Preston, Newcastle, York and Scotland.

8.1.2 This chapter assesses the value for money of the Phase 2b increment as an investment decision in its own right. We have assessed the costs and benefits of Phase 2b as an additional phase following the construction of Phase One and Phase 2a.

8.2 What has changed since the last Phase 2b Economic Case?

Updates to our appraisal data and frameworks

8.2.1 In November 2016, HS2 Ltd published an initial assessment of the Phase 2b increment[21]. A number of changes have since been adopted. These are summarised earlier in Chapters 5 and 6.

8.2.2 As set out in Section 6.3, we have adopted DfT's WebTAG guidance on forecasting benefits and revenues for the Phase 2b increment reference case. This means that the reference case:

- Has a final forecast year of 2037; and
- Includes benefits and revenues that have been extrapolated in line with population growth from 2037 to the end of the appraisal period in 2093.

8.2.3 As set out earlier in Chapter 6, in line with DfT guidance we have adopted the updated November 2016 forecast of GDP, by the OBR. This had the effect of lowering forecast passenger demand. We have also included observed growth in rail demand between the model base year (2015) and the present year, as recorded by the ORR.

Phase 2b Preferred Route Decision

8.2.4 Following the publication of the Phase 2b Strategic Outline Business Case, the DfT launched a consultation on seven proposed changes to the Phase 2b route. The DfT has published a Phase 2b Route Decision setting out the Secretary of State's decision on the areas covered by the consultation[22].

[21] HS2 Phase 2b Crewe to Manchester & West Midlands to Leeds: Economic Case, November 2016, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

[22] High Speed Two Phase 2b, West Midlands to Crewe – West Midlands to Leeds and Beyond, Phase 2b Route Decision, July 2017, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

8.2.5 A key change for the purposes of appraising the costs and benefits of the HS2 scheme is the eastern leg route between Derbyshire and West Yorkshire (the M18/Eastern Route). In our previous appraisal of the Phase 2b route,[23] we assessed the impact on the costs and benefits of the HS2 scheme of adopting the M18/Eastern Route.

8.2.6 The TSS modelled in this Economic Case adopts the decisions set out in the Route Decision on the M18/Eastern Route – namely that HS2 will:

- Build a 9.4km southern spur at Stonebroom off the HS2 mainline, enabling HS2 trains to run into Sheffield city centre along the existing rail network;
- Move the main north-south route alignment to follow a more easterly alignment between Derbyshire and East Yorkshire; and
- Create a connection back onto the HS2 mainline north of Sheffield through a northern junction at Clayton.

8.2.7 The M18/Eastern Route also introduces a change to the TSS originally modelled for the Meadowhall Route. The M18/Eastern Route utilises an additional train path to deliver the TSS set out in Appendix 1b. Two Birmingham to Leeds services are also modelled as being re-routed from the M18/Eastern Route to travel via Sheffield Midland using the southern spur and northern junction described above.

8.2.8 In order to operate services between Sheffield Midland and Leeds, via a northern junction, improvements will be needed to the existing rail line including: electrification of the MML south of Sheffield to the southern spur; and the electrification of the railway north of Sheffield to the northern junction.

8.2.9 The benefits of the electrification of the MML on conventional journey times have been incorporated into the 'without HS2' baseline (also referred to as the 'do minimum') for the purposes of our appraisal of the HS2 scheme. This assumes the electrification of the MML between Clay Cross and Sheffield Midland is completed before 2033; and that electrification of the existing railway from Sheffield to Clayton (and any signalling renewal at Sheffield) is taken forward as part of TFN's work and future Network Rail investment plans.

8.3 Phase 2b increment – Reference case results

8.3.1 Table 5 summarises the costs and benefits for the Phase 2b increment applying DfT's WebTAG guidance:

- *Our reference case with benefits grown in line with the population beyond 2037:* generates a BCR with a point estimate of 2.6 including WebTAG compliant WEIs;
- *Rail demand capped at 2037:* still generates a BCR with a point estimate of 2.3 including WebTAG compliant WEIs. We regard the capping of rail

[23] HS2 Phase 2b Crewe to Manchester & West Midlands to Leeds: Economic Case, November 2016, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

demand just four years after the full network opens as highly conservative as we would expect demand for rail services to continue to grow beyond the first four years of HS2 operation; and

- Both estimates are within the DfT's 'high' value for money category.

Table 5: Phase 2b increment Benefit Cost Ratio - £bn, 2015 prices, Present Value (PV)

		Phase 2b increment Reference Case	Phase 2b increment Demand Cap Case
	BCR Components	**Benefits extrapolated to 2093 Present Value (PV) £ billion, 2015 prices**	**Benefits capped in 2037 Present Value (PV) £ billion, 2015 prices**
1	Net Transport Benefits excluding WEIs	39.0	35.8
2	Net Benefits including WEIs	48.9	45.5
3	Total Costs	42.1	42.1
4	Revenue	23.5	22.0
5	Net Costs to Government = (3) – (4)	18.6	20.1
6	**BCR without WEIs = (1)/(5)**	**2.1**	**1.8**
7	**BCR with WEIs = (2)/(5)**	**2.6**	**2.3**

8.4 Phase 2b increment– Robustness of the Case

Overview

8.4.1 The appraisal of HS2 draws on a number of data sources and appraisal assumptions that seek to forecast the costs and benefits of the scheme over a 60-year timeframe. These assumptions are in line with DfT's WebTAG guidance. In the case of the Phase 2b increment, this reflects 60 years from the opening of Phase 2b in 2033. A number of these variables are subject to some uncertainty (e.g. the rate of GDP growth, the level of demand, fares, costs, and optimism bias assumptions).

8.4.2 This section examines the impact changes to these key variables could have on the Phase 2b increment BCR and therefore the value for money of the scheme, using the risk analysis model explained in Chapter 5.

Risk analysis results

8.4.3 Table 6 summarises the risk analysis sensitivities we have undertaken, mapping the relative probability of different levels of BCR against the DfT's value for money categories. It shows that the case for the Phase 2b increment is robust to a variety of potential changes to both scheme and cost assumptions:

- All of sensitivities tested provide around a 75% (or higher) chance of the Phase 2b increment providing medium, or higher, value for money;

- Only one of the six sensitivities tested – higher fares – provides a higher than 25% chance of the Phase 2b increment providing low, or poor, value for money; and
- Three out of the six sensitivities tested – higher GDP growth, lower fares and higher construction costs – provide over a 70% chance of the Phase 2b increment providing high, or very high, value for money.

Table 6: Phase 2b increment Benefit Cost Ratio – Risk analysis sensitivities

Phase 2b Inc (2093)	Poor VfM (BCR <1.00)	Low VfM (BCR 1.0 - 1.5)	Medium VfM (BCR 1.5 - 2.0)	High VfM (BCR 2.0 - 4.0)	Very High VfM (BCR > 4.0)
Reference Case	0.2%	4.6%	18.1%	62.6%	14.6%
Higher GDP Growth	0.1%	1.1%	6.8%	50.6%	41.5%
Lower GDP Growth	1.1%	17.7%	30.3%	48.5%	2.5%
Higher Fares	3.0%	23.4%	28.5%	41.6%	3.5%
Lower Fares	0.0%	0.4%	3.8%	53.6%	42.3%
50% OB	0.3%	7.7%	20.3%	60.6%	11.2%
Without Reliability	1.3%	19.7%	29.4%	46.8%	3.0%

Likelihoods based on 2000 simulations

8.4.4 The following sections look at the sensitivities in more detail. The reference case risk analysis is detailed in Appendix 8.

Assessing the impact of higher/lower demand assumptions

8.4.5 Our forecast of the number of passengers expected to travel on HS2 remains a central element of the Economic Case. Our approach to forecasting demand growth remains unchanged from previous economic cases, and follows standard DfT guidance drawing on a range of factors – including the cost of travel, population growth, employment rates and economic growth (as measured by GDP) over time. Projections of these drivers have been updated in line with DfT guidance, with the most significant change following the OBR's November 2016 GDP forecast.

8.4.6 Figure 8 and Figure 9 show the impact on the reference case BCR if we assume that GDP growth rates are 10% higher/lower than the reference case OBR GDP forecast up to the final forecast year (2037), and with passenger demand extrapolated in line with population growth thereafter.

- For the assumption of higher demand 92% of modelled scenarios are within the high, or very high, value for money categories; and
- With the assumption of lower demand, half the modelled scenarios are within the high, or very high, value for money categories.

Figure 8: Risk analysis – Phase 2b increment with 1.1x GDP growth rate

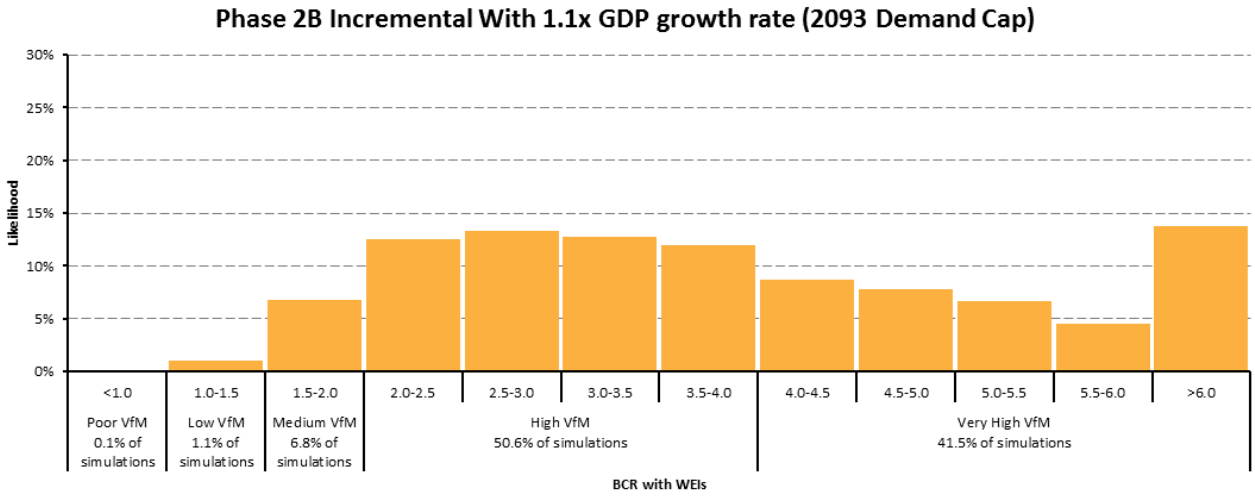
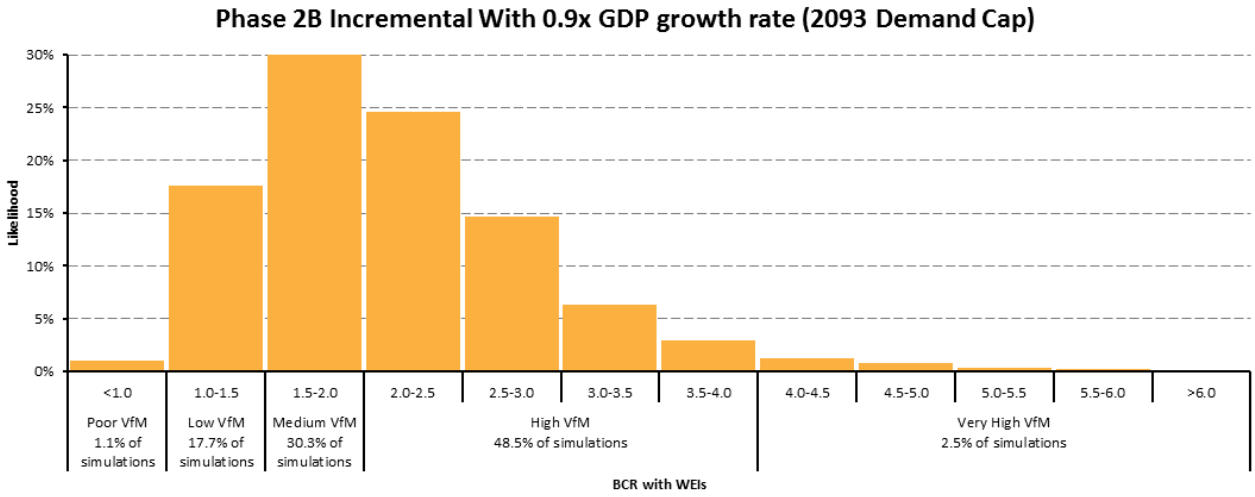


Figure 9: Risk analysis – Phase 2b increment with 0.9x GDP growth rate



Assessing the impact of higher/lower fares policy assumptions

8.4.7 The fares policy assumption is a key component of the BCR for the scheme, as future rail fares policy directly feeds through to our estimates of the likely revenue returned from the scheme. For this Economic Case, we have followed the Government's policy for the existing rail network and assumed that growth in regulated rail fares will be maintained at RPI until 2020. Rail fares are then assumed to increase at RPI+1% beyond 2020 until the final forecast year (2037). This is an assumption that was also included in the November 2016 economic assessment of Phase 2b.

8.4.8 Our approach to modelling rail fares is set out in Chapter 5, which notes that it does not take into account any differential fares or potential competitive responses between HS2 and existing train operating companies. Using that approach, Figure 10

and Figure 11 show the impact on the reference case BCR if we were to assume that fares are higher/lower than the reference case fares assumption.

8.4.9 As noted earlier, increasing fares has two effects on revenue, namely:

- the number of passengers travelling by rail falls as the cost of rail travel is higher; and
- Revenue per passenger (for remaining passengers) increases, as fares are higher.

The effect that dominates will determine whether the BCR increases or decreases.

8.4.10 In Phase 2b, the higher fares scenario reduces the BCR as the effect of the reduction in the number of passengers dominates the higher per passenger revenue. The lower fares scenario conversely increases the BCR. The specific impacts on our modelled scenarios is as follows:

- For the assumption of higher fares (RPI +2% per year after 2020), 45% of modelled scenarios are within the high, or very high, value for money categories;
- With the assumption of lower fares (RPI +0% per year after 2020), 95% of modelled scenarios are within the high, or very high, value for money categories.

Figure 10: Risk analysis – Phase 2b increment with higher fares

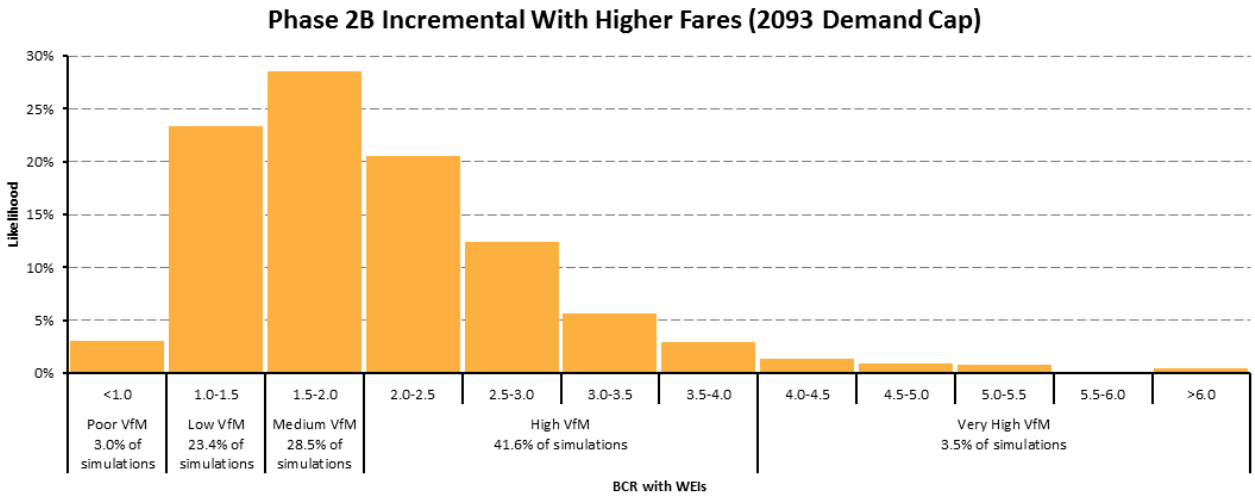
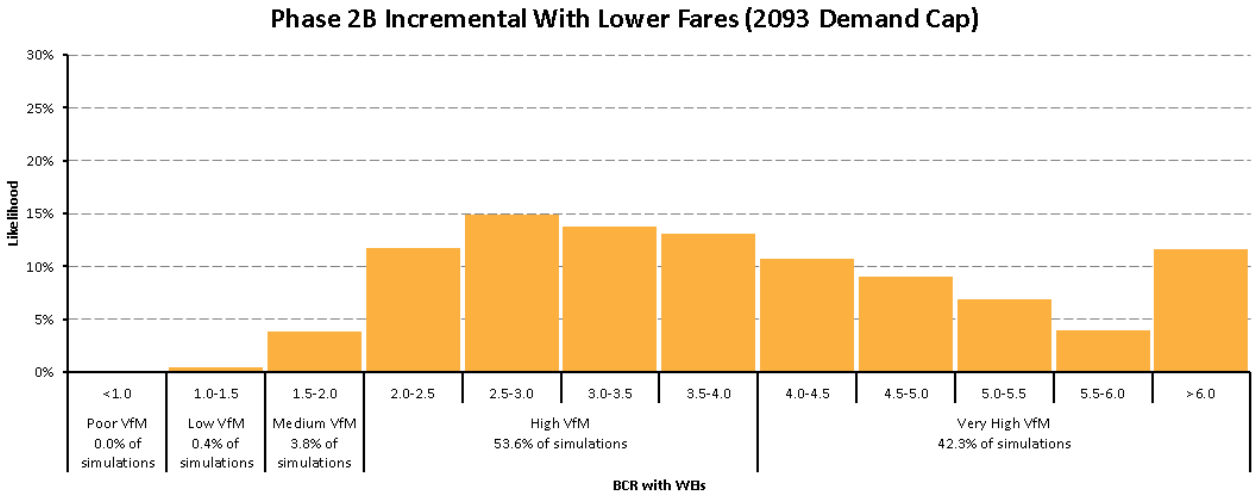


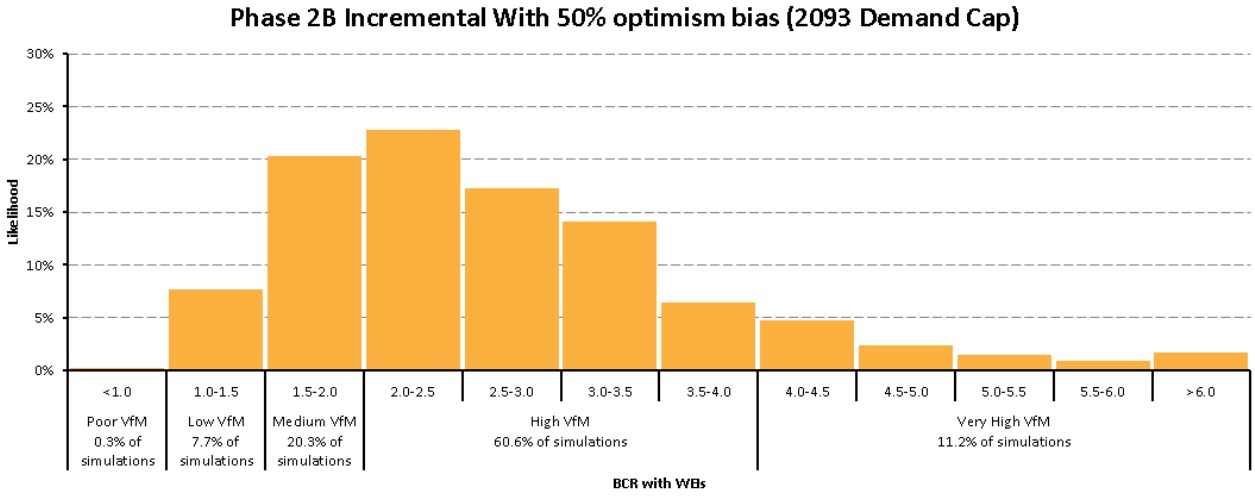
Figure 11: Risk analysis – Phase 2b increment with lower fares



Assessing the impact of higher construction costs (50% optimism bias)

8.4.11 To test the impact on the value for money of higher Phase Two construction costs, we assess the impact on the BCR of increasing Phase 2b optimism bias to 50%, i.e. an increase of 10 percentage points from our core assumption which follows HM Treasury guidance. An assumption of 50% optimism bias was applied, in addition to higher construction inflation for the years 2017/18–2021/22, giving a total contingency for Phase Two of about 58%. With this assumption, 71% of modelled scenarios are within the high, or very high, value for money categories (see Figure 12).

Figure 12: Risk analysis – Phase 2b increment with 50% optimism bias



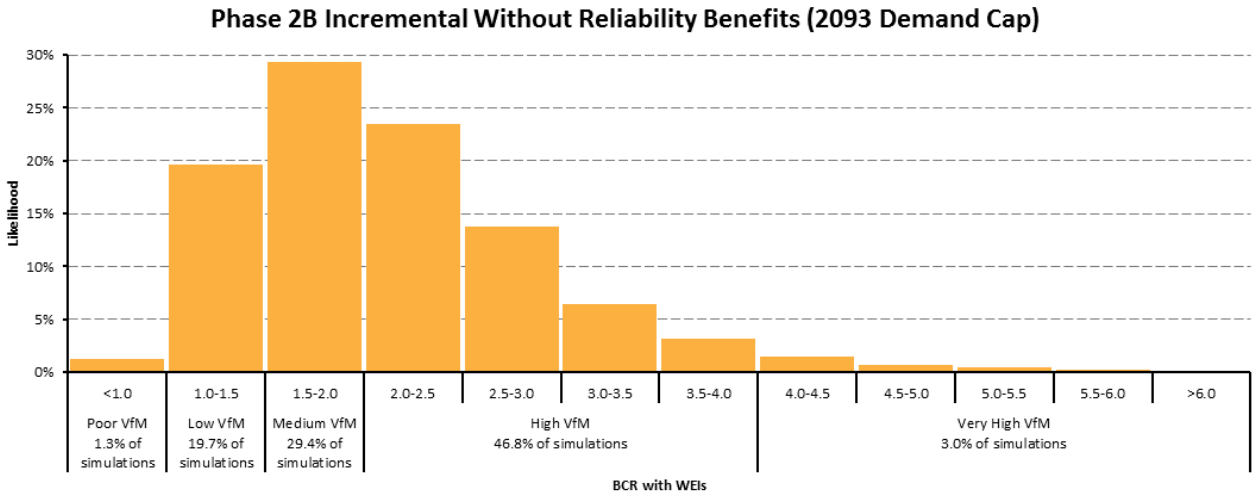
Assessing the impact of removing the assumption that the HS2 scheme will deliver improved reliability benefits.

8.4.12 A key benefit of HS2 concerns the opportunity for improved reliability in the service, which feeds through to reduced journey times for HS2 passengers, and is included within the monetised benefits for HS2. While we capture the higher reliability of high-speed services on the HS2 network in the Economic Case, our modelling does not reflect the reductions in delays that could be achieved by relieving the pressure on the rest of network.

8.4.13 The precise scale of reliability benefits are subject to some uncertainty as we seek to estimate the potential improvements that an operational high-speed railway will bring. To reflect the potential impact of this uncertainty on the value for money of the scheme, we tested the impact of removing any reliability benefits from our estimated benefits for the HS2 scheme. This is an extreme test, in that it assumes the HS2 network, despite being built-for-purpose, is no more reliable than the existing conventional network.

8.4.14 As expected, removal of all the benefits associated with reliability reduces the value for money of the Phase 2b increment. Figure 13 shows that for the Phase 2b increment, 79% of modelled scenarios are in the medium, or higher, value for money categories.

Figure 13: Risk analysis – Phase 2b increment without reliability benefits



8.5 Comparison with alternative eastern leg alignments

8.5.1 The November 2016 Phase 2b Strategic Outline Business Case[24] had, as its reference case, the previous eastern leg alignment that served Sheffield with services via a station at Meadowhall (the 'Meadowhall Route'). That Economic Case also assessed

[24] HS2 Phase 2b Crewe to Manchester and West Midlands to Leeds: Economic Case, November 2016, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

the impact on costs and benefits of an alternative alignment through South Yorkshire (The 'M18 Route').

8.5.2 Following a consultation on changes to the route, including through South Yorkshire, the Government has decided its preferred 2b route, the M18/Eastern Route. This includes an eastern leg that follows the M18 alignment through South Yorkshire. HS2 services - from Sheffield Midland station in the city centre to London, Birmingham and Leeds - are provided via a loop using the existing network.

8.5.3 Appendix 6 details a breakdown of the current Phase 2b increment reference case (this adopts the M18/ Eastern route) and an updated estimate for the Meadowhall Route that is consistent with the estimates made in this Economic Case.

8.5.4 The benefit cost ratios for the Meadowhall and M18 routes have always been very similar, in part because the remainder of the Phase 2b route is the same for both options. On current estimates, both routes generate a BCR of 2.6 including WebTAG complaint WEIs. Key things to note are that:

- The M18/Eastern Route uses an additional train path to deliver the TSS set out in Appendix 1b – using the additional train path to facilitate the provision of two services from London Euston to Sheffield Midland while retaining the original frequency of services to York and Leeds;
- The M18/Eastern Route generates an increase in net benefits (including WEIs) and revenue over the Meadowhall route;
- The M18/Eastern route provides an infrastructure cost saving against the HS2 funding envelope in the region of £1.2bn (including optimism bias);
- The operating costs of the M18/Eastern route are higher than Meadowhall, as a result of serving additional destinations and running additional train services using the additional train path described above; and
- As a result, the net costs to Government - in 2015 prices, present values (PV) and rounded to the nearest £0.1bn - are the same for both routes over the 60-year appraisal period.

8.5.5 The M18/Eastern route estimates are based on the Full Network TSS set out in Appendix 1b. If we were to model a train service that did not use an additional train path, the operating cost estimates would be lower. There would also be an impact on benefits and revenues; the size of this impact would depend on the exact nature of the change in services.

8.6 Conclusions

8.6.1 This chapter assessed the value for money of the Phase 2b increment as a stand-alone investment – that is, assessing the costs and benefits of Phase 2b as an additional investment to Phase One and Phase 2a. We continue to assess the costs and benefits using the DfT's WebTAG guidance; using this approach, the Phase 2b increment generates a BCR with a point estimate of 2.6, including WEIs.

Risk analysis shows that the case for the Phase 2b increment is robust to a variety of potential changes to both scheme and cost assumptions. The majority of the six sensitivities tested – including variations in construction costs, fares and GDP – provide around a 75% (or higher) chance of the scheme providing medium, or higher, value for money.

9 Case for the full HS2 network

9.1 The scope of this assessment

9.1.1 Here we present the case for the full HS2 network that will become operational in 2033. It will combine the incremental elements of Phases One, 2a and 2b to deliver a network that will provide a high-speed rail service between London and major cities in the Midlands and the North of England.

9.1.2 As set out in Section 6.3, we have adopted the latest DfT WebTAG guidance on forecasting benefits and revenues for the full HS2 network reference case. This means that the reference case:

- Has a final forecast year of 2037, i.e. 20 years after the appraisal year; and
- Includes benefits and revenues that have been extrapolated in line with population growth from 2037 to the end of the appraisal period in 2093.

9.2 What has changed since the last Phase 2b Economic Case?

9.2.1 HS2 Ltd published an assessment of the full HS2 network in 2016[25]. Since then a number of changes have been adopted relating to the line of route around Sheffield and the associated train service specification. These were summarised earlier in Chapters 5 to 8.

9.2.2 There have also been several noteworthy methodological developments that affect the assessment of the full HS2 network, as set out in Chapter 6, which include the following:

a) In line with DfT guidance, we have adopted the OBR's updated November 2016 forecast of GDP and observed growth in rail demand between the model base year (2015) and the present year, as recorded by the ORR;

b) We have undertaken the assessment of the full HS2 network by extrapolating benefits in line with population after the final forecast year (2037) and up to the end of the appraisal period (2093); and

c) We have included higher project specific inflation within the reference case from 2017/18 to 2021/22.

9.3 Full HS2 network – reference case results

9.3.1 Table 7 summarises the costs and benefits for the full HS2 network applying DfT's WebTAG guidance:

[25] HS2 Phase 2b Crewe to Manchester & West Midlands to Leeds: Economic Case, November 2016, available on gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

- *Our reference case with benefits grown in line with the population from 2037:* generates a BCR with a point estimate of 2.3, including WebTAG compliant WEIs;
- *Rail demand capped at 2037:* generates a BCR with a point estimate of 2.0, including WebTAG compliant WEIs. We regard the capping of rail demand just four years after the full network opens as highly conservative as we expect rail demand to continue to grow beyond the first four years of HS2 operation; and
- Both estimates are within the DfT's 'high' value for money category.

Table 7: Full HS2 Network Benefit Cost Ratio - £bn, 2015 prices, Present Value (PV)

		Full HS2 Network Reference Case	**Full HS2 Network Demand Cap Case**
	BCR Components	**Benefits extrapolated to 2093 Present Value (PV) £ billion, 2015 prices**	**Benefits capped in 2037 Present Value (PV) £ billion, 2015 prices**
1	Net Transport Benefits without WEIs	74.6	68.8
2	Net Benefits with WEIs	92.2	86.0
3	Total Costs	83.4	83.4
4	Revenue	43.6	41.0
5	Net Costs to Government = (3) – (4)	39.8	42.4
6	**BCR without WEIs = (1)/(5)**	**1.9**	**1.6**
7	**BCR with WEIs = (2)/(5)**	**2.3**	**2.0**

9.4 Full HS2 network – robustness of the case

Overview

9.4.1 The appraisal of HS2 draws on a number of data sources and appraisal assumptions that seek to forecast the costs and benefits of the scheme over a 60-year timeframe. These assumptions are in line with DfT's WebTAG guidance. In the case of the full HS2 network, this represents 60 years from the opening of the final phase in 2033. A number of these variables are subject to some uncertainty (e.g. the rate of growth of demand, the level of demand, fares, costs and optimism bias assumptions). This section examines the impact that changes to these key variables could have on the full HS2 network BCR, and therefore the value for money of the scheme. The analysis is conducted using the risk analysis model explained in Chapter 5.

Risk analysis results

9.4.2 Table 8 summarises the risk analysis sensitivities we have undertaken, mapping the relative probability of different levels of BCR against the DFT's value for money categories. This analysis shows that the case for the full HS2 network is robust to a variety of potential changes to both scheme and cost assumptions:

- All six of the sensitivities tested provide a 70%, or higher, chance of the scheme providing medium, or higher, value for money;
- Three of the six sensitivities tested – lower fares, higher optimism bias and high GDP growth - provide over a 60% chance of the scheme providing high, or very high, value for money.

Table 8: The Full HS2 Network Benefit Cost Ratio – Risk analysis sensitivities

Full Network (2093)	Poor VfM (BCR <1.00)	Low VfM (BCR 1.0 - 1.5)	Medium VfM (BCR 1.5 - 2.0)	High VfM (BCR 2.0 - 4.0)	Very High VfM (BCR > 4.0)
Reference Case	0.3%	8.3%	23.9%	61.4%	6.3%
Higher GDP Growth	0.1%	2.1%	11.5%	61.8%	24.6%
Lower GDP Growth	1.3%	24.7%	36.2%	37.1%	0.7%
Higher Fares	2.9%	27.0%	32.5%	36.1%	1.6%
Lower Fares	0.1%	1.1%	9.8%	68.7%	20.5%
50% OB	0.3%	10.1%	26.4%	58.2%	5.1%
Without Reliability	2.0%	26.1%	34.1%	36.8%	1.0%

Likelihoods based on 2000 simulations

9.4.3 The following sections look at the sensitivities in more detail. The reference case risk analysis is detailed in Appendix 8.

Assessing the impact of higher/lower demand assumptions

9.4.4 Our forecast of the number of passengers expected to travel on HS2 remains a central element of the Economic Case. Our approach to forecasting rail demand growth remains unchanged from previous economic cases, and follows standard DfT guidance drawing on a range of factors – including the cost of travel, population growth, employment rates and economic growth (as measured by GDP) over time. Projections of these drivers have been updated in line with DfT guidance - with the most significant change following the OBR's reduced November 2016 GDP forecast.

9.4.5 Figure 14 and Figure 15 show the impact on the reference case BCR if we assume that GDP growth rates are 10% higher/lower than the reference case GDP forecast up to the final forecast year (2037) with passenger demand extrapolated in line with population growth thereafter.

- For the assumption of higher demand 86% of modelled scenarios are within the high, or very high, value for money categories;

- With the assumption of lower demand 74% of modelled scenarios are within the medium, or higher, value for money categories.

Figure 14: Risk analysis – Full HS2 Network with 1.1x GDP growth rate

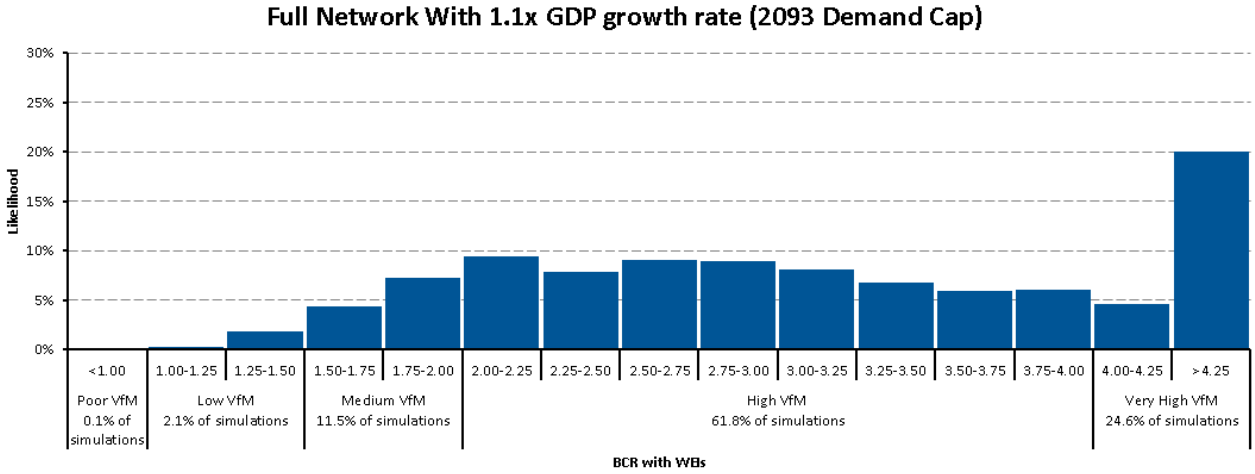
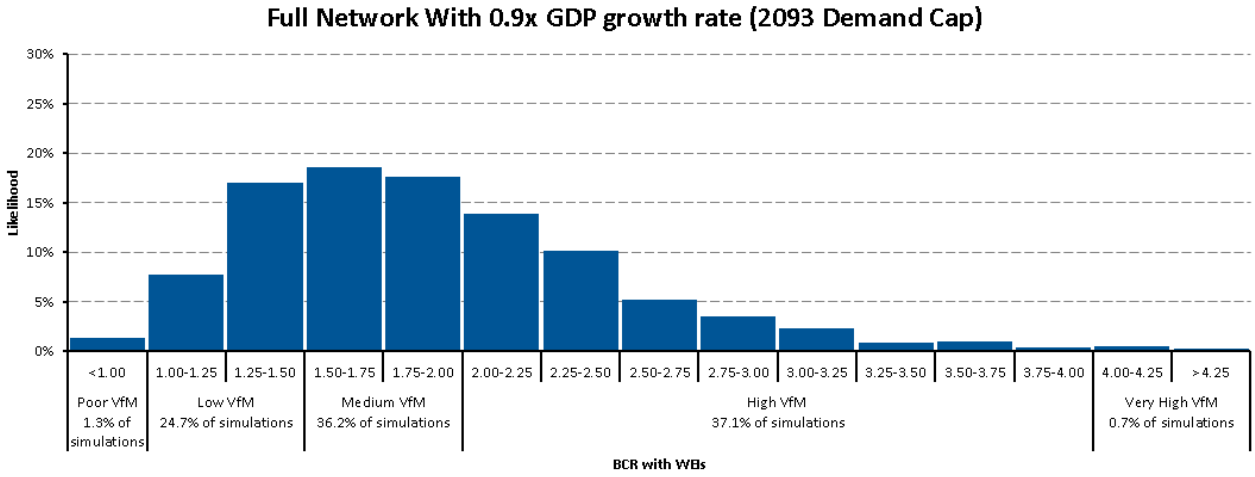


Figure 15: Risk analysis – Full HS2 Network with 0.9x GDP growth rate



Assessing the impact of higher/lower fares policy assumptions

9.4.6 The fares policy assumption is a key component of the BCR for the scheme as future rail fares policy directly feeds through to our estimates of the likely revenue returned from the scheme. For this Economic Case, we have followed the Government's policy for the existing rail network and assumed that growth in regulated rail fares will be maintained at RPI until 2020. Rail fares are then assumed to increase at RPI+1% beyond 2020 until the final forecast year (2037).

9.4.7 Our approach to modelling rail fares is set out in Chapter 5, which notes that it does not take into account any differential fares or potential competitive responses between HS2 and existing train operating companies. Using that approach, Figure 16 and Figure 17 show the impact on the reference case BCR if we were to assume that fares are higher/lower than the reference case fares assumption.

9.4.8 As noted earlier, increasing fares has two effects on revenue, namely:

- the number of passengers travelling by rail falls as the cost of rail travel is higher; and
- Revenue per passenger (for remaining passengers) increases, as fares are higher.

The effect that dominates will determine whether the BCR increases or decreases.

9.4.9 In the full network, the higher fares scenario reduces the BCR as the effect of the reduction in the number of passengers dominates the higher per passenger revenue. The lower fares scenario conversely increases the BCR.

9.4.10 The specific impacts on our modelled scenarios is as follows:

- For the assumption of higher fares (RPI +2% per year after 2020) 70% of modelled scenarios are within the medium, or higher, value for money categories;
- With the assumption of lower fares (RPI +0% per year after 2020) 89% of modelled scenarios are within the high or very high value for money categories.

Figure 16: Risk analysis – Full HS2 network with higher fares

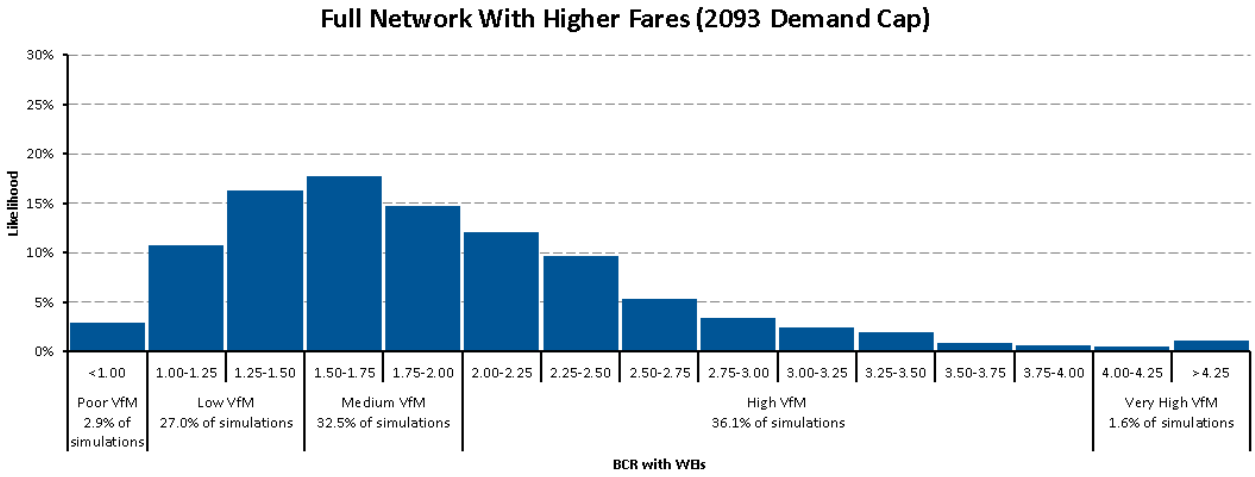
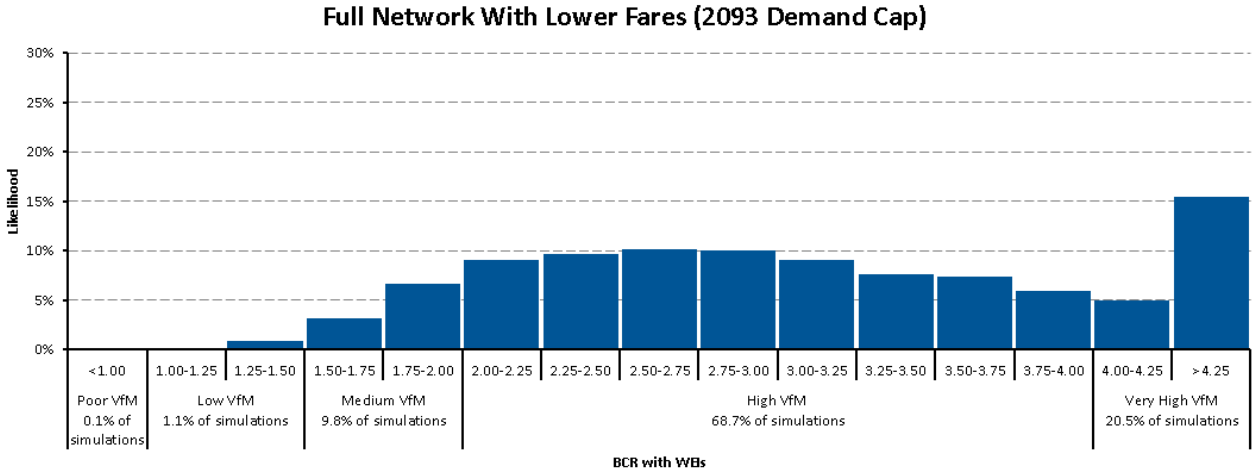


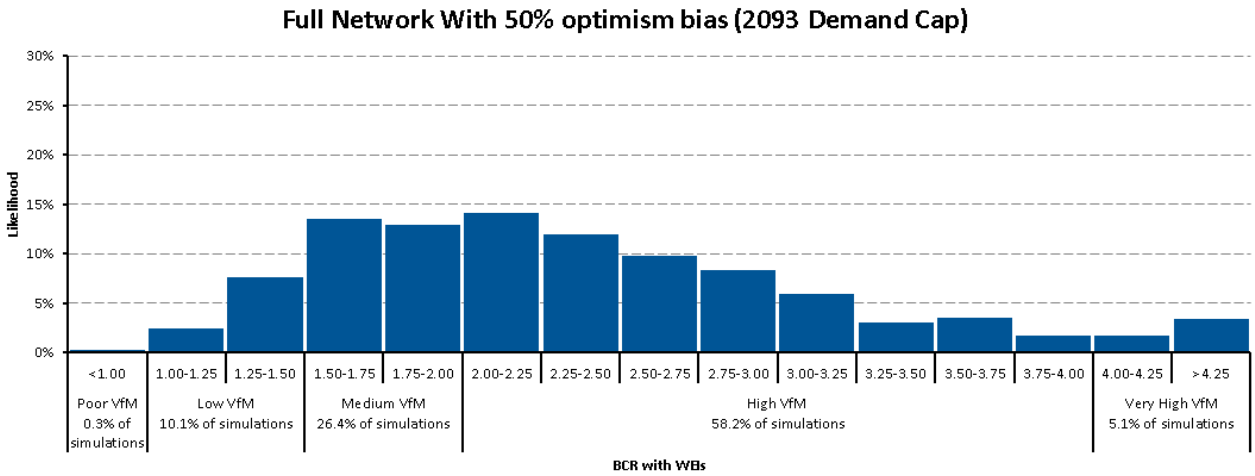
Figure 17: Risk analysis – Full HS2 network with lower fares



Assessing the impact of higher construction costs (50% optimism bias)

9.4.11 To test the impact on the value for money of higher Phase Two construction costs, we assess the impact on the BCR of increasing Phase 2b optimism bias to 50%, i.e. an increase of 10 percentage points from our core assumption, which follows HM Treasury guidance. An assumption of 50% optimism bias was applied, in addition to higher construction inflation for the years 2017/18–2021/22, giving a total contingency for Phase Two of about 58%. With this assumption, 63% of modelled scenarios are within the high, or very high, value for money categories (see Figure 18).

Figure 18: Risk analysis – Full HS2 Network with 50% optimism bias



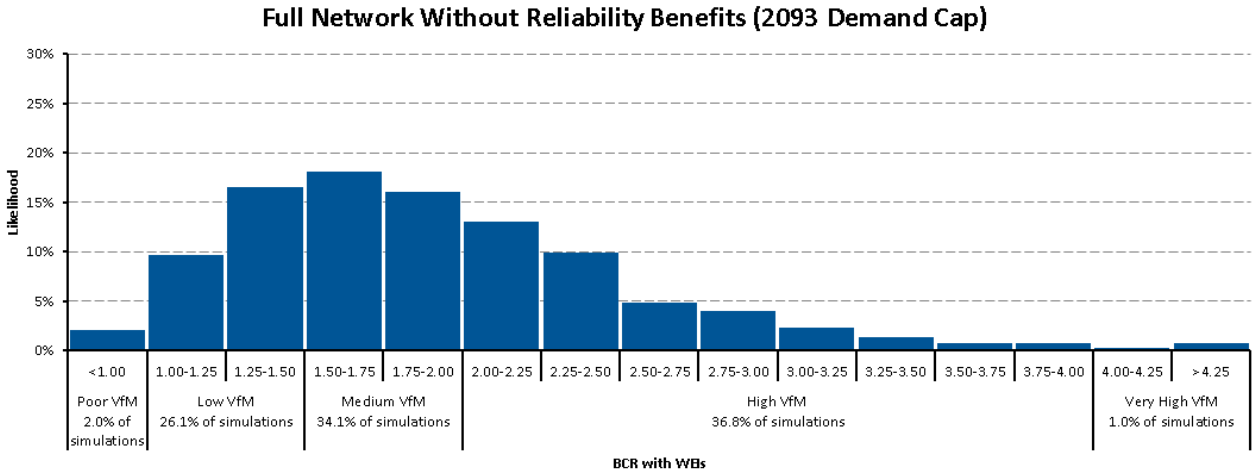
Assessing the impact of removing the assumption that the HS2 scheme will deliver improved reliability benefits.

9.4.12 A key benefit of HS2 concerns the opportunity for improved reliability in the service, which feeds through to reduced journey times for HS2 passengers, and is included within the monetised benefits for HS2. While we capture the higher reliability of high-speed services on the HS2 network in the Economic Case, our modelling does not reflect the reductions in delays that could be achieved by relieving the pressure on the rest of network.

9.4.13 Reliability benefits are subject to some uncertainty as we seek to estimate the potential improvements that an operational high-speed railway will bring. To reflect the potential impact of this uncertainty on the value for money of the scheme, we tested the impact of removing any reliability benefits from our estimated benefits for the HS2 scheme. This is an extreme test, in that it assumes the HS2 network, despite being built for purpose, is no more reliable than the existing conventional network.

9.4.14 As expected, removal of all the benefits associated with reliability reduces the value for money of the full HS2 network. Figure 19 shows that, for the full HS2 network, 71% of modelled scenarios are within the medium, or higher, value for money categories, whereas 37% of modelled scenarios are in the high, or very high, value for money categories.

Figure 19: Risk analysis – Full HS2 Network without reliability benefits



9.5 Conclusions

9.5.1 This chapter assesses the value for money of the full HS2 network. We continue to assess the costs and benefits applying the DfT's WebTAG guidance; using this approach, the full HS2 network generates a BCR with a point estimate of 2.3, including WebTAG compliant WEIs.

9.5.2 Risk analysis shows that the case for the full HS2 network is robust to a variety of potential changes to both scheme and cost assumptions. All six sensitivities tested – covering variations in construction costs, fares, GDP and network reliability – provide a 70% (or higher) chance of the scheme providing medium, or higher, value for money.

10 Crewe Hub – Potential future service options

10.1 Introduction

10.1.1 Earlier chapters have focussed on the core proposals for the HS2 scheme that are based on a set of assumptions as to the TSS that HS2 may operate. This TSS is set out in Appendix 1a and Appendix 1b.

10.1.2 The DfT has launched a public consultation on Crewe Hub, seeking views to inform the ongoing development of potential options to support a Crewe Hub and the business cases that would be required to take this forward[26]. These options around Crewe would result in amendments to the HS2 TSS set out in Appendix 1a and 1b.

10.1.3 There may be other ways in which HS2 services can be used to provide services that deliver benefits to the HS2 scheme. This chapter does not provide an exhaustive analysis of how the HS2 TSS could evolve to deliver additional benefits to the HS2 scheme. For the purposes of the current consultation, the two core options being considered are:

- Providing 400m platforms at Crewe station, to enable 400m HS2 services to make a station call at Crewe, and then split into two 200m trainsets to serve onward destinations; and
- Providing a junction north of Crewe station to connect the WCML and the high-speed line, in 2033 as part of Phase 2b. This will enable additional high-speed services to stop at Crewe station.

10.1.4 The DfT commissioned HS2 Ltd to examine the benefits of these options using the modelling and appraisal framework that is consistent with the rest of the Economic Case to assess their value-for-money potential. This chapter sets out the estimated benefits of these Crewe Hub options, based on a set of assumptions around the train services that would operate in and around Crewe and how these differ from the core HS2 scheme.

10.1.5 It should be noted that these options for a Crewe Hub station are in addition to the core HS2 scheme, and not part of the current HS2 funding envelope, although the cost of the works in and around Crewe to enable to current train service to operate is included in the Phase 2a hybrid Bill estimate of expense. The total cost of a Crewe Hub has not yet been estimated, and any future decisions on whether to take forward options for a hub will be subject to affordability and value for money.

10.1.6 For a number of these options, we also do not have sufficient information to include an estimate of the full infrastructure costs needed for construction. We have therefore focussed on assessing the potential benefits and revenues.

[26] Crewe Hub Consultation, available on gov.uk: https://www.gov.uk/government/organisations/department-for-transport

10.1.7 The results in Appendix 7 show the estimated economic appraisal results of the Crewe Hub service options. We have shown two sets of results: one for which these 400m services start in 2027, and another set of results for which they to start in 2033. The option for a junction north of Crewe relies on Phase 2b infrastructure; as a result, this service pattern could only begin from 2033.

10.2 Background to rail hub options at Crewe

10.2.1 Crewe station is a key transport hub in the north-west of England, enabling interchange between services to: London, Manchester and Scotland; Chester and Liverpool; Stoke-on-Trent, Stafford and Derby; South Wales; and Shrewsbury and North Wales. Phase 2a of the core HS2 proposal will extend the high-speed line from the West Midlands to Crewe in 2027, bringing benefits to the North West six years earlier than first planned.

10.2.2 Crewe's existing links, and its place on the proposed HS2 network, led Sir David Higgins to recommend that a North West hub station should be considered at Crewe in his reports HS2 Plus (March 2014)[27] and Rebalancing Britain (October 2014)[28].

10.2.3 Following these recommendations, the Government asked Network Rail and HS2 Ltd to undertake technical work to look at how the existing station at Crewe might be enhanced. Several options were explored, including how HS2 services could be extended to Stoke-on-Trent, and what interventions at Crewe would allow such a service to operate without needing an additional train path on the HS2 Phase One London to Birmingham line. These findings were summarised in the November 2016 HS2 Command paper[29].

10.2.4 A consultation on Crewe Hub has now begun, and HS2 Ltd has undertaken an indicative economic assessment of three different options for a Crewe Hub. It should be noted that these options are not exhaustive of all the possibilities around a Crewe Hub, and their purpose is to provide initial value-for-money advice. As the options around Crewe Hub evolve, it is anticipated that the modelling will be refined to reflect further decisions.

10.2.5 In carrying out this analysis, HS2 Ltd has made assumptions on operational requirements and journey times to model the amended train service specification. As infrastructure costs are also not yet fully defined, the following analysis focuses on the estimated transport benefits and revenue of the Crewe Hub options. It is noted against the following options where there are expected to be significant infrastructure cost requirements.

[27] HS2 Plus: A report by David Higgins, available at gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited
[28] Rebalancing Britain: From HS2 towards a national transport strategy, available at gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited
[29] High Speed Two: From Crewe to Manchester, the West Midlands to Leeds and beyond, November 2016, available at gov.uk: https://www.gov.uk/government/organisations/high-speed-two-limited

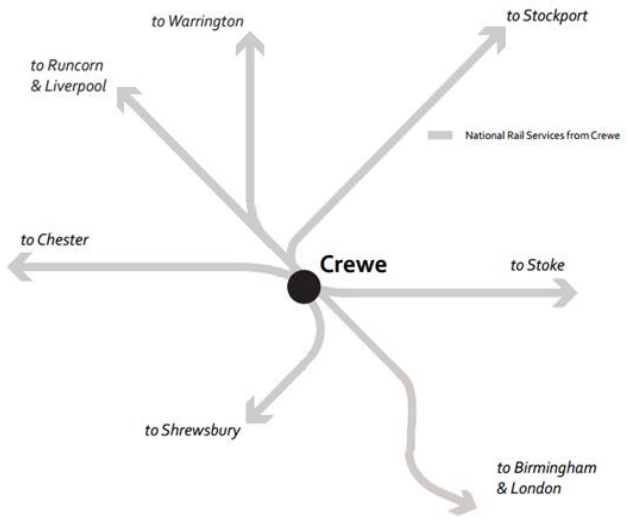
10.3 Infrastructure options at Crewe

10.3.1 The Crewe Hub scenarios we have modelled are based on two core options at Crewe:

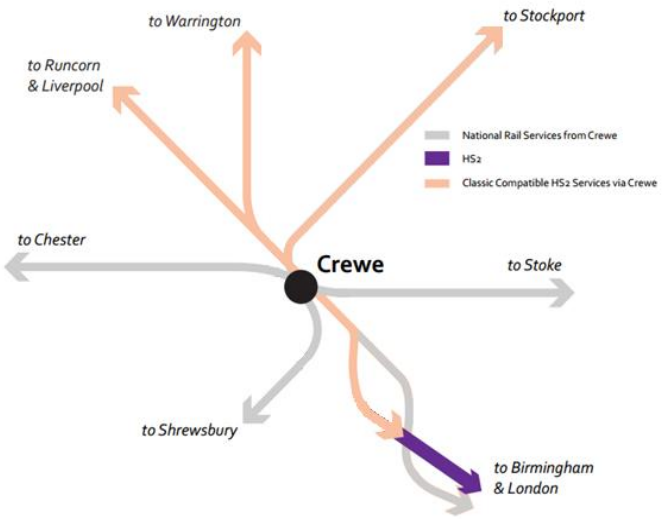
- Extending platforms at Crewe – creating 400m platforms at Crewe for HS2 services provides the opportunity to divide trains travelling from and to London at Crewe. For example, a full 400m service could travel to Crewe from London, then divide into two 200m services where one serves Preston, and the other serves Liverpool. This frees up a path on the Phase One route that could be used to serve Stoke-on-Trent with a high-speed service; and
- Building a HS2 junction north of Crewe – a junction between the WCML north of Crewe and the high-speed line could enable additional high-speed services to stop at Crewe before continuing on to Manchester and other destinations further north. We have looked at the case for stopping the planned two high-speed services each hour between Birmingham and Manchester, as well as the service from Birmingham to Scotland (which is assumed to alternate between Edinburgh and Glasgow in different hours, and also calls at Preston).

10.3.2 The network diagrams in Figure 20 demonstrate changes in the train services and infrastructure at Crewe station as a result of the HS2 scheme, and the consultation option of an HS2 junction north of Crewe.

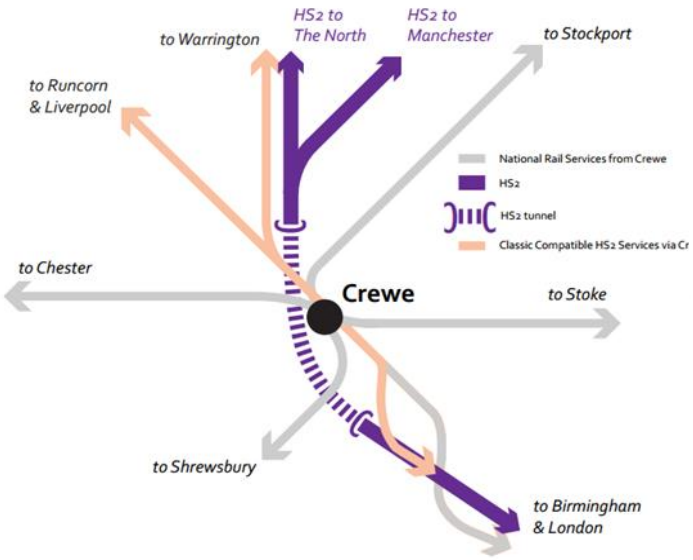
Figure 20: Crewe network – Current structure and its evolution within the HS2 scheme/potential Northern Junction option



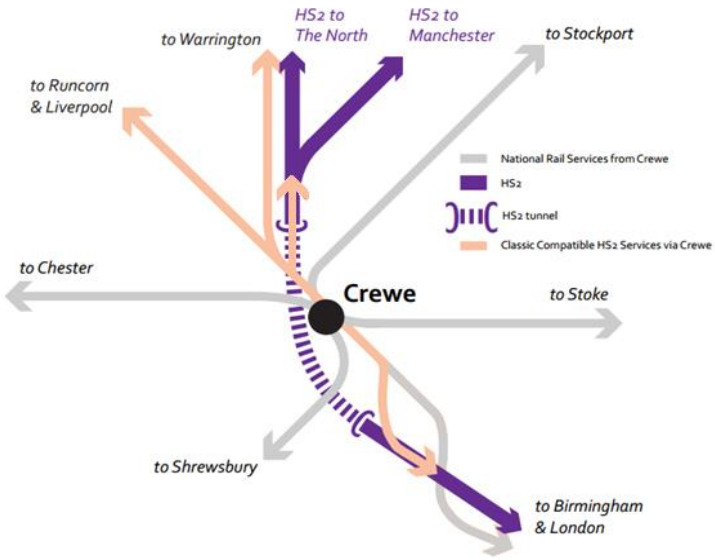
Crewe Network – Current



Crewe Network – HS2 Phase 2a



Crewe Network – HS2 Phase 2b



Crewe Network – HS2 Phase 2b with Northern Junction

10.3.3 The northern junction would enable high-speed services to make a calling point at Crewe and continue on the high-speed line. This would allow more high-speed services to stop at Crewe, increasing the number of potential interchanges at this station.

10.3.4 Using these options, we have modelled the following three scenarios to demonstrate the potential value for money of developing a 'Crewe Hub:'

- **Scenario 1** – Crewe Hub route upgrading capacity with one additional 200m unit travelling to Crewe each hour and adding Stoke-on-Trent as an additional destination;
- **Scenario 2** – Crewe Hub route upgrading capacity with two additional 200m units travelling to Crewe each hour and adding Stoke-on-Trent as an additional destination; and
- **Scenario 3** – Crewe Hub providing a new Northern Junction – which is in addition to scenario 2.

10.3.5 Figure 21 shows the scheme service pattern for scenarios 1 and 2 compared to our reference case TSS. Figure 22 shows the scheme service pattern for scenario 3 compared to our reference case TSS.

Figure 21: Crewe network – Potential scheme service patterns for Crewe Hub scenarios 1 and 2

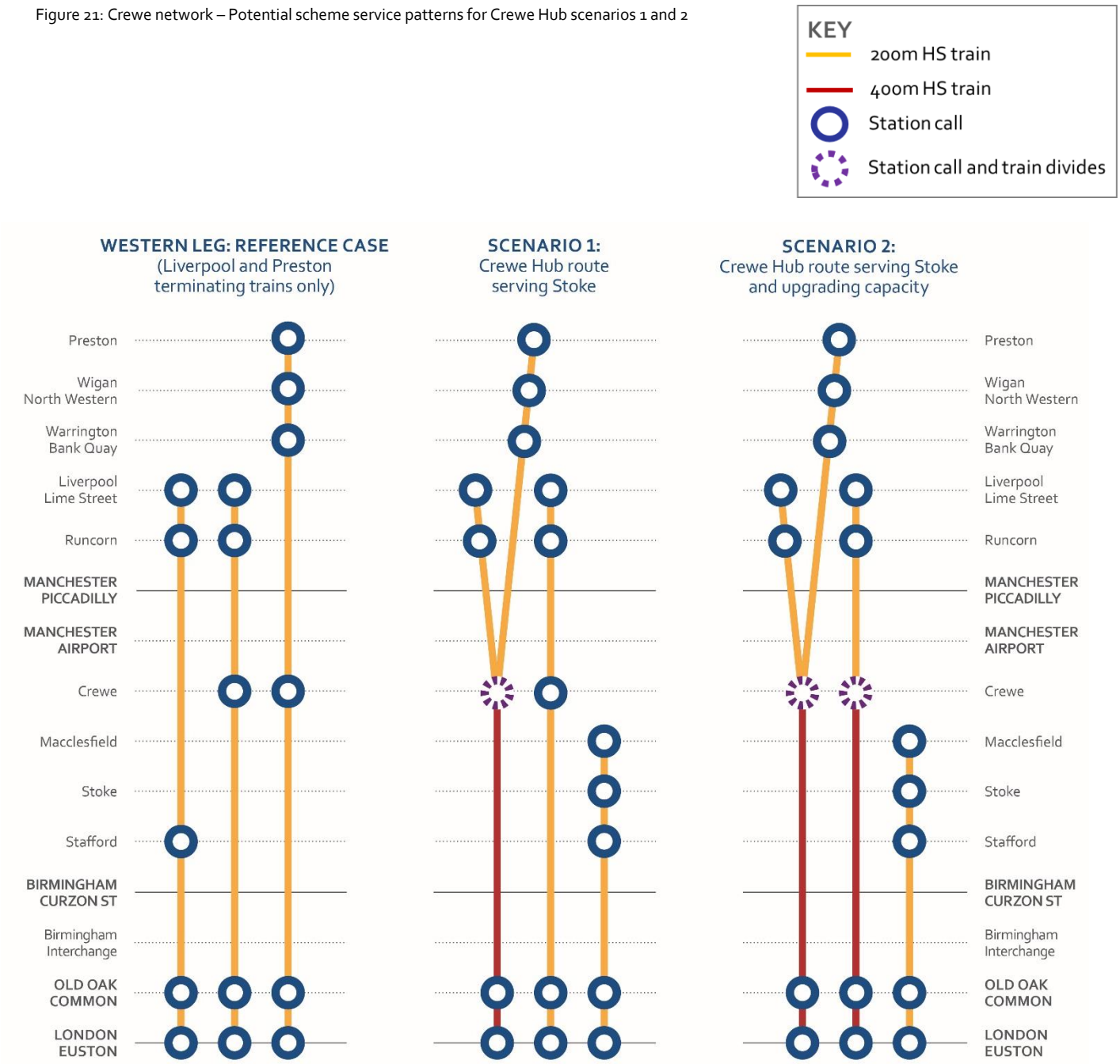
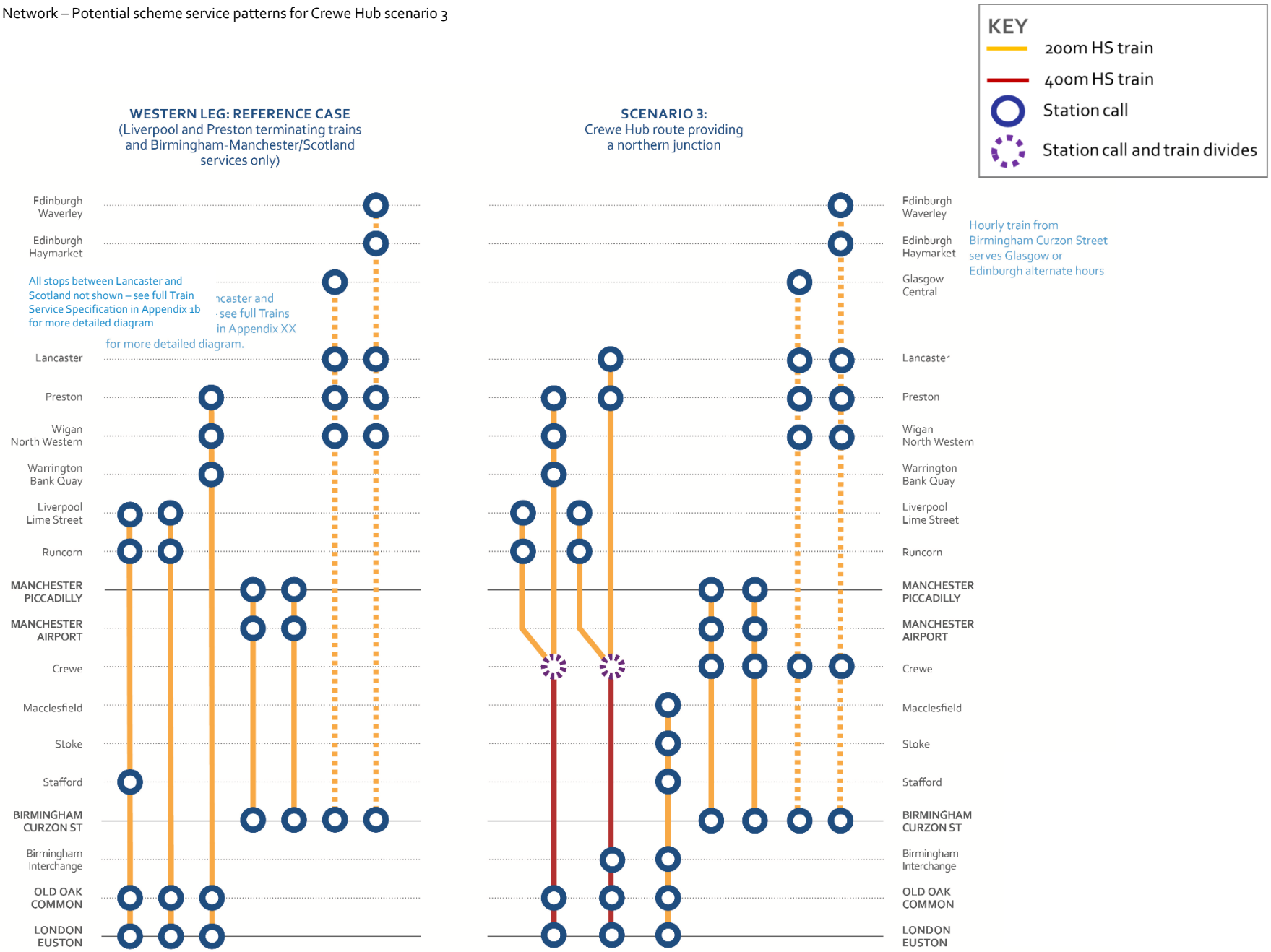


Figure 22: Crewe Network – Potential scheme service patterns for Crewe Hub scenario 3



10.3.6 The following sections present estimated benefits of each of these scenarios, using the modelling and appraisal framework that is consistent with the core HS2 economic case. The full set of scenario results are in Appendix 7.

10.4 Scenario 1 – Crewe Hub route serving Stoke-on-Trent

10.4.1 Under Scenario 1, a Liverpool and Preston service in the core HS2 service is combined between London and Crewe into a 400m train. Both destinations are still served as this train then divides at Crewe, with a 200m unit continuing to Liverpool, and the second 200m unit continuing to Preston.

10.4.2 Combining the services between London and Crewe frees up a path on the Phase One route. Our modelling is based upon this freed path being used to provide an additional service between London Euston and Macclesfield, with stops at Stafford and Stoke-on-Trent.

10.4.3 This option would increase the journey times of the Liverpool and Preston services that use the divided 400m train, as extra time would be needed to accommodate dividing or merging the train at Crewe. However, the Liverpool service has a net journey time reduction, due to the timesaving of removing the Stafford stop and using the Phase 2a high-speed line, rather than Handsacre junction.

10.4.4 Appendix 7 presents the estimated benefits and revenue for this Crewe Hub option as well as indicative operating costs and rolling stock requirements. Two sets of results are shown for services resuming in 2027 or 2033. We have made the assumption that four additional conventional-compatible rolling stock units would be required for the 400m trains and the additional London-Macclesfield service.

10.4.5 The reduction in journey times to Liverpool, the provision of additional capacity to Crewe, and providing markets around Stoke-on-Trent with a high-speed service, leads to an increase in benefits and revenue against the core HS2 case.

10.4.6 The total costs of this scenario have not yet been estimated, but expected infrastructure requirements would be 400m platforms at Crewe, and potentially other investments in the station building, access and local roads.

10.5 Scenario 2 – Crewe Hub route serving Stoke-on-Trent and upgrading capacity

10.5.1 Scenario 2 is as per Scenario 1, but with the addition of another 400m train between London and Crewe for the second Liverpool service. This service would also divide at Crewe, with a 200m unit continuing to Liverpool and the remaining 200m unit terminating at Crewe.

10.5.2 This provides an additional 200m trainset between London and Crewe compared to the core HS2 TSS. The additional capacity relieves crowding, providing benefits to passengers on the HS2 network.

10.5.3 Appendix 7 presents the estimated benefits and revenue for this second Crewe Hub option, as well as indicative operating costs and rolling stock requirements. Two sets of results are shown for services resuming in 2027 or 2033. We have made the assumption that eight additional conventional-compatible rolling stock units would be required for the 400m trains, and the additional London-Macclesfield service.

10.5.4 The additional capacity provides further benefits against the core HS2 reference case, compared with the Crewe Hub Scenario 1.

10.5.5 The total costs of this scenario have not yet been estimated, but expected infrastructure requirements would be 400m platforms at Crewe and potentially other investments in the station building, access and local roads. This option would also require somewhere to store a 200m unit, while the other half of the train travels to Liverpool.

10.6 Scenario 3 – Crewe Hub providing a Northern Junction

10.6.1 Scenario 3 is as per Scenario 2, but with the addition of a high-speed junction between the WCML north of Crewe and the high-speed line that will be built as part of Phase 2b. As such, this scenario could only operate from 2033.

10.6.2 The junction would enable more high-speed services to stop at Crewe. We have modelled a TSS whereby Crewe stops are added to the two high-speed services per hour between Birmingham and Manchester, as well as the service from Birmingham to Scotland (which calls at Preston and is assumed to alternate between Edinburgh and Glasgow each hour). This results in increased journey times for these services due to the addition of a calling point.

10.6.3 The junction would also mean that instead of terminating the second 200m unit at Crewe as in Scenario 2, this train could now be sent to another destination north of Crewe. The consultation document sets out the potential locations this additional train could serve; we have assumed the service calls at Lancaster for modelling purposes.

10.6.4 This revised specification for Crewe Hub could mean up to five high-speed trains per hour stopping at Crewe from the south. Under this option, Crewe would have direct HS2 services to London, Birmingham, Preston, Manchester Airport, Manchester Piccadilly, Glasgow and Edinburgh.

10.6.5 Increased frequency to these locations increases net transport benefits and revenues. The results also show Crewe becoming an attractive interchange hub, with travelling via Crewe becoming easier for long-distance travellers.

10.6.6 Appendix 7 presents the estimated benefits and revenue for this third Crewe Hub option, as well as indicative operating costs and rolling stock requirements. As this service relies on Phase 2b infrastructure, results are shown on the assumption that these services resume from 2033. In terms of rolling stock, we have made the assumption that sixteen conventional-compatible units are required to deliver the

train service – twelve of these are assumed to be additional units, and the remaining four are assumed to come from replacing captive units in the reference case fleet.

10.6.7 Indicative construction cost requirements for this scenario are the cost of the junction itself and the provision of 400m platforms at Crewe. In addition, the increased use of Crewe as an interchange would likely require re-designing aspects of the station in order to accommodate the expected increase in passenger flows through the station. There may also be wider connectivity aspects that require construction costs, such as local road or public transport access.

10.7 Summary of Crewe Hub options

10.7.1 The preceding analysis has examined the potential impact of potential options for a Crewe Hub. The methodology used to model these options is in line with that used for the core HS2 proposal, including the adoption of WebTAG guidance; in line with this, the results are also subject to the same risks and limitations.

10.7.2 The expected economic impacts of the three Crewe Hub options outlined above and in Appendix 7 are indicative, and subject to change through further modelling refinements and changes to assumptions. The assumed journey times used are likewise subject to change, once the full feasibility of any services via these routes has been undertaken.

10.7.3 In particular, the Northern Junction scenario has been modelled with the assumption of a spare unit at Crewe being sent to Lancaster, but the exact location is yet to be confirmed and this decision is part of the consultation process.

10.7.4 This chapter should be read in conjunction with the Crewe Hub consultation document, which sets out the options and strategic case around Crewe in more detail.

11 Extending our appraisal

11.1 Introduction

11.1.1 This Economic Case so far has focused on the case for the HS2 network and HS2 Ltd's standard approach to modelling and forecasting, which follows the latest WebTAG guidance on rail appraisal by the DfT. There are, however, a number of effects that are not currently assessed as part of the primary BCR measure. Some of these elements have the potential to add significantly to the measured benefits of the scheme. We report these appraisal issues in this section.

11.2 Extending the forecast horizon

11.2.1 In line with DfT guidance, the current Economic Case produces forecasts for passenger demand on HS2 services with a final forecast year 20 years after the appraisal year. For this Economic Case we have a final forecast year of 2037 and an appraisal year of 2017. These forecasts are modelled using the PFM, and the approach follows WebTAG guidance on rail appraisal. For a large-scale transformative project such as HS2, however, this approach may be considered highly conservative, as the latest forecast of passenger demand falls only four years after the full scheme is opened.

11.2.2 As explained in earlier chapters, when we extend benefits estimates beyond the final forecast year, we currently grow benefits in line with population to the end of the appraisal period. We intend to investigate options to extend the final forecast year / forecast horizon on a conservative basis beyond the latest forecast year of 2037. Longer-term forecasts produced by PFM will not only provide a wider range of inputs to the Economic Case, but will also provide valuable evidence to inform other areas of HS2's development. Forecasts produced beyond 2037 will likely show an increase in passenger demand for HS2 services. Thus, a key aspect of producing such forecasts will be to ensure that the process is technically robust and, in particular, that implied growth and impact on network capacity is plausible.

11.3 Endogenous demand response

11.3.1 PFM is a highly complex and detailed model. It takes in exogenous demand growth from an external source and uses this profile to forecast the future demand for HS2. This approach follows standard transport modelling practice.

11.3.2 There is one element of transport modelling that HS2 Ltd has not so far undertaken, that of endogenous forecasting. This means taking account of proposed and committed upgrades to sections of the existing rail network between now and the introduction of HS2. In this case, forecast passenger demand would be able to respond to these improvement schemes, as well as areas of the network that perform worse in future due to passenger demand growth and associated crowding.

11.3.3 We have conducted investigations to help us understand the inclusion of this additional step in our modelling process. The analysis suggests that, for the overall rail

network, we are likely under-forecasting demand. The scale of the under-estimate is, however, unlikely to change the BCR significantly. The full implementation of this additional modelling step is, nevertheless, an important component of providing a technically robust process to consider extending the forecast horizon, as described in section 11.2.

11.4 The impact of fixed land-use patterns

11.4.1 One long-standing limitation in the standard appraisal approach relates to the treatment of land-use changes and the likely impact of HS2 around the stations. There are two issues at work here. The first is that the standard appraisal method is known to produce less reliable results when used in circumstances where land-use has been allowed to change within the transport modelling framework.

11.4.2 Second, we expect that the scheme will trigger significant development in the areas immediately around HS2 stations, as they would become considerably more attractive places to locate for business. Any increase in the employment density around stations is likely to result in higher levels of HS2 and rail patronage, and higher levels of benefits and revenues as a result. These have not been captured in this analysis.

11.4.3 However, given the complexity and uncertainty inherent in forecasting land-use changes we have not, up to now, deviated from the WebTAG guidance and included the benefits of land-use changes in our BCR estimates. We will conduct further analysis to better understand the balance of the two effects.

11.5 Station improvements

11.5.1 In a number of locations, HS2 will either require the building of new stations or have a considerable impact on existing stations. Both these impacts may have a combination of effects such as:

- Improved passenger flow or connections in and around the stations;
- An enhanced retail offering; and
- Ambience impacts as a result of new station facilities and infrastructure.

11.5.2 HS2 Ltd published contract opportunities in April 2017 to develop and refine the detailed plans for three new Phase One stations, at Birmingham Curzon Street, Birmingham Interchange and London's Old Oak Common, as well as a major expansion of London Euston. The stations will welcome tens of thousands of passengers every day from all over the UK, providing easy and accessible onward connections to local transport, airports and rail services. A separate contest, also launched in April 2017, seeks a Master Development Partner to advise on, and later take forward, development opportunities for new homes, offices and retail space above and around the revamped London Euston. The Master Development Partner will work with HS2 Ltd, Network Rail, the station design contract winner and local authorities to deliver a unified plan to unlock the full potential of the area. The

assessment of some of these elements, such as changes in station ambience, is allowed for in WebTAG (Unit A5.3) covering some values from the Passenger Demand Forecasting Handbook. HS2 Ltd currently does not put any value on these aspects of station improvements due to the uncertainty around monetising them, although we do recognise them as important qualitative benefits.

11.6 Resilience and choice

11.6.1 The addition of the HS2 network alongside the existing rail network also improves the choice available to passengers. Widening the options available is an improvement for passengers in terms of gaining the benefits of additional route options to get to their destination, and also in terms of the ability to manage around any significant disruption on the rail network. For example, if there were disruption on the East Coast Mainline, HS2 would provide an additional alternative route to get to some destinations.

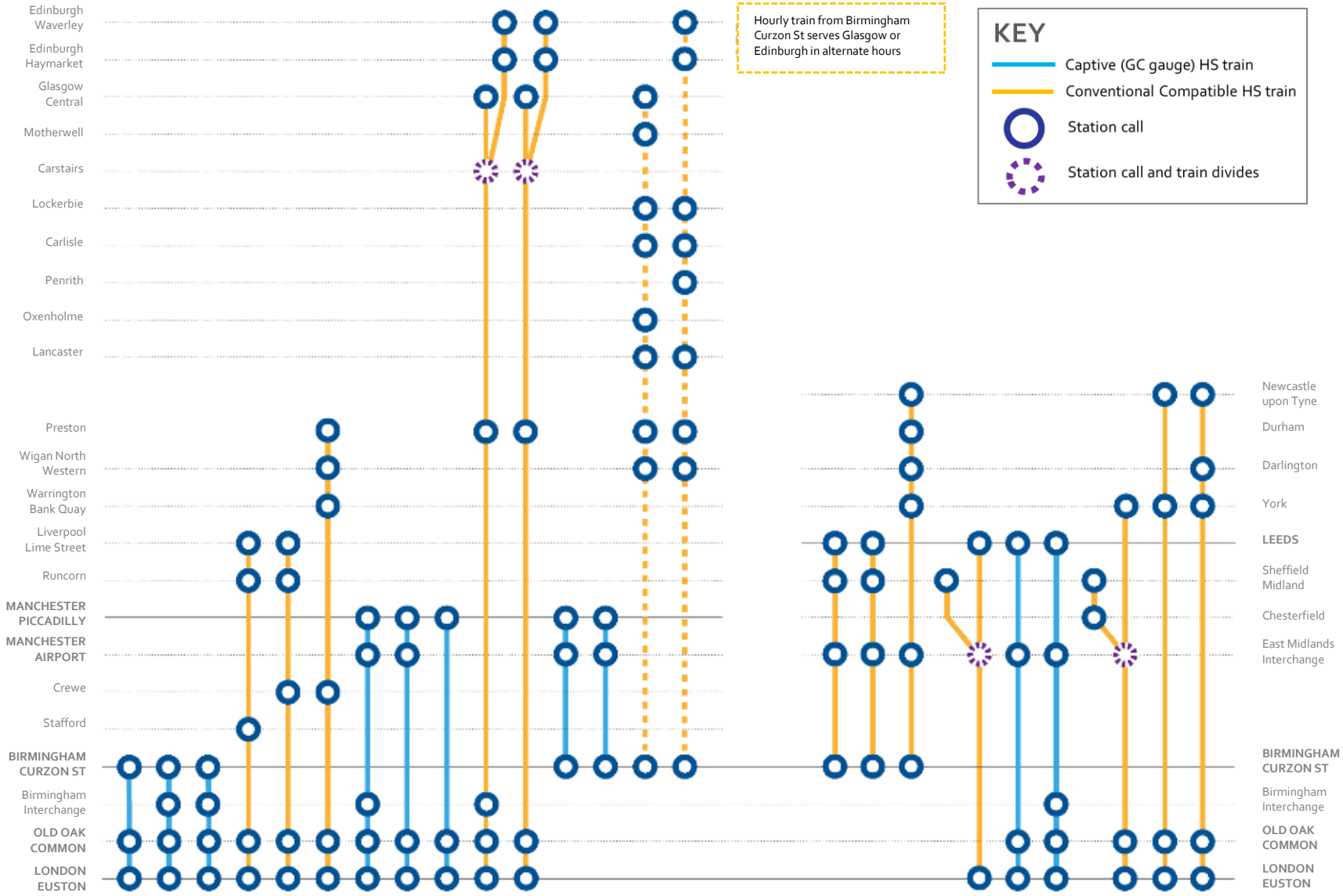
11.6.2 Assessing these benefits would be complex and an assessment of the value of these new choices, and the resilience they may bring, would be subject to uncertainty. We have not, up to now, deviated from the WebTAG guidance and included the benefits of resilience and choice in our BCR estimates. We believe, however, that a wider choice for passengers, and increased network resilience, is a significant benefit for the network.

Appendix 1a: Scheme service pattern: Phase 2a

Figure 23: Scheme Service Pattern – Phase 2a

Appendix 1b: Scheme service pattern: Full HS2 Network

Figure 24: Scheme Service Pattern – the Full HS2 Network including Phase 2b



Appendix 2: Cost assumptions

Overview

Costs are calculated in the two primary groups outlined below, and then combined with revenue estimates to give the net cost to Government. Costs have been calculated in 2015 prices to remain consistent with the rest of the economic analysis. The two groups are:

- Capital costs – including construction costs, rolling stock and depot costs, and infrastructure renewal costs; and
- Operating costs – including operation and maintenance of trains and track, train crew and station staff for HS2, and any operating cost savings from changes to the conventional network.

Capital costs - SR15 funding allocation

The cost estimates used for this analysis are consistent with the Spending Review 2015 allocation. The HS2 funding position is detailed in the Financial Case. The spending review set the long-term funding envelope for the HS2 scheme at £55.7bn in 2015 prices, and allocated the funding envelope across the phases as follows:

- Phase One including rolling stock (London – West Midlands) – £27.2bn;
- Phase 2a (West Midlands – Crewe) – £3.7bn; and
- Phase 2b including rolling stock (West Midlands – Manchester/Leeds) - £24.8bn.

There has since been a further amendment of the cost split between Phase 2a and Phase 2b:

- Part of the Phase 2a design is a tunnel required for Phase 2b under Crewe; the southern portal of this tunnel is a handover point between Phase 2a and Phase 2b. A route refinement to extend this tunnel was proposed in November 2015, and underwent consultation in September 2016.
- We have assumed the tunnel will be delivered in full during Phase 2b construction works, and therefore the costs of this extension (£0.24bn) are incurred within the Phase 2b budget. As a result, the SR15 budget for Phase 2a has been reduced from £3.72bn to £3.48bn, while the phase 2b budget increases from £24.83bn to £25.07bn. This results in no change to the £55.7bn funding envelope for the full HS2 programme.

Rolling stock and depot costs

It is currently assumed that two types of HS2 trains will be in operation; captive trains for use on HS2 track, and conventional-compatible trains, which are designed to be capable of using both high-speed track and the current rail network. All trains are assumed to be procured as 200m sets that can be used to form 200m or 400m services.

In a slight change to previous economic cases, we have applied different assumptions for Phase One and the Full Network:

- For the initial purchase of rolling stock (Phase One), we are assuming that HS2 will procure a conventional-compatible fleet only; and
- For subsequent purchases, we are assuming a mix of conventional-compatible and captive trainsets as required to deliver the full train service specification set out in Appendix 1b.

The number of 200m trainsets required under each phase and the expected base cost of purchase are outlined in Table 9 below[30]. The costs below are in 2015 prices. In addition to the per-trainset cost, non-recurring costs are added to cover design and other project costs, as well as an allocation to cover spares, maintenance tooling and simulators.

Table 9: Rolling Stock Cost Estimates

	Base cost per 200m trainset (£m)	**Total trainsets required for Phase One**	**Total trainsets required for Full Network**
Captive fleet	£19.63	0	70
Conventional-compatible fleet	£20.13	60	95

Rolling stock depot costs include the costs of one depot for Phase One and two depots for Phase Two. Efficiency Challenge Programme and Value Engineering reductions have been applied to these estimates.

It is assumed that rolling stock needs replacing after 35 years of operation, and a portion of depot costs are incurred at that point to account for renewal. Costs are discounted to present values and converted to market prices.

Infrastructure renewals

Since the Economic Case appraises the scheme for 60 years from opening, estimates are included to reflect the need to repair and renew infrastructure over this time. Painting, cleaning and general maintenance of the infrastructure will be covered by operating costs, but larger expenditures such as repairs and replacements will require capital expenditure. Renewal estimates are based on assumptions of how frequently different types of assets would require capital spend, information on the cost of these assets in the base construction cost and adjustments to reflect how the cost may be different in an operational environment. The stream of renewal costs is discounted to a present value and converted to market prices.

[30] Economic Case rolling stock assumptions vary between the M18/Eastern route and Meadowhall options, to take into account train service changes to London. This brings the M18 rolling stock fleet size in line with what was assumed at Spending Review 2015. However, it is expected that a further two units of rolling stock are required over the Spending Review assumption for Birmingham to Leeds services to be routed via Sheffield.

Operating costs

The HS2 Operating Cost Model is used to appraise the operating costs of the railway infrastructure and trains required for the HS2 project (including savings to services on the existing National Rail network that will be replaced or amended following the introduction of HS2 passenger service). The main items of operating costs calculated are:

- Rolling stock maintenance;
- Infrastructure operations and maintenance;
- HS2 staff costs;
- Traction electricity;
- Network Rail charges;
- HS2 train operator overheads and administration;
- HS2 station costs; and
- Savings to existing National Rail operators.

Table 10 shows the breakdown of operating costs used in this Economic Case.

Table 10: Breakdown of operating costs - £bn, 2015 prices Present Value (PV), including optimism bias

Item	Full Network (£ billion)	Phase 2a increment (£ billion)	Phase 2b increment (£ billion)	Includes
Rolling stock maintenance	10.8	0.0	6.7	Cleaning, repairing and servicing the trains.
Infrastructure maintenance	3.7	0.4	1.5	Inspecting and repairing the infrastructure, and infrastructure manager head office.
Electrical consumption	7.7	0.1	4.8	Cost of electricity used by the trains and electrification asset usage charge.
Staff, offices and stations	13.0	0.0	7.2	Station staff, station maintenance and utilities, train crew, TOC overheads and administration, including head office staff.
Other	3.0	-0.3	1.4	Fixed track access charge, variable usage charge, capacity charge, station access charge and rolling stock insurance.
Pre-Operations	0.5	0.0	0.3	
Conventional line savings	-11.1	0.0	-4.2	Staff, electricity, diesel, lease costs, maintenance and other.
Total*	**27.6**	**0.2**	**17.9**	**All costs net of conventional line savings**

* Total may not sum due to rounding.

Appendix 3: Calculation of the BCR

To generate a BCR for the scheme we need estimates of benefits, costs and revenues.

Description of benefits

As described in the introduction to the document, the estimation of the BCR is undertaken using a social cost benefit analysis. The benefits that are estimated therefore include both direct effects for rail passengers and indirect effects on the wider population.

The benefits for HS2 that are used in the economic appraisal are calculated following DfT's WebTAG guidance. The types of benefits that are assessed and their method of calculation are shown in the table below; the majority come from PFM. The benefits are then grouped into three primary groups as shown.

Table 11: Grouped and disaggregated benefits, what they are and where they are calculated

Grouped benefit	Disaggregated benefit	Description of benefit	Calculated using
Transport user benefits	Improved access/egress	The access/egress leg in the model is the part of a journey between the origin (house/work, etc.) and the rail station initially used. Changes in the service patterns can mean that stations are more (or less) attractive, which can lead to changes in benefits.	PFM
	Reductions in crowding	The introduction of HS2 leads to a reduction in the level of crowding for journeys, which means passengers will experience a more pleasant journey.	PFM
	Improvements in interchange	The introduction of HS2 and associated released capacity will change how often people change trains across the network - in some cases more interchanges will be required, in some cases fewer.	PFM
	Reductions in waiting	The introduction of HS2 and associated released capacity will provide increases in frequency to a number of destinations, which means that passengers will spend less time waiting for trains.	PFM
	Reductions in walking	Some parts of the journeys made by passengers include walking between stations. This represents the change in benefits from passengers needing to make more or less of these walks.	PFM
	Reductions in train journey times	The journey times between a large number of destinations are a reduced as a result of the introduction of HS2.	PFM

	Greater reliability on the HS2 network	HS2 will be a highly reliable service; passengers are therefore much more likely to be on time.	PFM
	Benefits to road users	The introduction of HS2 and associated released capacity takes vehicles off the road. There will be benefits for the remaining drivers who now encounter less traffic and enjoy faster journey times.	PFM
Wider economic impacts	Agglomeration benefits	The introduction of HS2 and associated released capacity will reduce the costs of travel between areas for business, which will lead to greater business interaction.	Wider Impacts in Transport Appraisal model
	Imperfect competition	Companies will be able to increase their production as a result of lower transport costs.	Wider Impacts in Transport Appraisal model
	Increased labour force participation	Transport changes can affect the individual's incentives to work and therefore affect the overall level of labour supply.	Wider Impacts in Transport Appraisal model
Other impacts	Reduction in car noise	The introduction of HS2 and associated released capacity takes cars off the road, so there will less noise caused by cars.	PFM
	Carbon	The introduction of HS2 and associated released capacity will reduce the total distance cars and diesel trains travel each year, which will reduce the carbon emissions they produce.	Spreadsheet model
	Reduction in car accidents	The introduction of HS2 and associated released capacity reduces the total number of cars on the road, which will mean fewer car accidents.	PFM
	Noise from HS2 trains	HS2 trains will create noise and this will have a negative impact on areas close to the track.	Spreadsheet Model
Tax impacts	Loss to Government of indirect tax	As there will be fewer passengers travelling by car or other means, there will be a reduction in the level of tax generated from these sources as a result.	PFM

The estimates of benefits are then combined to provide an estimate of net benefits:

Net benefits = Transport user benefits + WEIs + Other impacts + Tax impacts

Costs and revenue

Costs are estimated for three primary groups: construction, rolling stock and operating costs. Operating costs include both the costs of operating HS2 trains, and savings from changes to services on the conventional network. The costs of renewals are also included. Appendix 2 presents further detail on the cost assumptions.

Revenue is estimated using changes in passenger kilometres from the PFM model, again incorporating changes from both HS2 and conventional line passengers.

These estimates of cost and revenue are then combined to give a net cost to Government:

Net cost to Government = Construction cost + Rolling stock cost + Operating cost + Renewals - Revenue

Calculation of the BCR

All the estimates of the benefits and costs are then combined in the following equation to produce an estimate of the BCR:

BCR = Net benefits/Net cost to Government

Appendix 4a: Transport impacts - Full Network

Benefits breakdown – The full HS2 network

Table 12: Total net benefits including wider economic impacts - Full HS2 Network - £m, 2015 prices, Present Value (PV)

		Full network	
Grouped benefit	**Disaggregated benefit**	**Benefit value (£ million)**	**Percentage of total**
Transport user benefits	Improved access	£637	0.7%
	Reduction in crowding	£9,742	10.6%
	Improvements in interchange	£1,040	1.1%
	Reductions in waiting	£13,345	14.5%
	Reductions in walking	£152	0.2%
	Reductions in train journey times	£41,835	45.4%
	Greater reliability on the HS2 network	£10,238	11.1%
	Benefits to road users	£1,307	1.4%
	Total	**£78,296**	**84.9%**
Wider economic impacts	Agglomeration (businesses closer together)	£11,042	12.0%
	Imperfect competition (increased output due to reduced costs)	£6,115	6.6%
	Increased labour force participation	£463	0.5%
	Total	**£17,621**	**19.1%**
Other Impacts	Reduction of car noise	£26	0.0%
	Carbon	£185	0.2%
	Reduction in car accidents	£320	0.3%
	Noise from HS2 trains	-£187	-0.2%
	Infrastructure	£25	0.0%
	Total	**£369**	**0.4%**
	Loss to Government of Indirect tax	-£4,062	-4.4%
	Total Benefits	**£92,223**	**100.0%**

Totals may not sum due to rounding

Appendix 4b: Transport impacts - Phase 2a

Benefits breakdown – Phase 2a increment

Table 13: Total net benefits including wider economic impacts – Phase 2a - £m, 2015 prices, Present Value (PV)

		Phase 2a increment	
Grouped benefit	**Disaggregated benefit**	**Benefit value (£ million)**	**Percentage of total**
Transport user benefits	Improved access	-£7	-0.2%
	Reduction in crowding	-£944	-24.0%
	Improvements in interchange	-£119	-3.0%
	Reductions in waiting	£168	4.3%
	Reductions in walking	£14	0.4%
	Reductions in train journey times	£3,717	94.7%
	Greater reliability on the HS2 network	£636	16.2%
	Benefits to road users	-£3	-0.1%
	Total	**£3,462**	**88.2%**
Wider economic impacts	Agglomeration (businesses closer together)	£350	8.9%
	Imperfect competition (increased output due to reduced costs)	£296	7.5%
	Increased labour force participation	£39	1.0%
	Total	**£684**	**17.4%**
Other Impacts	Reduction of car noise	£1	0.0%
	Carbon	£5	0.1%
	Reduction in car accidents	£9	0.2%
	Noise from HS2 trains	-£56	-1.4%
	Infrastructure	£1	0.0%
	Total	**-£41**	**-1.0%**
	Loss to Government of Indirect tax	-£179	-4.6%
	Total Benefits	**£3,926**	**100.0%**

Totals may not sum due to rounding

Appendix 4c: Transport impacts - Phase 2b

Benefits breakdown – Phase 2b increment

Table 14: Total net benefits including wider economic impacts – Phase 2b - £m, 2015 prices, Present Value (PV)

		Phase 2b increment	
Grouped benefit	**Disaggregated benefit**	**Benefit value (£ million)**	**Percentage of total**
Transport user benefits	Improved access	-£37	-0.1%
	Reduction in crowding	£6,606	13.5%
	Improvements in interchange	£1,811	3.7%
	Reductions in waiting	£6,863	14.0%
	Reductions in walking	£70	0.1%
	Reductions in train journey times	£19,360	39.6%
	Greater reliability on the HS2 network	£5,638	11.5%
	Benefits to road users	£682	1.4%
	Total	**£40,992**	**83.7%**
Wider economic impacts	Agglomeration (businesses closer together)	£6,582	13.4%
	Imperfect competition (increased output due to reduced costs)	£3,090	6.3%
	Increased labour force participation	£305	0.6%
	Total	**£9,977**	**20.4%**
Other Impacts	Reduction of car noise	£16	0.0%
	Carbon	£129	0.3%
	Reduction in car accidents	£197	0.4%
	Noise from HS2 trains	-£107	-0.2%
	Infrastructure	£16	0.0%
	Total	**£251**	**0.5%**
	Loss to Government of Indirect tax	-£2,273	-4.6%
	Total Benefits	**£48,947**	**100.0%**

Totals may not sum due to rounding

Appendix 5: Regional benefits

Table 15 shows an illustrative distribution of benefits according to where a long-distance trip starts and finishes within PFM. The figures are proportions from our modelled year of 2037.

Table 15: Illustrative regional distribution of transport user benefits

Region	Full Network	Phase 2a increment	Phase 2b increment
London	40%	43%	36%
South East	3%	3%	3%
West Midlands	12%	1%	5%
North West	18%	39%	13%
East Midlands	4%	1%	7%
Yorkshire and Humber	10%	3%	17%
North East	4%	0%	6%
Scotland	5%	4%	7%
Other (East England, South West, Wales)	3%	5%	4%
Total	100%*	100%*	100%*

* Totals may not always equal 100% due to rounding

Appendix 6: HS2 Scenarios - Results

This section reports detailed single point BCR estimates.

Reference case

The reference case results in Table 16 align to all the WebTAG standard assumptions outlined in Chapters 5 and 6 of this document.

Table 16: Economic analysis results for the full HS2 Network - £bn, 2015 prices, Present Value (PV)

	BCR components		**Full Network** **Benefits extrapolated to 2093** **(£bn, 2015 prices, PV)**	**Phase 2a increment** **Benefits capped in 2037** **(£bn, 2015 prices, PV)**	**Phase 2b increment** **Benefits extrapolated to 2093** **(£bn, 2015 prices, PV)**
1	Transport User Benefits	Business	61.2	2.9	30.9
		Other	17.1	0.5	10.1
2	Other quantifiable benefits		0.4	-0.0	0.3
3	Loss to Government of Indirect Taxes		-4.1	-0.2	-2.3
4	Net Transport Benefits (PVB) = (1) + (2) + (3)		74.6	3.2	39.0
5	Wider Economic Impacts		17.6	0.7	10.0
6	Net Benefits including WEIs		92.2	3.9	48.9
7	Capital Costs		55.8	4.0	24.3
8	Operating Costs		27.6	0.2	17.9
9	Total Costs		83.4	4.2	42.1
10	Revenues		43.6	2.1	23.5
11	Net Costs to Government (PVC)		39.8	2.1	18.6
12	**BCR without WEIs (ratio) = (4)/(11)**		**1.9**	**1.6**	**2.1**
13	**BCR with WEIs (ratio) = (6)/(11)**		**2.3**	**1.9**	**2.6**

Totals may not sum due to rounding.

Alternative eastern leg route comparison

The results in Table 17 compare the Phase 2b increment BCR for the previous South Yorkshire route through Meadowhall, to the Government's preferred M18/Eastern Route, which follows the M18 alignment. The preferred route was confirmed in the July 2017 Phase 2b Route Decision[31].

Table 17 Economic analysis results for alternative eastern leg route- £bn, 2015 prices, Present Value (PV)

	BCR components		Phase 2b increment M18/Eastern Route - Reference Case Benefits extrapolated to 2093 (£bn, 2015 prices, PV)	Phase 2b increment Meadowhall Route Benefits extrapolated to 2093 (£bn, 2015 prices, PV)
1	Transport user benefits	Business	30.9	29.6
		Other	10.1	9.9
2	Other quantifiable benefits		0.3	0.2
3	Loss to Government of indirect tax		-2.3	-2.2
4	Net transport benefits = (1) + (2) + (3)		39.0	37.5
5	Wider economic impacts (WEIs)		10.0	9.9
6	Net benefits including WEIs = (4) + (5)		48.9	47.4
7	Capital costs		24.3	25.2
8	Operating costs		17.9	16.1
9	Total costs = (7) + (8)		42.1	41.3
10	Revenues		23.5	22.7
11	Net costs to Government = (9) - (10)		18.6	18.6
12	**BCR without WEIs (ratio) = (4)/(11)**		**2.1**	**2.0**
13	**BCR with WEIs (ratio) = (6)/(11)**		**2.6**	**2.6**

Totals may not sum due to rounding

[31] High Speed Two Phase 2b, West Midlands to Crewe – West Midlands to Leeds and Beyond, Phase 2b Route Decision, available at gov.uk:, https://www.gov.uk/government/organisations/high-speed-two-limited

Appendix 7: Crewe Hub Options - Results

All Crewe Hub services begin in 2033

This appendix reports the economic analysis results for the Crewe Hub options outlined in Chapter 10. The results show the estimates when compared to the HS2 reference case.

Table 18 shows results assuming the amended train services begin in 2033.

Table 19 shows results assuming scenarios 1 and 2 begin in 2027, and scenario 3 begins in 2033.

Table 18: Economic analysis results for Crewe Hub scenario options beginning in 2033 - £bn, 2015 prices, Present Value (PV).

	Economic appraisal components		**Scenario 1 - Crewe Hub route serving Stoke-on-Trent from 2033** **Benefits extrapolated to 2093** **(£bn, 2015 prices, PV)**	**Scenario 2 - Crewe Hub route serving Stoke-on-Trent and upgrading capacity from 2033** **Benefits extrapolated to 2093** **(£bn, 2015 prices, PV)**	**Scenario 3 - Crewe Hub providing a Northern Junction from 2033** **Benefits extrapolated to 2093** **(£bn, 2015 prices, PV)**
1	Transport user benefits	Business	0.7	1.4	2.0
		Other	0.2	0.3	0.9
2	Other quantifiable benefits		0.01	0.01	0.01
3	Loss to Government of indirect tax		-0.1	-0.1	-0.2
4	**Net transport benefits = (1) + (2) + (3)**		0.8	1.6	2.7
5	Wider economic impacts (WEIs)		0.2	0.3	0.7
6	**Net benefits including WEIs = (4) + (5)**		**1.0**	**1.9**	**3.4**
7	Capital costs				
8	Rolling stock costs		0.1	0.2	0.3
9	Operating costs		0.6	1.1	1.3
10	Total costs (excluding construction capital) = (8) + (9)		0.6	1.3	1.6
11	Revenues		0.4	0.8	1.4
12	**Net costs to Government (excluding construction capital) = (10) - (11)**		**0.2**	**0.5**	**0.2**

Totals may not sum due to rounding

Crewe Hub scenario 1 and 2 services begin in 2027

The results shown below assume that Crewe Hub scenarios 1 and 2 begin in 2027. The northern junction scenario relies on Phase 2b infrastructure, and therefore the results still assume these services begin in 2033.

Table 19 Economic analysis results for Crewe Hub scenario options beginning in 2027 and 2033 - £bn, 2015 prices, Present Value (PV).

	Economic appraisal components		Scenario 1 - Crewe Hub route serving Stoke-on-Trent from 2027 Benefits extrapolated to 2093 (£bn, 2015 prices, PV)	Scenario 2 - Crewe Hub route serving Stoke-on-Trent and upgrading capacity from 2027 Benefits extrapolated to 2093 (£bn, 2015 prices, PV)	Scenario 3 - Crewe Hub providing a Northern Junction from 2033 Benefits extrapolated to 2093 (£bn, 2015 prices, PV)
1	Transport user benefits	Business	0.8	1.5	2.0
		Other	0.2	0.4	0.9
2	Other quantifiable benefits		0.01	0.01	0.01
3	Loss to Government of indirect tax		-0.1	-0.1	-0.2
4	**Net transport benefits = (1) + (2) + (3)**		1.0	1.8	2.7
5	Wider economic impacts (WEIs)		0.2	0.4	0.7
6	**Net benefits including WEIs = (4) + (5)**		**1.1**	**2.2**	**3.4**
7	Capital costs				
8	Rolling stock costs		0.1	0.2	0.3
9	Operating costs		0.7	1.3	1.3
10	Total costs (excluding construction capital) = (8) + (9)		0.8	1.5	1.6
11	Revenues		0.5	1.0	1.4
12	**Net costs to Government (excluding construction capital) = (10) - (11)**		**0.3**	**0.5**	**0.2**

Totals may not sum due to rounding

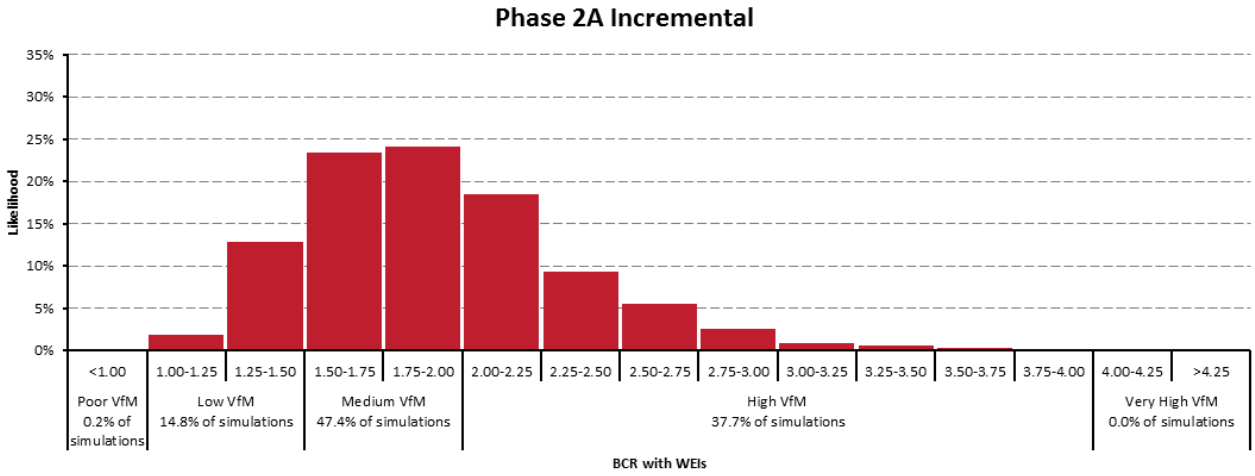
Appendix 8: Risk analysis sensitivity tests

Reference case risk analysis

Phase 2a increment

Figure 25 presents the risk analysis results for the Phase 2a increment. The chart shows the relative probability of different levels of BCR, mapped against the DfT's value for money categories. The chart shows that there is an 85% chance of having a BCR that delivers medium, or high, value for money, given variations in the core variables of GDP growth, values of time, rolling stock costs and construction costs.

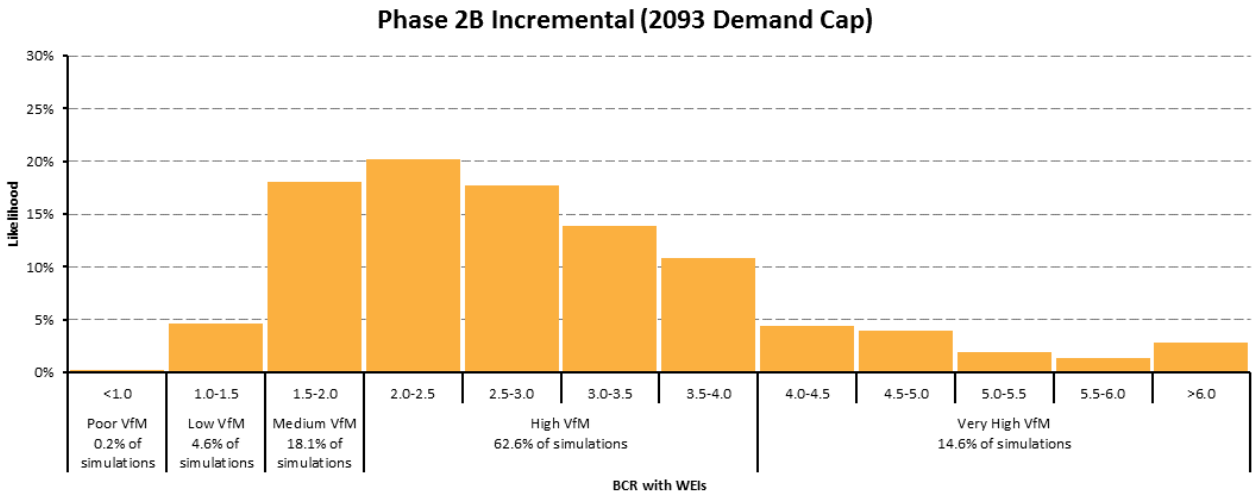
Figure 25: Risk analysis – Phase 2a increment



Phase 2b increment

Figure 26 presents the results for the reference case risk analysis for the Phase 2b increment. The chart shows the relative probability of different levels of BCR, mapped against the DfT's value-for-money categories. The chart shows that there is a 77% chance of having a BCR that delivers high, or very high, value for money given variations in the core variables of GDP growth, values of time, rolling stock costs and construction costs.

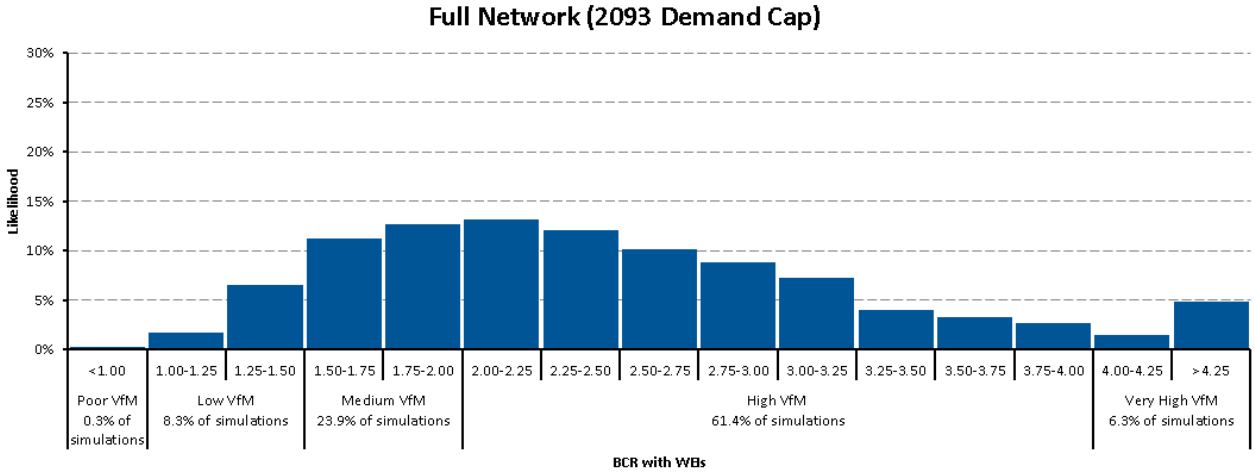
Figure 26: Risk analysis – Phase 2b increment



The full HS2 network

Figure 27 presents the results for the reference case risk analysis for the full HS2 network. The chart shows the relative probability of different levels of BCR, mapped against the DfT's value for money categories. The chart shows that there is a 67% chance of having a BCR that delivers high, or very high, value for money given variations in the core variables of GDP growth, values of time, rolling stock costs and construction costs.

Figure 27: Risk analysis – Full HS2 Network



Median spot point BCR estimates generated by the risk analysis model

This appendix sets out the median spot point BCRs that are generated by the risk analysis model when conducting the sensitivities set out in Chapters 7, 8 and 9.

Table 20: Risk analysis median BCR estimates

Description	Demand Cap	Median BCR Estimate
Phase 2a incremental	2037	1.9
Phase 2a incremental With 1.1x GDP Growth Rate	2037	2.2
Phase 2a incremental With 0.9x GDP Growth Rate	2037	1.6
Phase 2a incremental With Higher Fares	2037	2.0
Phase 2a incremental With Lower Fares	2037	1.8
Phase 2a incremental With 50% OB	2037	1.7
Phase 2a incremental Without Reliability Benefits	2037	1.3
Phase 2b incremental	2093	2.7
Phase 2b incremental With 1.1x GDP Growth Rate	2093	3.6
Phase 2b incremental With 0.9x GDP Growth Rate	2093	2.0
Phase 2b incremental With Higher Fares	2093	1.9
Phase 2b incremental With Lower Fares	2093	3.7
Phase 2b incremental With 50% OB	2093	2.5
Phase 2B incremental Without Reliability Benefits	2093	2.0
Full Network incremental	2093	2.3
Full Network incremental With 1.1x GDP Growth Rate	2093	3.0
Full Network incremental With 0.9x GDP Growth Rate	2093	1.8
Full Network incremental With Higher Fares	2093	1.8
Full Network incremental With Lower Fares	2093	3.0
Full Network incremental With 50% OB	2093	2.2
Full Network incremental Without Reliability Benefits	2093	1.8

The following three charts are percentile graphs, which show the BCR for different percentiles between P10 and P90. All of this information comes from the risk analysis model, which produces 2000 possible BCRs for each scenarios. The percentile indicates the BCR below which a given percentage of all of the simulated BCRs will fall. For example, the P80 BCR is the BCR in which 80% of simulations resulted in a lower BCR. This suggests there is an 80% chance that the BCR will be less than the P80 value and a 20% chance that it will be above P80.

Figure 28: Risk analysis – Phase 2a increment results by percentile

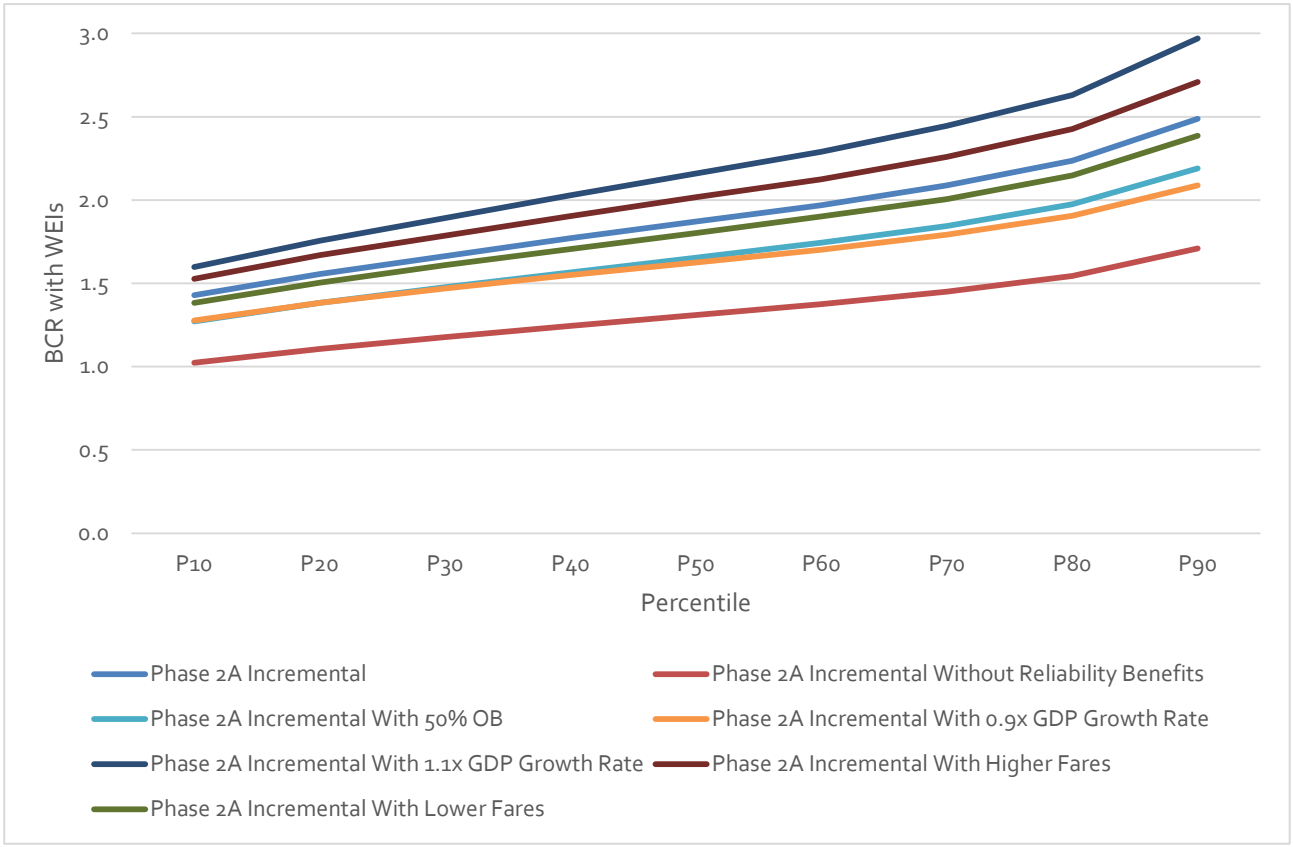


Figure 29: Risk analysis – Phase 2b increment results by percentile

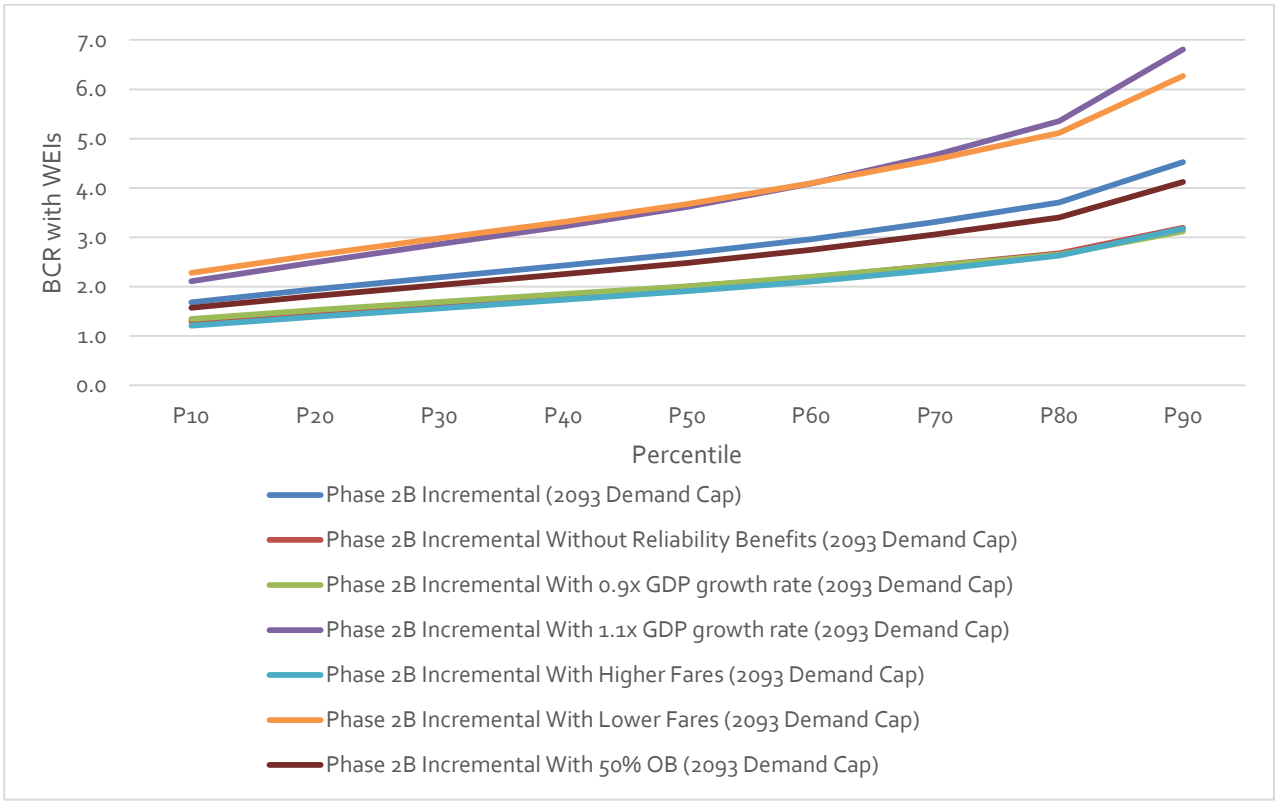
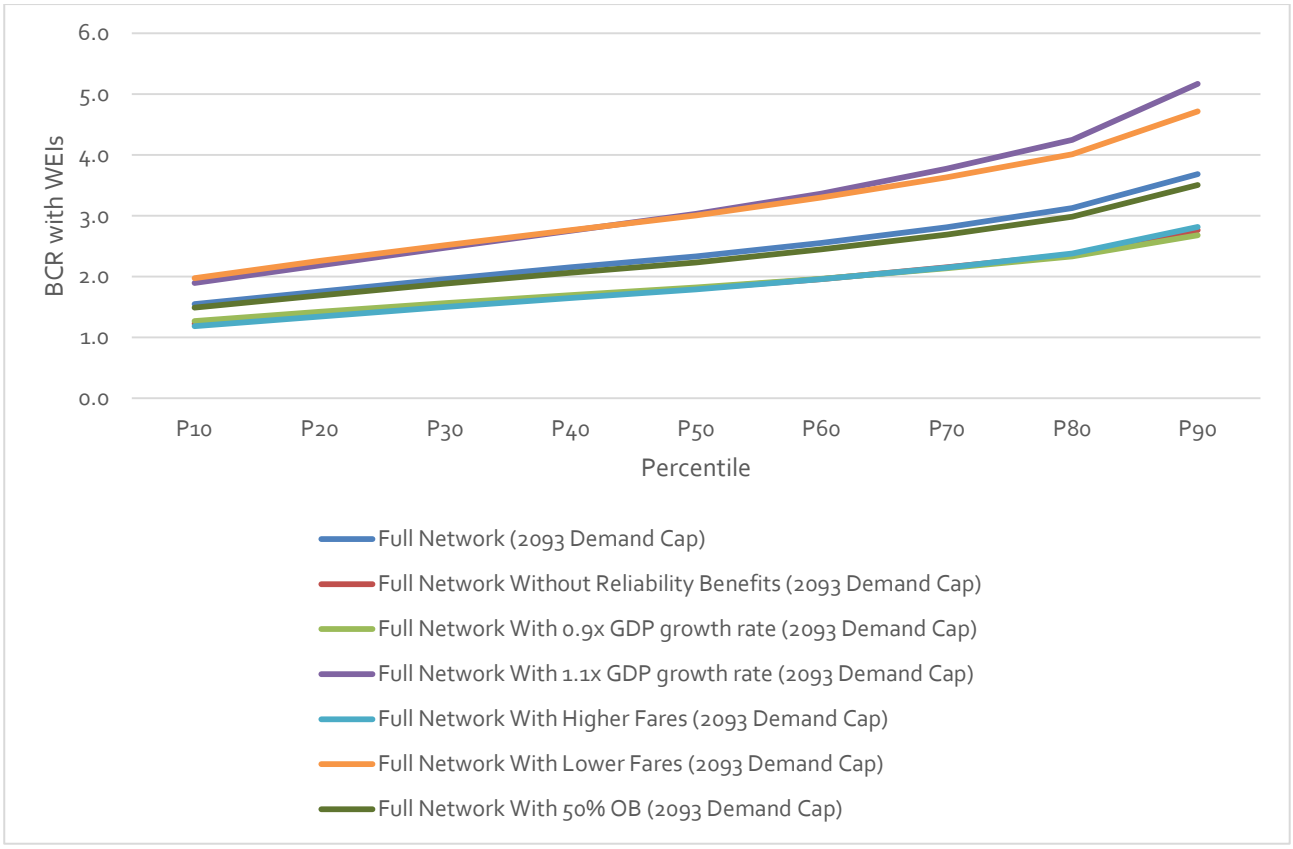


Figure 30: Risk analysis – Full HS2 Network results by percentile



Appendix 9: Modelled journey times

Table 21 and Table 22 set out some of the journey times used in the Economic Case modelling for the eastern and western legs of the route. These journey times are modelled within our 'reference case'. It should be noted that these journey times are estimates, and they evolve as we refine our modelling based on the route alignment.

The journey times used for modelling in the Economic Case occasionally differ from the journey times quoted in the Strategic Case/Command Paper. This is because when there is a difference in northbound/southbound journey times, the Economic Case takes the slowest of these times, to be conservative in the analysis.

Since the last Economic Case was published in November 2016, there have been the following changes:

- An increase in journey times in the full HS2 network for the Birmingham to Leeds service of 4 minutes (appears as 3 minutes in the table below due to rounding), which reflects updated modelling of the M18/Eastern route service on the eastern leg; and
- An increase in journey times in the full HS2 network for the London Euston to Edinburgh service of 2 minutes to allow for the time needed to split/join the service at Carstairs.

Eastern leg Journey Times

Table 21: HS2 eastern leg journey times for the full HS2 Network

Origin	Destination	Full Network Journey Time (Reference Case)
London Euston	East Midlands Hub	52
London Euston	Sheffield Midland	87
London Euston	Leeds	81
London Euston	York	84
London Euston	Newcastle	138
Birmingham Curzon Street	East Midlands Hub	20
Birmingham Curzon Street	Sheffield Midland	49
Birmingham Curzon Street	Leeds	78
Birmingham Interchange	East Midlands Hub	17
Sheffield Midland	Leeds	27

Western leg journey times

Table 22: HS2 western leg journey times for Phase 2a and the full HS2 Network

Origin	Destination	Phase 2a Journey Time (Reference Case)	Full Network Journey Time (Reference Case)
London Euston	Birmingham Interchange	38	38
London Euston	Birmingham Curzon Street	49	49
London Euston	Crewe	57	57
London Euston	Manchester Airport	N/A	63
London Euston	Manchester Piccadilly	90	68
London Euston	Preston	92	78
London Euston	Liverpool	95	95
London Euston	Glasgow	226	220
London Euston	Edinburgh Waverley	N/A	228
Birmingham Curzon Street	Manchester Piccadilly	N/A	41
Birmingham Curzon Street	Edinburgh Waverley	N/A	197
Birmingham Curzon Street	Glasgow	N/A	200
Birmingham Interchange	Glasgow	N/A	186
Birmingham Interchange	Manchester Piccadilly	N/A	38

Appendix 10: Glossary

Definitions	Acronym	
Appraisal period	-	The assumed useful life of the assets for analysis. For the full network analysis it is 60 years from the opening of Phase 2b i.e. from 2033 to 2093.
Benefit cost ratio	BCR	The ratio of project benefits to project costs.
Capital costs/capital expenditure	CAPEX	The cost of acquiring the physical assets for HS2, including construction, land purchases and rolling stock.
Cost benefit analysis	CBA	The process of calculating and comparing the benefits and costs of a project, usually to generate the BCR.
Consumer price index	CPI	A measure of inflation, currently the Government's official measure of price increases.
Demand cap year	-	The year in which the demand cap is reached.
'Do-minimum'	DM	The set of train services and demand which are assumed to be in place if HS2 did not happen – the base case – against which the 'do-something' is assessed.
'Do-something'	DS	The transport intervention – HS2 scheme – being considered.
Department for Transport	DfT	The Government department responsible for the English (and some of the Scottish) transport network.
East Coast Main Line	ECML	The existing rail route connecting London King's Cross, Peterborough, Doncaster, Wakefield, Leeds, York, Darlington, Newcastle, Edinburgh and Aberdeen.
Elasticity	-	The responsiveness of a change in X as a result of a change in Y.
Full network	-	The extent of the HS2 network currently being planned for construction.
Gross domestic product	GDP	The market value of all officially recognised final goods and services produced in the UK within a given period.
Gross wage rate	-	The money you earn based on your hourly pay, before any taxes or other deductions.
Green Book	-	HM Treasury's guidance for public sector bodies on how to appraise options before committing funds to a policy, programme or project.
High-speed rail	HSR	A railway that can operate at speeds of over 150 mph.
Hybrid Bill	-	An option for new legislation that will provide the powers to build HS2.
National Audit Office	NAO	The body responsible for auditing central Government accounts and reporting on value for money issues.
National Air Passenger Allocation Model	NAPALM	A model used to forecast airport capacity constraints and the distribution of passengers between airports.
National Rail Travel Survey	NRTS	A survey of passenger trips on the national rail system in Great Britain on weekdays outside school holidays.
National Transport Survey	NTS	The primary source of data on passenger travel patterns in Great Britain.
National Passenger Survey	NPS	A network-wide survey of customer' satisfaction with rail travel.

Definitions	Acronym	
Optimism bias	OB	A financial allocation to compensate for the systematic tendency for appraisers to be over-optimistic about key project parameters.
Office for Budget Responsibility	OBR	An independent body that analyses the UK's public finances.
Office of National Statistics	ONS	The UK's largest independent producer of official statistics.
Operating Costs/Operating Expenditure	OPEX	The costs associated with running the railway including the maintenance of the track and trains and staff costs.
PLANET Framework Model	PFM	The suite of models used by HS2 Ltd to analyse the impact of HS2 on rail travel in the UK.
Passenger Demand Forecasting Handbook	PDFH	A summary of over 20 years of research on rail demand forecasting, service quality and fares.
Phase One	-	The section of HS2 between London and the West Midlands with a connection via the West Coast Main Line at conventional speeds to the North West and Scotland. Phase One includes stations at London Euston, Old Oak Common (West London), Birmingham Interchange (near the National Exhibition Centre and Birmingham Airport) and Curzon Street.
Phase Two	-	The section of HS2 that extends beyond the West Midlands to Manchester and Leeds with connections to conventional railway lines via the West Coast and East Coast Main Lines. Phase Two includes stations at Manchester Airport, Manchester Piccadilly, East Midlands Hub (between Nottingham and Derby), Sheffield Midland and Leeds. Phase Two is split between Phase 2a and Phase 2b.
Phase 2a West Midlands to Crewe	-	The section of HS2 between the West Midlands and Crewe.
Phase 2b Crewe to Manchester, West Midlands to Leeds	-	The section of HS2 from the West Midlands to Leeds (the eastern leg), and from Crewe to Manchester (the western leg).
Quantified risk assessment	QRA	A formal method of calculating the quantity of individual risks.
Real terms	-	The financial value, after removing the effects of inflation.
Released capacity	-	The availability of capacity on the conventional network created by the introduction of HS2.
Retail Price Index	RPI	An alternative measure of inflation previously adopted by the Government as the official measure of price increases.
Service specification	-	The train service assumptions used in our modelling.
Standard case	-	Our scenario that most rigidly applies the assumptions in the Department for Transport's WebTAG guidance.
Sunk cost	-	A cost that has already been incurred and cannot be recovered.
Train operating company	TOC	A company that holds an operating contract for a rail franchise.
Value of time	VoT	The implicit value people place on time.

Definitions	Acronym	
Web Based Transport Analysis Guidance	WebTAG	The Department for Transport's guidance that provides guidelines on how to conduct transport studies.
West Coast Main Line	WCML	The existing rail route connecting London Euston, Birmingham, Manchester, Liverpool, Glasgow and Edinburgh. It is the busiest mixed-traffic railway route in Europe.
Wider economic impacts	WEIs	The agglomeration, imperfect competition and increased labour force participation benefits.
Wider Impacts in Transport Appraisal	WITA	Software that has been developed to estimate wider economic impacts (WEIs) of transport schemes, as explained in WebTAG Unit A2.1
Willingness to pay	WTP	The maximum value a consumer is willing to pay for a good or service.

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