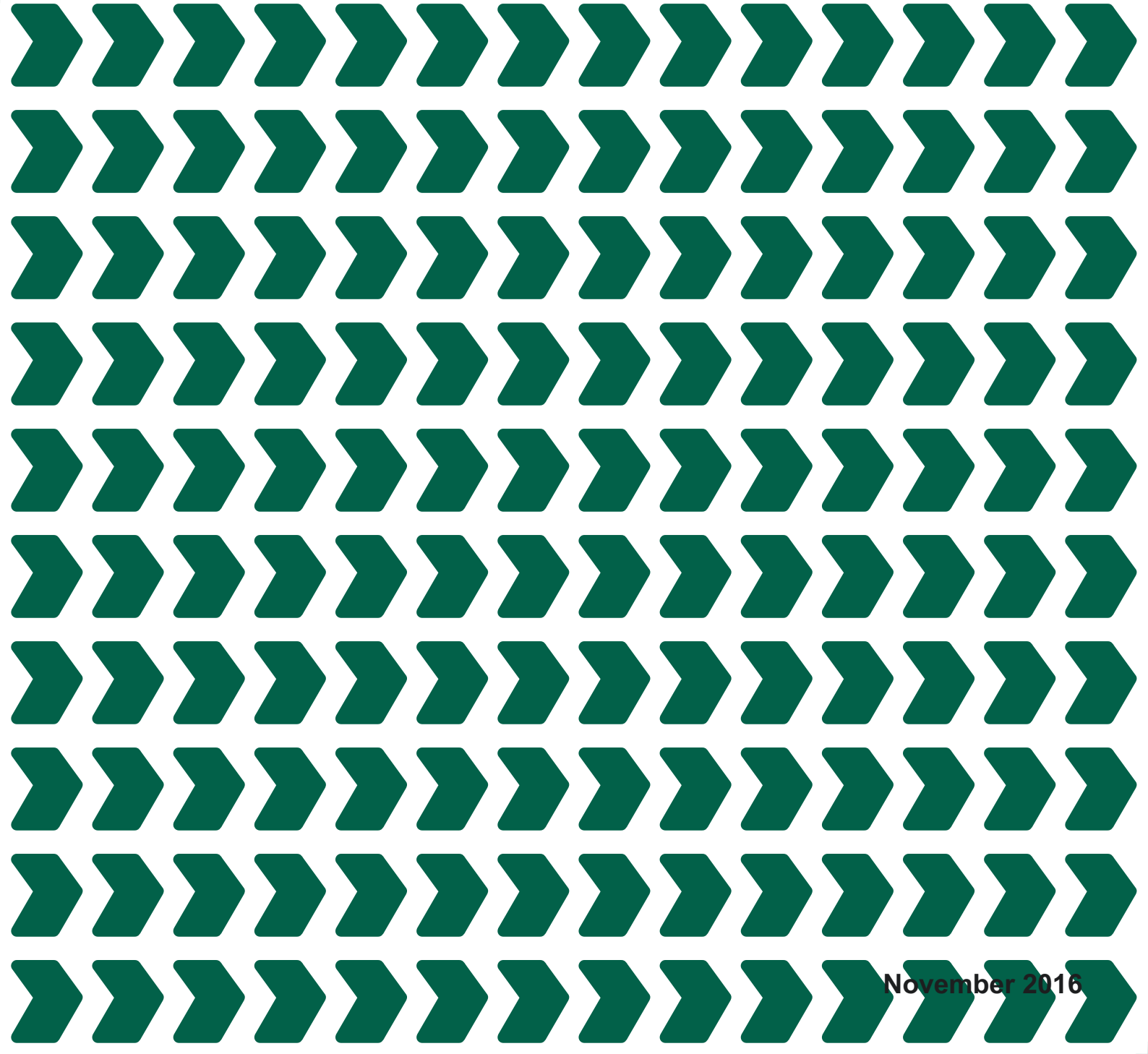
Department for Transport

High Speed Two Phase 2b Strategic Outline Business Case

Economic Case

Moving Britain Ahead



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Executive summary

HS2 Phase 2b is the section of high speed line from Crewe to Manchester and from Birmingham to Leeds, together with the connections to the West Coast Main Line and the East Coast Main Line. This part of Phase 2 will complete the HS2 Y network.

HS2 will improve capacity and connectivity between the North, the Midlands and London, with Phase 2b providing transformational changes in connectivity between the North and the Midlands in particular. This will help to generate economic growth throughout the UK. Phase 2b is estimated to deliver over £52bn in total benefits to society, of which £21bn comes from faster journey times and around £16bn from improving capacity and other connectivity benefits. The remaining benefits are attributed to other impacts including reliability and wider economic impacts (WEIs). This could be considered a conservative assessment as the modelling assumes no increase in passenger demand after 2036 and no changes to population or employment as a result of the scheme.

Phase 2b has the potential to support a step-change in economic growth. Faster journey times and increased frequency and reliability of rail services between areas can help generate economic benefits by bringing businesses and people closer together. Over 80 per cent of the welfare benefits of Phase 2b are expected to translate directly into the real economy: completing the Y network is estimated to contribute around £44bn in GDP (in present value terms) over the appraisal period to 2093. This is without taking account of businesses moving to more productive locations, and the benefits that this can ultimately bring to workers (through higher employment) and to consumers (through lower prices). We also do not include the potential benefits of property developers upgrading housing stock in reaction to improved transport links, leading to regeneration. We therefore expect the full impact of HS2 on the economy to be larger than currently estimated.

The central benefit cost ratio (BCR) for Phase 2b, for the preferred route in South Yorkshire with an M18 alignment and Sheffield ‘loop’, is 3.1 including WEIs, which indicates that the scheme is high value for money. This assessment is shown to be robust to a number of sensitivity tests which vary some of the key demand, cost and appraisal assumptions used in this Economic Case. Non-monetised impacts have also been assessed, ranging from ‘Moderate Adverse’ impacts on for example landscape to ‘Slight Beneficial’ effects on passenger experience from new rolling stock and stations. Overall, these non-monetised impacts are considered not to affect the conclusion that Phase 2b represents high value for money.

The central BCR for the HS2 network as a whole (including WEIs for ‘M18 loop’) is 2.7, providing over £102bn in total welfare benefits. The BCR has increased from 2.2 as last published in the Strategic Outline Business Case for Phase 2a (November 2015) due to a number of updates to improve our modelling and appraisal framework, ensuring we are using the most up-to-date information and are consistent with the latest guidance in appraising rail schemes (WebTAG).

This has included:

- Policy assumptions – updating non-HS2 rail services to reflect latest DfT commitments, HS2 scheme design to reflect minor route refinements which increase some journey times by generally between 1 and 3 minutes, and the preferred route in South Yorkshire (the M18 alignment with Sheffield loop)
- Demand assumptions – using more recent outturn demand data and moving the 'demand cap' to a fixed forecast 20 years in the future (i.e. 2036) in line with standard rail appraisal guidance
- Appraisal methodology – improving the accuracy of the calculation of user benefits, adopting recently published guidance on values of travel time saving and updating the price base to 2015. Costs and benefits are discounted back to 2016

The value for money of strategic alternatives to Phase 2b has also been assessed. The rail alternatives considered provide lower benefits (over £15bn lower, including WEIs) but are lower-cost (around £4-9bn lower present value capital costs). The alternatives are shown to have BCRs ranging from 2.7 to 3.9 (including WEIs), and two options have higher BCRs than HS2 Phase 2b. The alternatives do not perform as strongly as HS2 Phase 2b against the strategic objectives of the scheme. Overall, Phase 2b is shown to be the best way to provide the desired capacity, connectivity and economic growth benefits to the Midlands and the North.

1. Our assessment of Phase 2b

Introduction

The HS2 route

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 is a Y-shaped network that will be delivered in several stages. Trains will also run beyond the Y network to serve places such as Liverpool, Preston, Newcastle, and on to Scotland.

1.2 Phase One of HS2 will see a new high speed line constructed from Euston to north of Birmingham, where it will join the existing West Coast Main Line (WCML). New high speed trains will serve Birmingham city centre and an interchange station designed to serve the wider West Midlands. At Old Oak Common in West London, a new interchange will be built connecting HS2 with Crossrail and the Great Western Main Line. Phase One will be built and operational by 2026 (subject to Parliamentary approval of the Phase One hybrid Bill).

1.3 The proposals for Phase Two extend the line to the North West and North East, to Manchester with connections to the WCML at Crewe and Golborne, and to Leeds with a connection to the East Coast Main Line (ECML) approaching York. There will be new stations in Manchester, Leeds and the East Midlands, and the route will also serve South Yorkshire. Phase Two will be completed seven years after Phase One, in 2033.

1.4 In November 2015 the Government announced its intention to accelerate delivery of the section of Phase Two between the West Midlands and Crewe (Phase 2a). This document now sets out the Economic Case for the remainder of the Phase Two route (Phase 2b), from Crewe to Manchester and Golborne, and from the West Midlands to Leeds and Church Fenton.

1.5 The Western Leg of Phase 2b has a total length of 51 miles (82km). At its southern end it connects to Phase 2a to the south of Crewe. Going north, it passes under Crewe in a tunnel. At its northern end the Western Leg joins the WCML at Golborne, south of Wigan. A spur from the main line serves a new station at Manchester Airport before entering into an 8 mile (13km) tunnel to reach a new station adjacent to the existing station at Manchester Piccadilly. Following refinements developed since the 2013 consultation, we are proposing that the Western Leg also includes a rolling stock depot located to the north of Crewe, between the HS2 route and the WCML.

1.6 The Eastern Leg of Phase 2b has a total length of 123 miles (198km). At its southern end it connects to the Phase One route at Marston. At its northern end, the Eastern Leg joins the ECML via a connection near Church Fenton. The Eastern Leg includes a new station at Toton (East Midlands Hub) and a spur from the main line goes to a new station at Leeds. Following refinements developed since the 2013 consultation, we are proposing that South Yorkshire is served via a new link from the HS2 route, allowing services to join the Midland Main Line south of Chesterfield at Clay Cross,

and travel on to Sheffield Midland station. The Eastern Leg also includes an infrastructure maintenance depot located at Staveley, and a rolling stock depot at New Crofton.

The purpose of this document

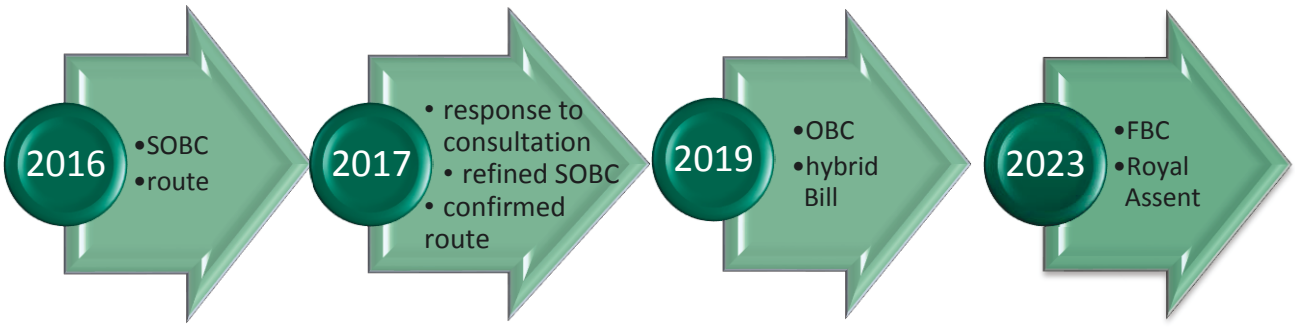
1.7 This document sets out the Economic Case for completing the full HS2 Y network, building on Phase One and Phase 2a. It is part of the Government's Strategic Outline Business Case[1] (SOBC) for HS2 Phase 2b, in line with the HM Treasury (HMT) Green Book guidelines. The SOBC stage of developing a major project outlines the high level outcomes which the project intends to deliver. The five cases are the:

- Strategic Case
- Economic Case
- Financial Case
- Commercial Case
- Management Case

1.8 HS2 Ltd's economic analysis[2] provides the basis for analysis in this Economic Case.

1.9 The scope, costs and schedule are refined as the project moves forward, and an Outline Business Case (OBC) is developed. This will be done alongside the deposit in Parliament of a hybrid Bill for Phase 2b in 2019. The business case is then further refined to give greater confidence in delivery by the time a final investment decision is taken at the Full Business Case (FBC) stage. Therefore, the designs and train service specification (TSS) referred to in this SOBC are intended to give the Government sufficient confidence in the intentions and outputs of the project to proceed, but will continue to be refined and may change as the project develops.

1.10 Below is our indicative timetable of the key stages of the process:



[1] See https://www.gov.uk/government/collections/hs2-phase-two-from-the-west-midlands-to-leeds-and-manchester
[2] *HS2 Phase Two – Phase 2b Economic Case*, HS2 Ltd (November 2016).

How we assess the case

1.11 The route decision on Phase 2b represents an investment decision to complete the remainder of the Y network by delivering both the Eastern Leg and the remainder of the Western Leg of Phase Two. An assessment is therefore presented of both:

- The value for money of Phase 2b assuming Phases 1 and 2a of HS2 are in place
- The value for money of the full Y network of HS2 assuming Phase 1 is delivered by 2026, Phase 2a by 2027 and Phase 2b by 2033

1.12 A complete assessment of the value for money of a transport scheme requires the comparison of a range of options. We have therefore looked in detail at the case for alternatives based on enhancements to the existing rail network. All of these schemes have been compared to a common scenario that allows us to assess the incremental economic, social, environmental and public accounts impacts that each package of transport interventions may bring about.

1.13 By bringing together and summarising information on costs, benefits and risks on a number of alternative options, the Economic Case supports and informs decision making. However, it should not be seen as unequivocally providing the 'right' or only answer. Decision makers are presented with evidence against all five Cases when considering investment decisions such as HS2. Therefore while value for money is a very important consideration, other factors are also considered when selecting options for the next stage in the decision making process.

1.14 This value for money assessment adheres to the general guidance on evaluating proposals published by HMT in the Green Book and the more detailed advice provided by DfT on how to apply Green Book principles to investments in transport (WebTAG[3]). To comply with both the Green Book and WebTAG, we provide a consolidated assessment of the costs and benefits of each of the options considered.

The appraisal framework

Methodology

1.15 Our appraisal aims to capture all of the impacts – positive and negative – as well as the associated risks and uncertainty, so that the decision maker is provided with a full assessment of the pros and cons of different courses of action. Where possible, these impacts are expressed in units of money, and it is from these monetary valuations that the benefit cost ratio (BCR) – a measure of the return on the investment – is calculated.

1.16 A wide range of benefits are quantified in monetary terms, ranging from direct benefits to transport users from travel time savings, reductions in crowding and improvements in reliability, to wider economic impacts (WEIs) and environmental impacts, such as noise and air quality. There are also non-monetised impacts where we make a qualitative assessment of impacts of Phase 2b on aspects such as heritage and townscape, to inform the value for money decision in Chapter 3.

1.17 The range of monetised and non-monetised impacts of Phase 2b are set out in Figure 1.1.

[3] https://www.gov.uk/guidance/transport-analysis-guidance-webtag

Initial BCR: robust, monetised impacts	Adjusted BCR: less robust, monetised impacts	Monetised impacts not included in the BCR	Non-monetised, qualitative impacts
Travel Time Savings Crowding Benefits Noise Carbon Impact Air Quality Accidents Indirect Tax Revenue Reliability	Wider Economic Impacts (WEIs)	Landscape	Townscape and Landscape Heritage Biodiversity Water Environment Severance Physical Activity Accessibility Journey Ambience Option Values

Figure 1.1: Monetised and non-monetised impacts of HS2 Phase 2b

1.18 The PLANET Framework Model (PFM) is the tool used to assess changes in behaviour as a result of HS2. It is a complex model that provides a strategic view of the road, rail and air markets, drawing on detailed information on passenger travel from ticket sales and other data. PFM assesses the impact of HS2 on the behaviour of existing travellers who may now use a different mode, switch to HS2 or make a different trip. It also assesses the extent to which HS2 and the associated capacity released on the existing network attracts new travel demand. The outputs from PFM therefore form the basis of the benefits and revenue assessments.

1.19 WEIs are estimated using DfT's Wider Impacts in Transport Appraisal (WITA) tool. This aims to capture the benefits of knowledge sharing in agglomerations, as well as some benefits from higher employment and higher output by businesses.

1.20 There are other impacts which are not assessed as the techniques to do so need further development and in some cases there is insufficient information on their likely scale. These impacts largely constitute second order transformational effects, i.e. those impacts which are not a direct result of the transport investment – such as travel time savings – but rather those which arise as a result of those direct impacts. These can include:

- Higher foreign investment into the UK, as it is a more attractive investment location due to better transport
- Dynamic clustering, where businesses relocate to be closer together, forming clusters around well-connected places and benefiting from knowledge sharing[4]
- Workers moving to more productive jobs, in response to changes in transport costs, to areas that have higher productivity due to a variety of factors such as agglomeration and capital
- Dependent development, where property developers may react to the transport improvements from HS2 by upgrading housing stock, which could lead to regeneration

[4] Note that static clustering, which is the result of businesses effectively being closer together due to better transport links without actually moving, is already monetised in the appraisal.

1.21 We have also not included in this Economic Case a quantification of potential freight benefits that could arise from the spare capacity generated by HS2, as we do not assume a particular pattern of additional freight services.

1.22 Our assessment of the costs incorporates the entirety of expected costs to Government of the HS2 scheme. This includes the capital costs of building the scheme and the operating costs of running the railway once opened, from which the revenue arising from additional rail passengers is deducted. To estimate operating costs we combine a series of assumptions on the operational characteristics of HS2 and the existing rail network with our knowledge of the cost of operating rail services. Capital cost estimates originate from HS2 Ltd, who undertake detailed cost estimation exercises and supplement this with an allowance to reflect the risks and uncertainties associated with those estimates (including contingency).

1.23 It is important to note that benefits and costs are valued across the British rail network as a whole rather than solely focusing on HS2. For example, the analysis captures the benefits to those passengers who may not use HS2 services but benefit from services that could use some of the capacity HS2 releases on the existing network. The benefits as described above are combined with the net costs to Government to derive a BCR.

Updating our appraisal framework

1.24 We have made a number of significant updates to improve our modelling and appraisal framework, ensuring we are using the most up-to-date information and are consistent with the latest guidance in rail scheme appraisal. HS2 Ltd have produced a full report[5] on the changes we have made to our analysis for this Economic Case.

1.25 The highlights of these changes are described below (with an estimate of the impact on BCRs) and are shown in Figure 1.2:

- Model updates have a slightly positive impact on BCRs overall (+0.2). This category of changes includes corrections to train service stopping patterns and train capacities in the previous version of PFM
- Also shown is the negative impact (-0.4) of updating 'do minimum' (non-HS2) rail services to reflect latest DfT commitments including TransPennine Express, Northern and the addition of an open access service on the West Coast Mainline
- The demand update has a large positive impact on BCRs (+1.6). This category includes updating the base year demand in the model to 2014/15, changing from a bespoke HS2 demand cap (at a certain level of demand) to a standard rail approach 20 years in the future, and updating forecasts of travel demand drivers in line with recent guidance
- Appraisal changes have a negative impact on BCRs (-0.9)[6]. The largest impact comes from moving from the standard 'rule of a half' to 'numerical integration' (a more accurate method of calculating passenger user benefits). Revenues have been revised down due to changes in assumed future Retail Price Index (RPI) and Gross Domestic Product (GDP) deflators. We have also adopted DfT's latest values of travel time following a detailed study, which has a modest positive impact

[5] *Summary of Key Changes to the Economic Case Since 2015*, HS2 Ltd (November 2016). Note that Figure 1.2 in this Economic Case starts from a full Y network BCR of 2.2 as presented in the DfT Economic Case in November 2015 which had already incorporated HS2-specific cost inflation, see https://www.gov.uk/government/collections/hs2-phase-two-from-the-west-midlands-to-leeds-and-manchester

[6] This differs from the impact shown in the HS2 Ltd report which includes HS2-specific cost inflation in the 'appraisal changes' step.

- The impact of scheme design on BCRs is slightly negative (-0.2). This category reflects minor route refinements which increase some journey times typically by between 1 and 3 minutes
- Adopting the M18 alignment in South Yorkshire with a Sheffield 'loop' has a small positive impact (0.1) – this is shown in more detail in Chapter 2

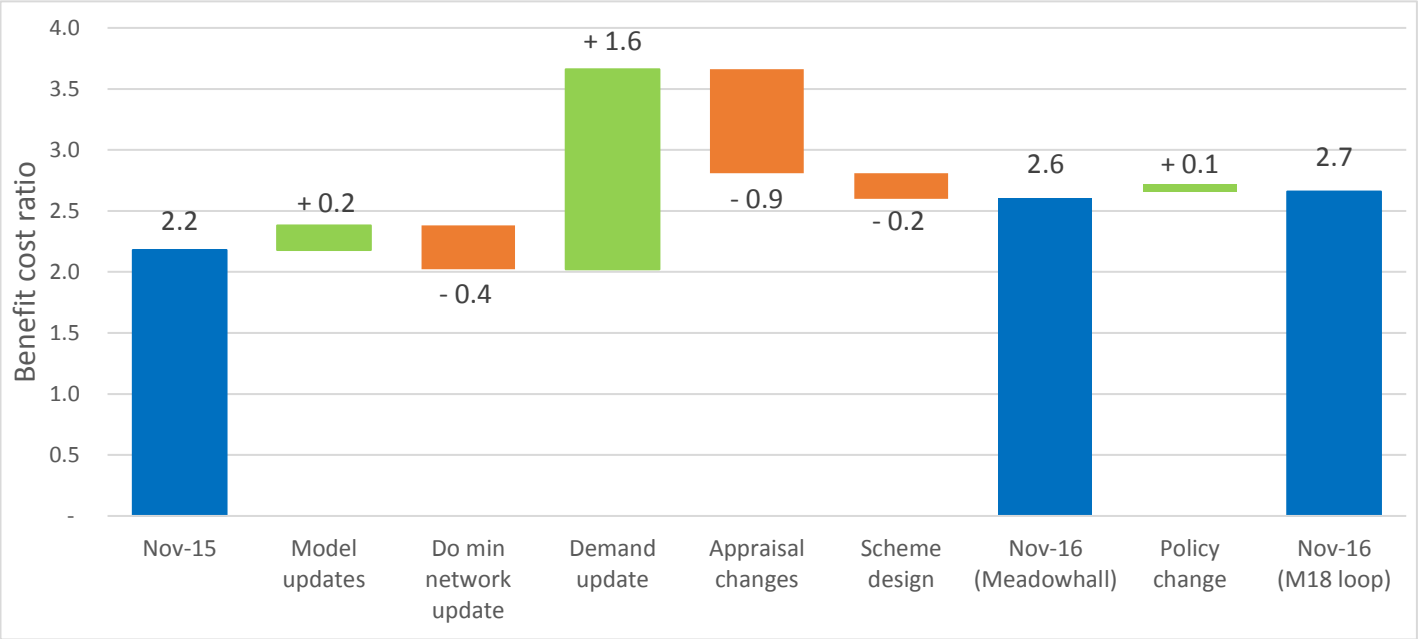


Figure 1.2: Step-through of changes to the full Y BCR last published in 2015

Risk and uncertainty

1.26 Our appraisal of HS2 requires a number of assumptions to be made about factors that will influence the assessment of benefits, revenues and costs. Where these factors have statistically robust probabilities of taking a range of values, these ranges have been used to produce 'risk analysis' of the HS2 scheme: a spread of BCR values and their likelihood of occurring. The factors considered in the risk analysis include: economic growth, values of travel time savings and rolling stock costs.[7]

1.27 It is worth noting that, due to the change in the demand cap from a fixed level to a fixed year (2036), the variation in factors considered in the risk analysis will affect the level of demand in 2036 and in all years thereafter. Previously this analysis affected the year in which the fixed-level cap occurred (changing it by a few years) which had a smaller effect on benefits. Therefore, risk analysis spreads of probable BCRs in this Economic Case are wider than shown in previous Economic Cases.

1.28 Where these influential factors are more uncertain, we present a number of scenarios that vary the assumptions used in estimating benefits and costs, to explore the potential impact on the value for money case for Phase 2b and the whole Y network. Again, the fixed year demand cap means that sensitivity tests of changes in assumptions that affect demand, benefits or revenues are likely to have a larger impact on appraisal results than in previous Economic Case modelling.

1.29 There are also scenarios presented in this Economic Case that look at alternative policy assumptions regarding the Phase 2b route in South Yorkshire.

[7] For more information on how risk analysis is conducted, see the HS2 Ltd report *Risk analysis for the HS2 economic case – Technical documentation* (November 2016).

The strategic goals of HS2

1.30 As set out in more detail in the Strategic Case for Phase 2b, the strategic objectives of HS2 and of Phase 2b are to improve capacity and connectivity, and therefore support economic growth.

1.31 The economic benefits of providing additional capacity are assessed through the services we assume to run in the future. This includes services on the classic network that are made possible by moving certain intercity services onto HS2, making capacity available for commuter services. These are examples of services that could run in the future, assumed here for modelling purposes, to give an indication of the level of benefits the increased capacity from Phase 2b can provide. We have not estimated any economic benefits from any future increase in freight capacity that could be possible following the introduction of Phase 2b.

1.32 We assess the economic benefits of connectivity by looking at the value of improving journey times – not just to London, but also connecting northern cities to the Midlands.

1.33 HS2 Phase 2b has the potential to support a step-change in economic growth. In addition to reducing transport costs and therefore production costs ('business user benefits'), faster journey times and increased frequency and reliability of rail services between areas can help generate benefits by bringing firms and people closer together to:

- Encourage sharing of knowledge and best practice ('agglomeration benefits')
- Increase output for some firms (those in markets with imperfect competition)
- Improve access to potential jobs and encourage labour market participation

1.34 These benefits are estimated by looking at the WEIs generated by Phase 2b, using DfT's WITA tool.

1.35 We can also estimate the potential increase in GDP associated with the social benefits brought about by completing HS2's Y network. Since producing the update to the HS2 business case in November 2015, DfT has worked closely with leading transport economists to develop a conservative standardised approach to estimating how the welfare benefits of transport schemes translate into impacts on economic output. DfT guidance[8] (currently out for consultation) provides a simple equation which can be applied to the business user benefits and wider economic impacts in the Economic Case to estimate the impact on the UK economy related to the social benefits of HS2.

1.36 Adopting this approach in anticipation of the new guidance, we provisionally estimate that over 80 per cent of the welfare benefits of the HS2 full Y network, worth around £86bn (in present value terms), would be realised as higher GDP over the course of the appraisal period[9].

1.37 Phase 2b in particular makes a substantial contribution to achieving these GDP impacts, generating £44bn (51 per cent) of the full Y network GDP impacts over the appraisal period. Completing Phase 2b of the HS2 network therefore has the potential to unlock growth and regeneration across the UK. As the GDP impact is constructed from the static welfare impacts, the diagram below shows the crossover between welfare and GDP impacts.

[8] https://www.gov.uk/government/consultations/transport-investment-understanding-and-valuing-impacts
[9] For HS2 the appraisal period continues to 60 years after the opening of Phase 2b in 2033.

Figure 1.3: Estimated GDP and welfare impacts of HS2 Phase 2b

1.38 The *Transport Investment and Economic Performance* report[10] (October 2014) states that methodologies for estimating the impact of transport schemes on productivity need to be context-specific and that there is no single correct encompassing method. In the context of HS2, the approach to estimating GDP impacts in the draft guidance does not capture the full transformational economic impacts of HS2 on the economy.

[10] https://www.gov.uk/government/publications/transport-investment-and-economic-performance-tiep-report

In particular, the approach does not account for changes in spatial patterns of economic activity as businesses and people cluster in areas with improved transport connectivity and the potential economic gains from regeneration along the HS2 route. This guidance will continue to be developed in consultation with the wider academic community.

1.39 As set out in the Strategic Case, underlying the strategic objectives for HS2 are a number of supporting goals for the scheme, including passenger experience and environmental impacts. Passenger experience benefits are assessed in this Economic Case through monetising improved access to stations and reductions in walk time. As part of the non-monetised impacts considered in Chapter 3, there is the potential for improvements in journey quality from new rolling stock and stations. A number of sustainability impacts are monetised as part of the BCR, such as the noise impacts of HS2 trains and carbon impacts from the reduction in car use. There is a consideration of non-monetised impacts on the natural and cultural landscape.

2. The case for completing the Y

Appraisal of benefits and costs

2.1 In this chapter we set out the estimated benefits, costs and revenues from delivering Phase 2b and therefore the whole HS2 network. The proposed route for Phase 2b is as described in Chapter 1, with the Eastern Leg via the M18 alignment having both northern and southern connections to the existing network to serve Sheffield Midland (termed the 'M18 loop')[11].

2.2 The central benefit cost ratio (BCR) for Phase 2b as an increment over Phases One and 2a is estimated as 2.5 without wider economic impacts (WEIs) and 3.1 including WEIs.

2.3 Figure 2.1 below sets out each of the appraisal elements that comprise the BCR, for both Phase 2b as an increment and for the whole Y network. The table shows that Phase 2b delivers £52bn in total benefits, accounting for around half of the benefits of HS2 as a whole.

	BCR components (present value, 2015 prices)	Phase 2b	Full network
1	Net transport benefits	£41.2bn	£81.5bn
2	Wider economic impacts (WEIs)	£11.2bn	£21.3bn
3	Net benefits including WEIs = (1) + (2)	£52.4bn	£102.8bn
4	Capital costs	£23.5bn	£56.2bn
5	Operating costs	£16.4bn	£27.0bn
6	Total costs = (4) + (5)	£40.0bn	£83.1bn
7	Revenues	£23.3bn	£44.5bn
8	Net costs to Government = (6) - (7)	£16.7bn	£38.7bn
9	**BCR without WEIs (ratio) = (1)/(8)**	**2.5**	**2.1**
10	**BCR with WEIs (ratio) = (3)/(8)**	**3.1**	**2.7**

Figure 2.1: BCRs for Phase 2b (M18 loop) and the full Y network

2.4 The capital cost shown for Phase 2b (M18 loop) contains both rolling stock capital costs and the present value (PV) discounted infrastructure capital cost from the 2015 Spending Review funding allocation, shown in the Financial Case[12]. 40 per cent optimism bias (OB) has been applied to construction costs.

[11] Phase 2b is assumed to include constructing a junction north of Sheffield near Clayton and a connection (along with some electrification of the classic line) to the south of Sheffield near Clay Cross, which allows HS2 services to run onto the existing rail network to serve Sheffield Midland. The Midland Main Line is assumed to be electrified in our baseline.
[12] HS2-specific construction cost inflation has been applied from financial years 2015/16 to 2020/21.

2.5 Of the benefits of Phase 2b (as an increment) shown above, the largest driver is the improvement in journey times which accounts for £21bn in transport user benefits. However, over half of the benefits of Phase 2b are not due to speed: around £16bn of benefits are attributed to the improved capacity and connectivity benefits that Phase 2b provides, reducing disbenefits of crowding, wait time and interchanging between services. The remaining benefits are attributed to other impacts including reliability and wider economic benefits.

2.6 The WEIs of Phase 2b are estimated at around £11bn, around half of the WEIs for the whole of HS2. The breakdown of WEIs shown in Figure 2.2 below indicates that agglomeration benefits account for almost 70 per cent of the WEIs for Phase 2b.

Wider economic impacts (PV, 2015 prices)	**Phase 2b**	**Full network**
Agglomeration	£7.7bn	£14.3bn
Imperfect competition	£3.2bn	£6.4bn
Labour market impact	£0.3bn	£0.6bn
Total wider economic impacts	**£11.2bn**	**£21.3bn**

Figure 2.2: Wider economic impacts for Phase 2b and the full Y network

2.7 The full Y network is shown to have a central BCR of 2.1 without WEIs and 2.7 including WEIs. This has increased from the 2015 Economic Case estimate for the full HS2 network of 2.2 including WEIs mainly due to the changes in our modelling approach outlined in Chapter 1 above, of which the increase in background demand has had the largest impact.

2.8 The results presented above are modelled from one potential train service specification (TSS) that could be operated with Phase 2b in place. This TSS has been used for modelling purposes and we would expect it to be refined over the scheme's lifetime until opening date. It is shown diagrammatically in annex B.

2.9 As explained in Chapter 1 we also examine the robustness of these BCR results by undertaking risk analysis: the likelihood of the BCR including WEIs for Phase 2b taking any particular value due to variation in a small number of factors for which we have probabilistic distributions. The factors considered in the risk analysis include economic growth, values of travel time savings and costs (including rolling stock costs and the Quantified Risk Adjustment for Phase One).

2.10 The risk analysis results for Phase 2b and for the full HS2 network are shown in Figure 2.3 below. The graphs indicate that there is a 91 per cent chance of Phase 2b having a BCR above 2.0 and an 81 per cent chance of the full Y network having a BCR above 2.0.

2.11 It is important to note that in deriving these results all other scenario assumptions for which we do not have a probabilistic representation of uncertainty are kept constant. As such, when taken in isolation they only offer a partial view of the uncertainty around the HS2 BCRs. In order to derive a better understanding of uncertainty, the risk analysis has been combined with a number of discrete sensitivity tests around key scenario variables. These tests are described in the following sections.

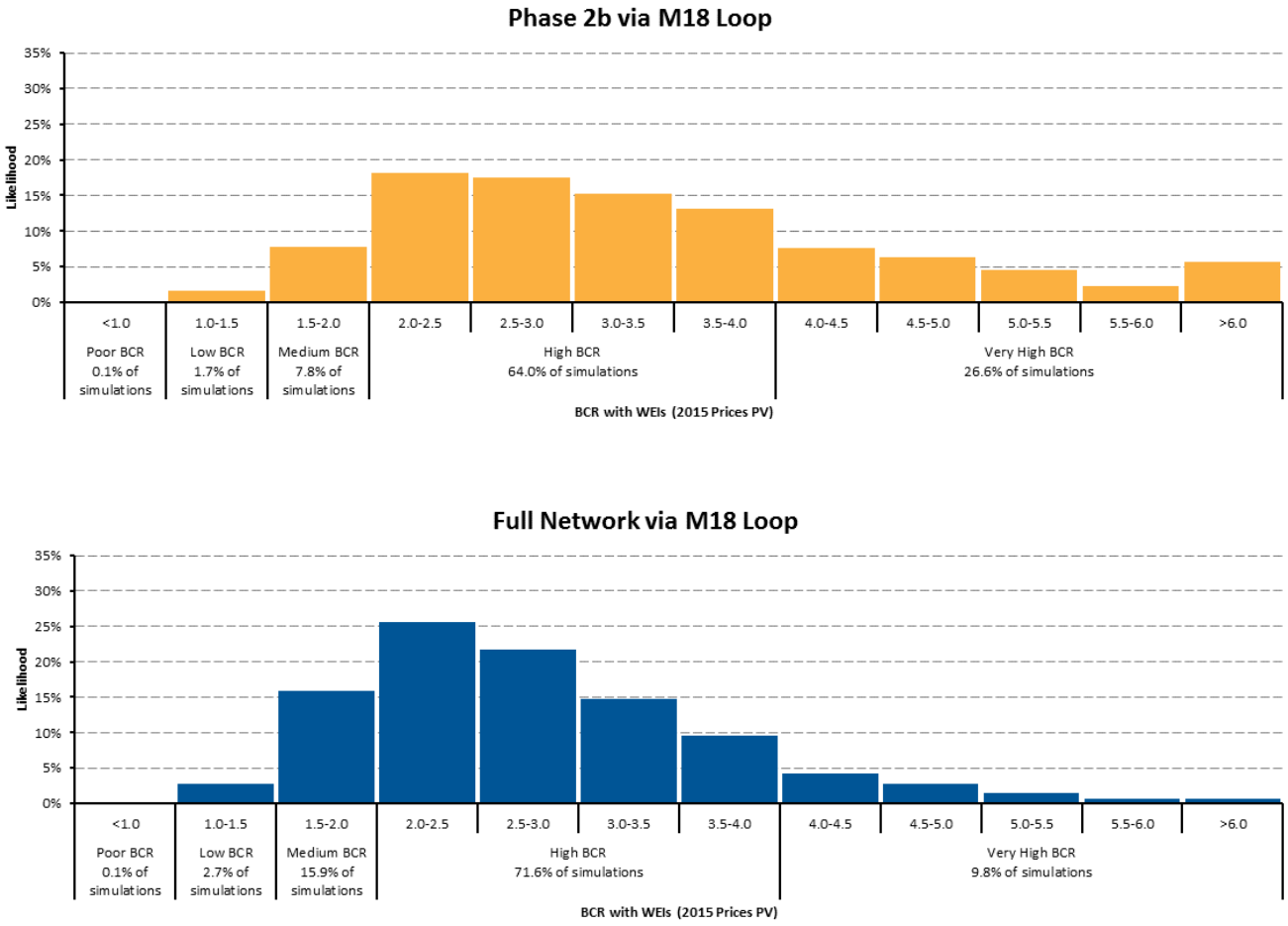


Figure 2.3: Risk analysis for Phase 2b and the full Y network

M18 southern connection only

2.12 The M18 route through South Yorkshire could also be constructed with only a southern connection to the existing network for HS2 services to serve Sheffield Midland. In other words, without the northern junction in the Clayton area which allows connectivity of HS2 services from Sheffield to Leeds. We have examined a scenario in which only the southern connection to the existing network is built, serving Sheffield Midland with two trains per hour from London termed 'M18 spur'.

2.13 The appraisal results for Phase 2b and the whole Y network are shown in Figure 2.4 below. Serving Sheffield Midland with two trains per hour from London (with no connectivity of HS2 services from Sheffield to Leeds) has a central BCR of 3.2 (including WEIs) for Phase 2b and 2.7 (including WEIs) for the whole HS2 network.

(PV, 2015 prices)	Phase 2b	Full Y network
Net benefits (excluding WEIs)	£41.2bn	£81.5bn
Net benefits (including WEIs)	£52.5bn	£102.8bn
Net costs to Government	£16.1bn	£38.7bn
BCR excluding WEIs	**2.6**	**2.2**
BCR including WEIs	**3.2**	**2.7**

Figure 2.4: BCRs for Phase 2b (M18 spur) and the full Y network

2.14 The costs shown above include discounted infrastructure capital cost of the 2015 Spending Review funding allocation subtracting the potential saving from not building the northern junction.

2.15 The analysis suggests that if only a southern connection were built to the preferred M18 route through South Yorkshire, this scheme ('M18 spur') would be considered high value for money. The scenario presents a marginally higher BCR for Phase 2b with a southern spur only compared to the full loop but this is not considered to be a significant difference. The spur delivers fewer of the scheme's original strategic objectives than the loop in terms of improving connectivity to Sheffield and South Yorkshire. Furthermore, we have modelled only two trains an hour from Sheffield to Leeds when the infrastructure provided on Phase 2b could be used for more services between South and West Yorkshire, supporting Transport for the North's Northern Powerhouse ambitions. There could be a good value for money case to run additional services between Sheffield and Leeds, which is not covered in the analysis to date. These additional benefits are not captured in our current appraisal of the loop.

Meadowhall route

2.16 We have also appraised the previous proposal for the Phase 2b Eastern Leg serving South Yorkshire via Meadowhall station, modelling the 2013 consulted TSS. The appraisal results for Phase 2b and the whole Y network considering a Meadowhall alignment are shown in Figure 2.5 below. This scenario is shown to have a central BCR of 3.0 (including WEIs) for Phase 2b and 2.6 (including WEIs) for the whole HS2 network, slightly lower than the results for our preferred Phase 2b route.

(PV, 2015 prices)	Phase 2b	Full Y network
Net benefits (excluding WEIs)	£39.3bn	£79.6bn
Net benefits (including WEIs)	£50.4bn	£100.8bn
Net costs to Government	£17.0bn	£38.9bn
BCR excluding WEIs	**2.3**	**2.0**
BCR including WEIs	**3.0**	**2.6**

Figure 2.5: BCRs for Phase 2b (Meadowhall) and the full Y network

2.17 The cost shown above is higher than the cost shown for the proposed Phase 2b route to reflect the savings from the M18 route, as shown in the Financial Case.

2.18 The risk analyses for Phase 2b and the full HS2 network in this alternative South Yorkshire scenario are shown in Figure 2.6 below. The graphs indicate that there is an 89 per cent chance of Phase 2b having a BCR above 2.0, and an 80 per cent chance of the full Y network having a BCR above 2.0. This is similar to the preferred Phase 2b route via the M18 alignment, shown above.

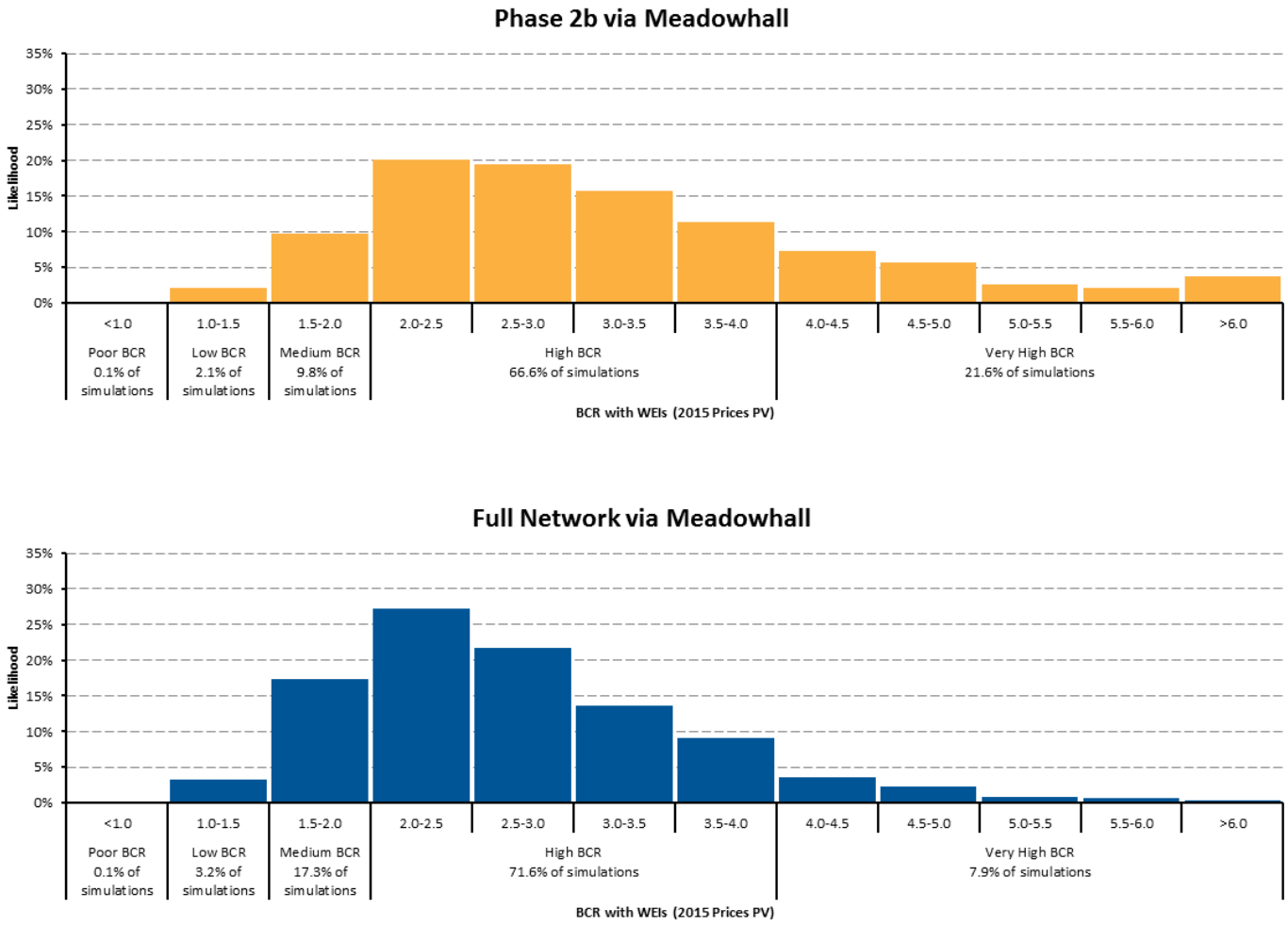


Figure 2.6: Risk analysis for Phase 2b and the full Y network

Robustness of the assessment

2.19 In line with DfT guidance, our appraisal of the impacts of HS2 extends for 60 years after scheme completion (and therefore until 2093). It is important to take this long term view for infrastructure that will be long-lived and which could continue to deliver benefits well beyond the end of the appraisal period. However, accurately forecasting benefits and costs such a long way into the future is inherently challenging and subject to significant uncertainties and unknowns. It is important therefore to understand the robustness of the Economic Case to changes in those factors in the appraisal which have the largest impact on the results.

2.20 A spread of BCRs has been shown above to account for variations in the probability of different events occurring (known as 'risk analysis'). In addition, we have also explored a number of sensitivity tests which test the robustness of our results in response to a change in some of our key assumptions on costs, demand and appraisal. We have reported the impact on the median BCR for Phase 2b taken from risk analysis spreads (which can be found in HS2 Ltd's Economic Case analysis).

2.21 Due to the long lead time in demand modelling, the original 'reference case' for this Economic Case was the Eastern leg route of Phase 2 serving Meadowhall. This means that the sensitivity tests regarding demand and appraisal assumptions shown in this chapter are on the results of the Meadowhall scenario results. However, we don't expect there to be any material differences in conclusions drawn, since our

preferred M18 alignment provides similar BCRs to the Meadowhall route and the vast majority of route and journey times are similar. We believe that the sensitivity testing shown in this chapter would apply equally to the preferred Phase 2b alignment. We will update this testing for the preferred route following consultation. Sensitivity tests on cost assumptions are on the results of the proposed Phase 2b route (the M18 loop scenario).

Cost assumption: Further efficiency savings

2.22 The capital cost assumed for Phase 2b (M18 loop) includes a discounted infrastructure capital cost from the 2015 Spending Review funding allocation. As set out in the Financial Case, to ensure that the HS2 network delivers value for money HS2 Ltd has investigated potential opportunities to reduce cost of the network. To date, an additional £2.4bn of savings (undiscounted, excluding OB and before construction cost inflation) has been identified for Phase 2b beyond the Spending Review allocation.

2.23 We have examined the impact on the BCR if we were to successfully deliver these efficiency savings, reducing the capital cost of Phase 2b (benefits, revenues and operating costs are not affected). The results indicate that this could increase the median BCR of Phase 2b to 3.7 and of the full Y network to 2.8.

Cost assumption: Optimism bias

2.24 In the results above we have assumed an OB factor of 40 per cent added to Phase 2b construction costs. As set out in the Financial Case, this assumption is a blended rate reflecting a detailed, bottom-up attribution of different assets to different risk categories, with additional mitigations. The blended rate is consistent with the Green Book Supplementary Guidance on OB, and has also been validated using a reference class forecasting method which compares the outturn cost and estimated cost of similar historic projects.

2.25 Nevertheless, a sensitivity test of a higher OB assumption of 50 per cent has also been considered. Assuming 50 per cent OB on Phase Two (M18 route) infrastructure costs reduces the median BCR for Phase 2b by 0.2 and for the HS2 network by 0.1.

Demand assumption: GDP growth

2.26 One of the largest drivers of rail demand forecasts is the assumption made about GDP growth. We have examined the impact on the BCRs for Phase 2b and the whole HS2 network of increasing or decreasing the Office for Budget Responsibility's forecast GDP growth rate by 10 per cent in each year. For example, a 2 per cent rate of growth in the central GDP forecast would become 2.2 per cent in the high GDP scenario. By 2036, in the high GDP test, the level of GDP is 5 per cent higher than current forecasts, and in the low test is 4.8 per cent lower.

2.27 The results indicate that increasing GDP growth beyond current projections would increase the median BCR of Phase 2b by 0.7 compared to the Meadowhall scenario. The low GDP test reduces the median Phase 2b BCR by 0.6.

Demand assumption: Population growth

2.28 Another important assumption in our appraisal is the approach taken to extrapolating benefits and revenues beyond our modelled year in 2036. Modelling for this Economic Case assumes that demand is capped 20 years after our appraisal year (i.e. in 2036), following the general principle that beyond a certain time horizon it is difficult for models to forecast rail demand with accuracy. This is a change from previous HS2 Economic Case modelling, which used a 'level' demand cap (demand for rail is capped at a specific level of long distance journeys). This change has been implemented to bring HS2 appraisal in line with standard DfT rail approach set out in WebTAG. If we had continued with the previous HS2 demand cap approach using a level cap with updated higher demand, the demand cap may have applied as early as 2030 (before the opening year of Phase 2b in 2033)[13].

2.29 While projecting future demand is inherently uncertain, the application of a demand cap could be regarded as conservative: since the 1990s rail demand growth has been strong, particularly on the routes that HS2 intends to serve. Our modelling indicates an average growth rate in long distance rail demand of 2.6 per cent per year between 2014 and 2036. There is no evidence to suggest that demand will stop growing only three years after Phase 2b opens. If we assume there is population growth beyond 2036, the demand cap as applied in this analysis also implicitly assumes a reduction in the rate of long distance trips made per person.

2.30 We have examined the impact of allowing benefits and revenues (driven by demand) to increase after the introduction of the cap year, in line with long term projections for population growth from the Office for National Statistics (ONS). In this case, the median BCR for Phase 2b (Meadowhall) would be around 3.5, compared to 3.0.

Appraisal assumption: Fares policy assumptions

2.31 The relationship between rail fares and the Economic Case for HS2 is complex. It is relevant to note that the results presented here assume the same fares are charged across both the HS2 network and the existing rail network. The Economic Case for HS2 is not predicated on higher fares being charged for HS2 services.

2.32 Our central assumption is that fares rise at a rate equivalent to growth in the Retail Price Index (RPI) until 2020 and thereafter fares are assumed to rise at RPI plus one per cent (an assumption commonly applied in the appraisal of rail schemes) until 2036. If fares were assumed to be lower than this then demand for rail (and therefore HS2) would increase faster than this. The fares assumption applied also affects forecast revenue[14].

2.33 We have examined the impact on the median BCR for Phase 2b of varying the assumption on fares after the current Parliament. Our low fares test looks at the resulting BCRs if all rail fares were to continue to rise in line with RPI only after the current Parliament. We have also looked at a high fares test in which all rail fares rise in line with RPI plus two per cent after 2020.

[13] If we had continued with the level demand cap this would have reduced the median BCR of Phase 2b to around 2.1, since the cap applies before the opening of Phase 2b. The median BCR for HS2 as a whole would be around 2.0.
[14] Following Green Book guidance we do not add a deadweight cost from collecting tax revenue, therefore raising fares always reduces the BCR of a scheme. Increasing fares reduces transport user benefits, but increasing tax instead has no deadweight cost.

2.34 The low fares test is shown to increase the median BCR of Phase 2b to 4.2, compared to the Meadowhall case of 3.0. The high fares test is shown to reduce the median BCR of Phase 2b to 2.1 compared to the Meadowhall case of 3.0. Note that in this test the median BCR for the whole Y network falls to 1.9 from 2.6.

Appraisal assumption: Reliability benefits

2.35 It is expected that HS2 will result in an improvement in the reliability of rail services. However until the line is operational and therefore the full extent of the interactions between HS2 services and the existing rail network become known, the scale of reliability benefits is uncertain. Reliability benefits currently account for around 10 per cent of the benefits of HS2 (and of Phase 2b). We are undertaking further work to improve our modelling of HS2 performance which may refine these numbers.

2.36 We have examined the effect on the BCR results for the whole HS2 network of removing any reliability benefits from the modelling, assuming that HS2 is no more reliable than the existing network. This extreme sensitivity test reduces the BCR for the full HS2 network to 2.0 compared to the Meadowhall route full Y network BCR of 2.6.

3. Value for money

How we assess value for money

3.1 The Economic Case needs to reach a conclusion on whether the Phase 2b scheme represents value for taxpayers' money. The analysis in Chapter 2 quantified the economic impacts of Phase 2b. This quantified analysis forms the basis of the value for money assessment of the scheme proposed.

3.2 There are limits to the ability of a single benefit cost ratio (BCR) to generate informative conclusions on value for money. To reflect the long term forecasting horizon required when considering such a project, combined with its inherent scale and complexity, it is appropriate to consider how robust the value for money of Phase 2b remains across a range of possible future scenarios. This analysis was also outlined in Chapter 2.

3.3 To compare across schemes, WebTAG specifies value for money categories within which schemes can be placed, and the table below describes these categories. When categorising a scheme it is relevant to not only take account of the BCR but also the associated risks and uncertainty.

Value for Money Category	BCR
Poor	Less than 1.0
Low	Between 1.0 and 1.5
Medium	Between 1.5 and 2.0
High	Between 2.0 and 4.0
Very High	Greater than 4.0

Figure 3.1: Value for money categories

3.4 The results set out in Chapter 2 showed that our proposed route for Phase 2b (the 'M18 loop') has a central BCR of 2.5 excluding Wider Economic Impacts (WEIs) and 3.1 with WEIs, which indicates that the scheme is high value for money. HS2 as a whole network has a central BCR of 2.1 without WEIs and 2.7 with WEIs, so is also considered a high value for money scheme.

3.5 The risk analysis indicates that when varying factors in our modelling that have a probability of taking a range of values, Phase 2b has a 91 per cent chance of having a BCR of at least 2.0 and therefore would be reliably considered to be high value for money. The likelihood of Phase 2b having a BCR less than 2.0 was estimated at less than 10 per cent. It is worth noting that only a small number of variables in our modelling have these probability distributions, and in deriving the risk analysis results all other assumptions are kept constant. As such, when taken in isolation they only offer a partial view of the uncertainty around the HS2 BCR.

3.6 The sensitivity tests set out above show that the BCR for Phase 2b and the wider HS2 network can vary with the assumptions used, with assumptions such as high GDP, allowing benefits to increase in line with population growth, delivering efficiency savings and low fares all having a positive impact on the BCR. The largest positive impact is shown to be the low fares assumption, which increases the median BCR of Phase 2b (the Meadowhall scenario) to 4.2.

3.7 Conversely there are a number of assumptions which are shown to have a negative impact on the BCR, such as lower GDP growth, higher optimism bias, higher fares or removing reliability benefits. Again the fares assumption has the largest impact on the results: in the high fares tests the median BCR (for the Meadowhall scenario) falls to 2.1. Therefore the value for money of Phase 2b is considered to be robust to variations in the assumptions on demand, costs and appraisal examined.

3.8 As explained in Chapter 1, there are also impacts of Phase 2b that are not included as part of the BCR appraisal. These are outlined in the following sections.

Landscape impacts

3.9 The assessment of landscape impacts has two complementary approaches:

- Quantitative appraisal of the landscape impacts based on the value to society of the different types of underdeveloped land traversed by HS2 and the current scope of mitigations. The appraisal applies the guidance outlined in DfT's value for money assessment guidance[15]. This approach has the benefit of providing a monetary assessment but is based on very high level data and limited categorisation of landscape types
- Qualitative appraisal based on an understanding of natural and cultural features, the character of the specific areas and the impact that the line and the current scope of mitigations will have on them. This results in a qualitative assessment of the impacts consistent with the approach outlined in WebTAG

3.10 The quantitative approach uses monetised values for categories of landscape type on either side of the line of route to estimate a reduction in the monetary value of the land from the introduction of Phase 2b, accounting for mitigations. Two types of adjustments are applied: firstly for any existing loss of land value from current infrastructure such as roads, motorways and rail lines, and secondly for any mitigations applied to the Phase 2b line itself such as tunnels and cuttings.

3.11 Our monetised estimates of the disbenefits of landscape impacts are presented in Figure 3.2 below. Two values are shown reflecting different approaches to the period over which this impact is subjected to appraisal. The methodology to assess the value of underdeveloped land has recommended valuing landscape impacts in perpetuity[16]. However, the typical appraisal period for a transport project is 60 years after scheme opening, beyond which uncertainty around future conditions prevents us from forecasting benefits and costs.

[15] https://www.gov.uk/government/publications/value-for-money-advice-for-local-transport-decision-makers
[16] http://webarchive.nationalarchives.gov.uk/20050111222833/http:/www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_606459.hcsp (Annex 3)

Appraisal period	Indicative disbenefit (PV, 2015 prices)
In perpetuity	£2.3bn
To 2093	£1.0bn

Figure 3.2: Landscape impacts of Phase 2b

3.12 If either value of landscape disbenefit shown above were included in the BCR calculation, it would reduce the central BCR for Phase 2b by around 0.1. However, the extent to which we can incorporate an estimate accurately into our value for money assessment is restricted by the inherent limitations of the methodology applied. DfT makes every effort to be as thorough and rigorous as possible by using methods outlined in its guidance to quantify landscape impacts, though there remains inherent uncertainty and subjectivity applied in the assessment.

3.13 The second approach outlined below under non-monetised impacts is based on more detailed and comprehensive information on both townscape and landscape impacts, but does not produce a monetary assessment. We expect the approaches to overlap in part, therefore the resulting assessment is based on a balanced judgement of both appraisals.

Non-monetised impacts

3.14 DfT's guidance set out in WebTAG requires us to consider any impacts that cannot be robustly translated into monetary values by making a qualitative assessment based on the inputs of experts from the relevant fields. The results of this assessment for Phase 2b are summarised in Figure 3.3 below, using analysis in the Sustainability Statement[17] for Phase 2b.

3.15 The assessment below considers permanent impacts from Phase 2b on the natural and cultural environment around the proposed route and on passenger experience, beyond the monetised benefits[18]. There are also likely to be temporary impacts on noise and air quality that occur during construction of the route. These have not been assessed at this stage of scheme design.

3.16 Consideration of the additional environmental impacts is not believed to alter the value for money assessment of Phase 2b. We will continue to review our assessment of non-monetised impacts as the HS2 scheme design progresses.

[17] https://www.gov.uk/government/publications/hs2-phase-2b-sustainability-statement-2016. Note that the Sustainability Statement has assessed the impacts of the Phase 2b route with a southern spur into Sheffield Midland and a possible location of a northern junction, and has not considered any additional impacts of services using the northern junction to run between Sheffield and Leeds.

[18] No assessment has been made of security or personal affordability impacts at this stage of the project.

Impact	Assessment	Comment
Landscape & Townscape	Moderate Adverse	Some sections of route will have major impacts on landscape character and wider countryside. Regeneration of areas around stations may ultimately improve townscape impacts.
Water Environment	Moderate Adverse	Major waterways diverted, flood risk and minor potential ground water impacts.
Heritage	Moderate Adverse	Some heritage sites will be adversely affected and 6 Grade II buildings may be demolished.
Biodiversity	Moderate Adverse	Potential for some significant impacts to regionally important and locally designated sites. More minor impacts to nationally designated sites. Impacts are subject to further review and potential mitigation.
Severance	Slight Adverse	212 dwellings could experience a degree of severance although where the route crosses roads and paths access is intact in the vast majority of cases.
Physical Activity	Neutral	Unlikely to have significant impact.
Accessibility	Slight Beneficial	Potential to improve with new stations.
Journey Quality	Slight Beneficial	New rolling stock and new stations expected to improve journey experience.
Option Values	Slight Beneficial	Improves possible journey options, potentially allowing passengers more choice of routes to their destinations.

Figure 3.3: Non-monetised impacts of Phase 2b

Extending our appraisal

3.17 The supporting analysis provided by HS2 Ltd to this Economic Case also highlights a number of factors that are not currently included in our appraisal. The modelling approach currently does not have an endogenous demand response, in which improvements in services prior to the introduction of HS2 generate more demand for these services. This could provide a larger number of potential passengers for HS2, but also potentially increases levels of crowding in some locations.

3.18 Our modelling also does not take account of businesses moving to more productive locations, and the benefits that this can ultimately bring to workers through higher employment and to consumers through lower prices. It does not include the potential benefits of property developers upgrading housing stock in reaction to improved transport links, leading to regeneration. An initial investigation into each of these areas indicates there could be significant benefits which are not yet modelled.

3.19 There are however also factors which aren't included that would worsen the appraisal, such as the welfare impacts of disruption during construction of HS2. Note that costs of rail disruption have been included in the cost estimates using the standard industry approach of looking at compensation to rail operating companies during line closures. Also, due to the lack of a robust methodology, the monetary estimates of landscape impacts are omitted from the BCR estimates and have only been considered as a sensitivity.

4. Alternatives to Phase 2b

Introduction

4.1 As discussed in the Strategic Case for Phase 2b, the Department for Transport (DfT) and HS2 Ltd have previously considered a number of alternatives to a high speed network throughout the development of HS2. This work showed that a dedicated high speed Y network is the best way to meet our strategic objectives.

4.2 This chapter sets out work undertaken to update the appraisal of possible rail alternatives to Phase 2b[19] in light of recent developments in the rail industry.

Scope of rail alternatives work

4.3 DfT asked consultants Atkins to update previous work on the strategic rail alternatives to Phase 2b to take account of:

- New rail schemes either built or committed and committed franchise timetables
- Work done by Network Rail to consider capacity on the East Coast Main Line (ECML) and the potential speed improvements on this line under "L2E4" (Leeds in two hours, Edinburgh in four)
- The acceleration of HS2 West Midlands to Crewe, so Phase 2a is now included in the baseline for appraising Phase 2b

4.4 Any alternatives proposed to Phase 2b were to designed to serve both Eastern and Western HS2 destinations together, therefore replicating as far as possible the journey times and frequencies of Phase 2b from both London and Birmingham. Following the introduction of Phase 2a, there are fewer options on the West Coast Main Line (WCML) and the alternatives work has focused mainly on different options for the ECML and Midland Main Line (MML).

4.5 In all options, a connection is proposed from HS2 Phase One to the current rail line from Birmingham to the East Midlands via Tamworth, and the WCML North of Phase 2a is upgraded with minimal variation between options. The options take different approaches to serving Leeds and Edinburgh, and options 2, 3 and 4 include building a northern section of the HS2 line between Leeds and Sheffield (the M18 route). Option 2 looks at two different lengths of high speed route. A summary of the variation between alternative options is shown below.

[19] The full report from Atkins on the rail alternatives to Phase 2b can be found at https://www.gov.uk/government/publications/strategic-alternatives-to-hs2-phase-2b

Option	Route option to Edinburgh	Route option to Leeds	Route option to Nottingham
Option 1	Via ECML	Via ECML	Via new link to HS2 Phase 1
Option 2S	Via ECML	Via new link to HS2 Phase 1 and **short** new section of HS2 M18 route	Via new link to HS2 Phase 1
Option 2L	As 2S	As 2S except **longer** section of HS2 M18 route	As 2S
Option 3	Via HS2 and WCML	As 2S	As 2S
Option 4	As 2S	As 2S	Via upgraded MML

Figure 4.1: Phase 2b rail alternatives options

Appraisal results

4.6 Each alternative option has been assessed assuming Phases One and 2a of HS2 are in place. The analytical approach, assumptions and methodology for assessing the alternative options has been kept as consistent as possible with that adopted by HS2 Ltd for the assessment of Phase 2b.

4.7 The table below sets out the appraisal elements for the benefit cost ratios (BCRs) for each of the alternative options, compared to Phase 2b. These have been assessed as an increment over Phases One and 2a.

BCR Components (PV, 2015 prices)	Option 1	Option 2S	Option 2L	Option 3	Option 4	*Phase 2b*
Net Transport Benefits	£27.1bn	£29.4bn	£29.8bn	£29.6bn	£28.2bn	*£41.2bn*
Wider Economic Impacts (WEIs)	£7.9bn	£7.8bn	£8.0bn	£7.9bn	£7.9bn	*£11.2bn*
Net Benefits including WEIs	£34.9bn	£37.2bn	£37.8bn	£37.5bn	£36.1bn	*£52.4bn*
Capital Costs	£15.3bn	£18.0bn	£19.3bn	£14.8bn	£16.8bn	*£23.5bn*
Operating Costs	£12.7bn	£9.6bn	£9.5bn	£11.8bn	£10.6bn	*£16.4bn*
Revenues	£15.2bn	£16.6bn	£16.8bn	£16.9bn	£15.9bn	*£23.3bn*
Net Costs to Government	£12.8bn	£11.0bn	£12.0bn	£9.7bn	£11.5bn	*£16.7bn*
BCR (excl WEIs)	**2.1**	**2.7**	**2.5**	**3.0**	**2.4**	***2.5***
BCR (incl WEIs)	**2.7**	**3.4**	**3.1**	**3.9**	**3.1**	***3.1***
NPV (excl WEIs)	**£14.2bn**	**£18.4bn**	**£17.8bn**	**£19.9bn**	**£16.7bn**	***£24.5bn***
NPV (incl WEIs)	**£22.1bn**	**£26.2bn**	**£25.8bn**	**£27.8bn**	**£24.6bn**	***£35.8bn***

Figure 4.2: BCRs for rail alternatives compared to HS2 Phase 2b

4.8 The results shown in the table above demonstrate that all of the alternative options considered have lower benefits than Phase 2b, by at least £15 billion including wider economic impacts (WEIs). This is driven mainly by the smaller reductions in journey times that the alternatives achieve to key northern destinations when compared to Phase 2b. Using the new methodology of translating around 80 per cent of welfare benefits into Gross Domestic Product (GDP) – as set out for Phase 2b above – the GDP impacts are on average £13bn less than Phase 2b.

4.9 The alternatives are typically lower cost than HS2 Phase 2b. Present value capital costs are between £4bn and £9bn lower than Phase 2b. However, once net operating position is taken into account, the difference in net costs to Government falls to about £5bn lower on average. In Network Rail's review of the infrastructure costs for these alternatives, they suggested that it would be more appropriate to consider a range of capital costs, which on average would reduce infrastructure capital costs by around 3 per cent at the low end of the range and increase them by 15 per cent at the high end. Atkins also test a high cost sensitivity in which the present value infrastructure cost of schemes is 20 per cent higher on all options, to account for any further schemes that could be required to operate the alternatives' train services.

4.10 The BCRs for all of the alternatives indicate that these options would be considered high value for money. The BCRs are broadly similar to the central BCR for HS2 Phase 2b; two options present higher BCRs than the proposed scheme (at 3.9 and 3.4 compared to 3.1, including WEIs). In Atkins' high cost sensitivity test, the BCRs for all alternatives but one fall below that of Phase 2b (option 3 has the highest BCR, equalling Phase 2b at 3.1 including WEIs). The Net Present Value (NPV) of Phase 2b is higher than for the alternatives.

4.11 The Strategic Case sets out a broader assessment of the alternatives against the strategic objectives of HS2 Phase 2b. It shows that the alternative options struggle to achieve the same capacity (in terms of both train paths and seats), connectivity and reliability as Phase 2b. The estimated welfare and GDP benefits above show that the alternatives do not perform as strongly on the objective of providing economic benefits to the UK.

5. Conclusions

5.1 This Economic Case sets out the value for money assessment of HS2 Phase 2b. We have appraised the proposed Phase 2b route with an Eastern leg via the 'M18 route' and serving South Yorkshire by services running onto the classic network to Sheffield Midland station. Parts of this route are subject to consultation.

5.2 We have set out the modelling approach used to appraise Phase 2b, showing a number of improvements we have made to the modelling, updating assumptions about policy decisions, demand and appraisal methodology. Combined, these have had the effect of increasing the central benefit cost ratio (BCR) for the whole HS2 network to 2.7 including wider economic impacts (WEIs), from 2.2 as shown in autumn 2015.

5.3 The central BCR for Phase 2b is 2.5 without WEIs and 3.1 including WEIs. Phase 2b delivers over £52bn in welfare benefits, of which over 80 per cent can be translated into direct impacts on the UK economy (£44bn). The BCR is shown to be robust to a number of risks and uncertainties examined, testing alternative assumptions on demand, costs and appraisal (rail fares, demand cap and removing reliability benefits). These tests reduce the median BCR at most to 2.1 including WEIs in the case of high fares, or increase the median BCR at most to 4.2 in the case of low fares.

5.4 We have also considered other impacts of Phase 2b which are more difficult to monetise or include in the BCR. Estimated landscape impacts are not considered to be sufficiently robust to include in the BCR, but we consider would not be large enough to have a substantial impact on the assessment. A range of non-monetised impacts have also been assessed, ranging from 'Moderate Adverse' impacts on landscape and water environment to 'Slight Beneficial' effects on passenger experience from new rolling stock and stations. Overall Phase 2b is considered to be high value for money.

5.5 This Economic Case has also examined the value for money of alternatives to Phase 2b. The options considered are alternative investments in the existing rail network that aim to deliver the same improvements in connectivity and capacity as HS2 Phase 2b. The alternatives are shown to be high value for money schemes (BCRs are above 2), with the best-performing alternative showing a BCR of 3.9 (including WEIs). The alternatives are lower-cost than Phase 2b (between £4bn and £9bn lower present value costs) but deliver significantly (over £15bn) lower benefits. As set out in the Strategic Case, the alternatives do not perform as strongly as HS2 Phase 2b against the strategic objectives of the scheme. Overall, Phase 2b is shown to be the best way to provide the desired capacity, connectivity and economic growth benefits to the Midlands and the North.

Annex A: Journey times

A.1 The table below shows some of the key HS2 journey times. Where there are multiple services serving the same origin-destination pair with different stopping patterns, the fastest service is shown. Journey times will evolve as our understanding of the route alignment and likely route times improves.

A.2 The times in this table differ slightly from those used in the demand modelling and reported in the HS2 Ltd Economic Case. The demand modelling uses the slowest of the northbound and southbound journey times by convention, whereas the table below shows the fastest.

A.3 For this Economic Case, journey times have been re-estimated to reflect route refinements to the HS2 route and changes in assumptions on the classic network. Notably:

- Journey times on the southern section of the Eastern Leg have increased by one minute due to the route change around East Midlands airport, although the faster alignment of the M18 route reduces times further North
- Times to Crewe and Liverpool have increased due to changes in the junction design to the south of Crewe proposed as part of Phase 2a, and times to Scotland have increased slightly due to route refinements in the Culcheth area
- The journey times for Phase 2a assume that all three London to Manchester services are pathed through Crewe. This means that all three services use the additional HS2 infrastructure delivered by Phase 2a, and so all take advantage of the associated journey time improvements – rather than one of the Manchester services being routed via Stoke on Trent (but not stopping there) as is assumed in Phase One. With this third service re-routed via Crewe, we have prudently included a pathing 'penalty' to allow for possible congestion on the line between Crewe and Manchester. This corresponds to the 're-routing HS2 service' scenario set out in the Phase 2a SOBC in 2015[20]

A.4 The times shown for the M18 loop route are an indicative estimate and may change once the full feasibility of any services via this route has been undertaken.

[20] See https://www.gov.uk/government/collections/hs2-phase-two-from-the-west-midlands-to-leeds-and-manchester

Origin	Destination	Current (minutes)	Phase 2a (minutes)	Phase 2b (minutes)
London	Crewe	90	55	55
London	Manchester Airport	144	-	63
London	Manchester Piccadilly	127	91	67
London	Preston	128	88	78
London	Liverpool	134	93	93
London	Glasgow	271	223	220
London	Edinburgh	262	-	220
Birmingham Curzon Street	Manchester Piccadilly	88	-	40
Birmingham Curzon Street	Edinburgh	247	-	191
Birmingham Curzon Street	Glasgow	242	-	200
Birmingham Interchange	Glasgow	256	-	186
Birmingham Interchange	Manchester Piccadilly	106	-	37

Figure A.1: Western Leg journey times

Origin	Destination	Current	Phase 2b M18 route (minutes)
London	East Midland Hub	-	52
London	Sheffield Midland	121	85
London	Leeds	131	81
London	York	110	84
London	Newcastle	169	137
Birmingham Curzon Street	East Midlands Hub	-	20
Birmingham Curzon Street	Sheffield Midland	63	48
Birmingham Curzon Street	Leeds	118	49 / 75 (with stop at Sheffield)*
Birmingham Interchange	East Midlands Hub	-	17
East Midlands Hub	Sheffield Midland	-	26
Sheffield Midland	Leeds	40	25*

Figure A.2: Eastern Leg journey times

*Assuming a northern junction and associated electrification, indicative estimates at this stage.

Annex B: Modelled train service specification (M18 loop)