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THE ECONOMIC CASE FOR HS2

Cost and risk status report

October 2013

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Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

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Contents

List of figures

List of tables

List of acronyms

BIM	Building Information Modelling
CBRE	CB Richard Ellis
DfT	Department for Transport
EoE	Estimate of Expense
HS2	High Speed Two
IEP	Intercity Express Programme
IMD	Infrastructure maintenance depot
LLAU	Limits of Land to be Acquired
OB	Optimism bias
OHLE	Overhead line equipment
PSC	Professional service contractor
QRA	Quantified risk assessment
RSD	Rolling stock maintenance depot
TOC	Train operating company
UIC	International Union of Railways
VTAC	Variable track access charge

Executive summary

This is HS2 Ltd's status report on the cost of the full HS2 network, detailing the methodology behind the estimate that formed the basis of the 2013 Spending Round submission.

This paper describes how we have arrived at the estimated cost for the network.

The principal components of the estimated cost of HS2 are:

- capital construction cost – the cost of land purchases, design, materials and construction (including labour and power), plus allowance for risk and optimism bias in line with HM Treasury guidance[1];
- rolling stock capital costs – the purchase costs of rolling stock (trains), plus an allowance for optimism bias; and
- operating costs – the operation and maintenance of the railway infrastructure and its trains, including train crew and station staff, plus an allowance for optimism bias.

Capital cost summaries are shown for both Phase One (London-West Midlands) and the full network after the implementation of Phase Two (running lines to Manchester and Leeds). Phase One costs are based on the London-West Midlands route as amended post-consultation[2]. For the legs to Manchester and Leeds, we have used the routes contained in the Phase Two Route Engineering Reports[3].

The Spending Round 2013 set an overall funding envelope within which the Government will deliver HS2. This is £21.4 billion for Phase One, £21.2 billion for Phase Two and £7.5 billion for rolling stock.

The funding envelope is expressed in Q2 2011 prices, is set at the P95 level of delivery confidence, and excludes VAT.

This represents a reasonable settlement, allowing for substantial contingency for the project: £14.4 billion out of a total of £42.6 billion for construction, and £1.7 billion out of the £7.5 billion for rolling stock.

The Economic Case for HS2 uses figures set at a P50 level of confidence. The figures used are £19.4 billion for Phase One, £19.0 billion for Phase Two and £6.9 billion for rolling stock in 2011 prices, excluding VAT[4].

[1] HM Treasury, Green Book, http://www.hmtreasury.gov.uk/data_greenbook_index.htm
[2] Hs2 Ltd 2012, Review of possible refinements to the proposed HS2 London to West Midlands Route, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3657/hs2-review-of-possible-route-refinements.pdf
[3] HS2 Ltd, 2013, Route Engineering Report, West Midlands to Leeds & West Midlands to Manchester
[4] These costs are slightly higher than those used in the Economic Case for HS2 as they include the spending in 2012/13. As this spending has already occurred these are sunk costs, and are therefore not included in economic appraisal, in line with WebTAG 3.5.9

The Estimate of Expense that accompanies the hybrid Bill documentation is based on the agreed SR2013 budget at P50 for Phase One.

To calculate HS2 rolling stock capital costs and operating costs, assumptions are made regarding the train service specification used for Phase One and then for full network operations.

The HS2 operating cost assumptions are described in this document. See the updated Economic Case for HS2[5] for further details on the HS2 and conventional line operating costs included within the HS2 business case.

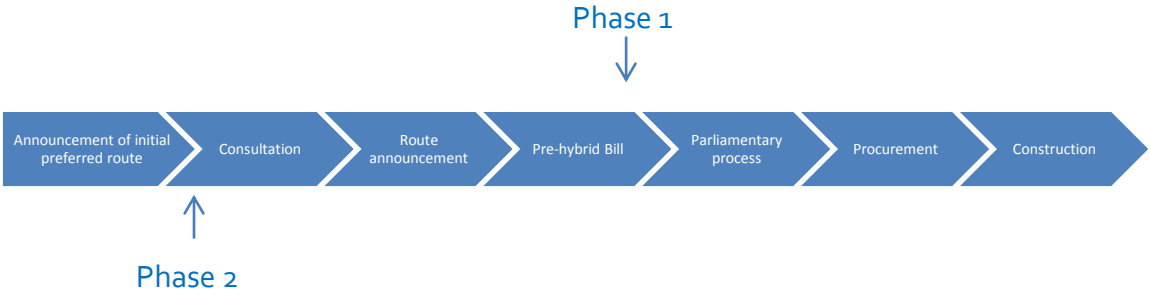
[5] HS2 Ltd 2013, *Economic Case for HS2*

1 Introduction

1.1.1 This is HS2 Ltd's Cost and Risk Status Report on the cost of the full HS2 network, detailing the methodology behind the estimate that formed the basis of the 2013 Spending Round application and the figures used in the economic case.

1.1.2 As the diagram below illustrates, the two phases of the scheme are at different stages. There is a difference in design maturity and the process behind building the estimate reflects this. For Phase One, the hybrid Bill is being finalised for deposit in November 2013; Phase Two has just entered a consultation period.

Figure 1: Project timeline



1.1.3 To reflect this, the report is now arranged into sections which detail the different phases and the relevant assumptions underlying them.

1.2 London-West Midlands

1.2.1 Phase One will run from London Euston station, through the Chilterns, South Northamptonshire and Warwickshire to Birmingham Interchange and Curzon Street station in central Birmingham. It will join the West Coast Main Line (WCML) north of Lichfield for services on to Manchester.

1.3 West Midlands to Leeds/Manchester

1.3.1 Phase Two will run from the West Midlands to Manchester and Leeds, with stations at Manchester Airport (subject to agreement of a suitable funding package), Manchester Piccadilly, the East Midlands (close to Derby and Nottingham), Sheffield and Leeds. It will connect to the existing railway at Crewe, near Golborne (south of Wigan), and south-west of York. Details of the route can be found in the Route Engineering Reports[6].

[6] HS2 Ltd, 2013, *Route Engineering Report, West Midlands to Leeds & West Midlands to Manchester*.

Figure 2: The proposed HS2 network

1.4 Estimate

1.4.1 The components of the estimated cost of HS2 are:

- capital construction cost – the cost of land purchases, design, materials and construction (including labour and plant), plus allowance for risk and optimism bias in line with HM Treasury guidance;
- rolling stock capital costs – the purchase costs of rolling stock (trains), plus an allowance for contingency; and
- operating costs – the operation and maintenance of the railway infrastructure and its trains, including train crew and station staff, plus an allowance for contingency.

1.5 Scope

1.5.1 The design upon which the base construction costs are estimated is in response to the Sponsor's Requirements. For both phases, the calculated estimate covers the following construction elements:

Table 1: Coverage of estimate

Element	Includes
Tunnels	Running tunnels, cross-passages, vent shafts and tunnel systems
Civil engineering	Earthworks, retaining walls, structures, highways
Stations	Station buildings
Depots and stabling	Depot buildings, facilities
Railway systems	Permanent way, switches and crossings, overhead line equipment, train control systems
On-network works	Works related to existing infrastructure
Land and Property	property, disturbance, severance and resale values within the planned railway corridor.

1.5.2 Added to these are corporate costs for running HS2 Ltd over a 20-year period and contract and delivery costs (design, project management and insurance).

1.5.3 The difference between the estimates for each phase is in the detail of cost applied. On Phase One, the estimates are now specific to each of the design components. On Phase Two, the relative lack of maturity has led us to use high-level costs for element types (e.g. cost per kilometre for tunnels, cuttings and embankments).

1.6 Price base date

1.6.1 For our report to Government in March 2012, and since then, we have used prices at Q2 2011, to aid transparency.

1.7 2013 Spending Round

1.7.1 As part of the Spending Round process, budgets were agreed by Government[7] for HS2 for the period to 2020/21 with an overall project total.

1.7.2 The overall level of contingency for the project as announced now reflects a 95% probability of delivery within the budget set.

[7] HS2 Ltd, 2012, Cost and Risk model report, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69741/hs2-cost-and-risk-model-report.pdf

1.7.3 For Phase One, in 2011 prices, the budget is £21.4 billion. This includes contingency of around £5.7 billion. The budget which has been set relates to the revised scope of the Phase One scheme, following consultation[8]. HS2 Ltd, as part of the settlement, has been set a target price by DfT of £17.16 billion (£15.6 billion plus 10% contingency); the remaining funding allocation will be managed by DfT and HM Treasury.

1.7.4 For Phase Two, in 2011 prices, the budget is £21.2 billion. This includes contingency of around £8.7bn. The budget which has been set relates to the consultation[9] route[10].

1.7.5 For rolling stock, in 2011 prices, the SR2013 budget allocation is £7.5bn. This includes contingency of £1.7bn.

1.8 Estimate of expense

1.8.1 The hybrid Bill seeks to obtain the necessary legal powers from Parliament to construct Phase One of the HS2 route. The Government intends to seek these powers through the deposit of a hybrid Bill later this year, currently timetabled for 25 November 2013.

1.8.2 The 'estimate of expense' is the title given to one of the components of the hybrid Bill document. It sets out a single page summary of the estimated cost of the works.

1.8.3 The format and breakdown structure of the EoE summary are set requirements and therefore will differ from tables within this document.

1.8.4 The EoE is based on the agreed SR2013 budget at P50 for Phase One.

1.9 Scope of cost estimates

1.9.1 There are a number of areas which are not within the scope of the current cost estimates. The key areas are summarised below:

1.9.2 Inflation – costs are presented in Q2 2011 prices. This reflects appropriate guidance for major projects and is an aid to transparency. Actual project outturn costs will reflect relevant inflation rates at the time.

1.9.3 VAT – HS2 Ltd is currently liable for unrecoverable VAT. In order to recover VAT incurred on the costs of constructing the railway, HS2

[8] Hs2 Ltd 2012, Review of possible refinements to the proposed HS2 London to West Midlands Route, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3657/hs2-review-of-possible-route-refinements.pdf

9 The consultation on HS2 Ltd's proposed routes for Phase Two of HS2, connecting the West Midlands with Leeds, Manchester and beyond, launched on 17 July 2013 and will run until 31 January 2014. This consultation seeks views on the proposed high speed rail route, as well as on the sustainability impacts of the proposed line of route

[10] HS2 Ltd, 2013, *High Speed Rail: Investing in Britain's Future, Consultation on the route from the West Midlands to Manchester, Leeds and beyond.*

Limited will have to register for VAT. To do so, it will have to satisfy HMRC that it intends to make taxable supplies. However, as the NAO pointed out in May, VAT 'is an internal transfer within government rather than an additional cost'[11]. It would therefore not be right to include VAT within construction cost estimates.

1.9.4 Stamp Duty Land Tax on land and property acquisitions – this is not included within the current property cost estimates. It will be payable where compulsory purchase powers are not used. Like VAT, it should be seen as an internal transfer within government rather than an additional cost.

1.9.5 Cost recovery from third parties, including any contributions from commercial or over-station developments – it is the government's policy that where third parties stand to benefit directly from HS2 they should consider making a contribution. This could take the form of funding commitments, the provision of land, or the alignment of local investment plans to deliver the widest possible set of local economic and regeneration benefits from the railway. A cautious approach has been taken and no contributions have been assumed in the cost estimates.

[11] 'HS2: A Review of Early Programme Preparation' – published May 2013. See paragraph 3.12.

2 Infrastructure capital cost estimate: Phase One

2.1 Introduction

2.1.1 Phase One of HS2 will run from Euston station, through the Chilterns, South Northamptonshire and Warwickshire to Birmingham Interchange and Curzon Street station in central Birmingham. It will join the West Coast Main Line (WCML) north of Lichfield for services on to Manchester.

2.1.2 Following the Secretary of State's announcement in January 2012, the design for Phase One has progressed from a high-level route appraisal to a full preliminary design and environmental statement sufficient to support the hybrid Bill process.

2.1.3 The previous estimates[12] for Phase One were based on large-scale route alignment drawings and generic design assumptions, and consisted of a relatively small number (250) of approximate rates (e.g. cost per km for tunnels, cuttings and embankments).

2.1.4 The design development work, undertaken over the past 18 months, included extensive survey work, refinement of the design, detailing of elements that had not been designed before (e.g. road diversions), development of plans for how we will construct the railway, land referencing, and development of environmental impact mitigation measures.

2.1.5 This process has delivered more than 5,000 plans, sections, schedules and specifications, allowing the production of a bottom-up estimate of project costs that is appropriately detailed and robust. The estimates are now specific to each of the design components and comprise more than 4,000 unit rates and allowances.

2.1.6 The current cost estimate (see Appendix A) has been prepared by a number of the industry's leading engineering consultancies, supported by embedded quantity surveying and expert contracting resources. In addition to the in-house assurance work carried out by these consultancies, the estimate has been subject to:

[12] HS2 Ltd, 2012, Cost and Risk model report, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69741/hs2-cost-and-risk-model-report.pdf

- challenge and scrutiny from our Development Partner, CH2M Hill – its expert teams have worked on Crossrail, Thames Tideway and the 2012 Olympics – and from the internal HS2 Ltd commercial team;
- peer review from industry experts in the DfT's Project Representative team.
- independent review by leading construction cost consultants; and
- audit of associated processes and procedures.

2.1.7 The project has fully embraced the efficiency challenges set out in the Government's construction strategy. Through the engagement of a dedicated team, and a programme drawing in national and international evidence and involving people across the industry, we have developed realistic assumptions about the scope for making efficiencies.

2.2 Construction base cost

2.2.1 The cost estimate for the construction and installation works has been prepared by a number of the industry's leading engineering consultancies, supported by embedded quantity surveying and expert contracting resources.

2.2.2 The construction and installation works upon which the base construction cost has been calculated cover the sum of the point estimates, including enabling and advance works, third-party costs, contractors' preliminaries, overheads, profit and risk.

2.3 Approach to other cost elements

2.3.1 In line with our previous estimates, we have applied the following allowances for Phase One:

- surveys (ground and topography) – allowance per route kilometre;
- rail possession / isolation / safety management – 2% of base construction cost for route sections affecting the existing railway; and
- train operating company compensation – 8% of base construction cost for route sections affecting existing railway.

2.4 Approach to indirect costs

2.4.1 In previous estimates, we adopted an approach of using percentage add-ons for costs relating to contractor preliminaries and supervision, design and client costs.

2.4.2 This was an appropriate approach at an early stage in the design process, recognising the levels typically seen on other projects and the constrained time and resources available to undertake further assessment.

2.4.3 As the design has progressed we have moved to a bottom up approach to calculate these costs. Work has been undertaken over the past 18 months by the Phase One cost team who have considered the level of resource required to design and deliver the project as a whole. This approach provides a more appropriate cost for the HS2 project, recognising the scale of work required but also some of the efficiencies that are achievable in terms of value engineering and efficiency opportunities on overheads, etc.

2.5 Land costs

2.5.1 HS2 Ltd's land and property consultants, CBRE, have estimated the overall property costs for the route profiled over the life of the scheme. This assessment includes property, disturbance, severance and resale values within the planned railway corridor.

2.5.2 The estimate also includes an allowance for the property costs of the indicative discretionary and voluntary purchases schemes that are the subject to public consultation during July to December 2013, where properties may lie outside of the limits of land to be acquired (LLAU), excluding a property bond scheme.

2.6 Efficiency Challenge Programme (ECP)

2.6.1 The Efficiency Challenge Programme team was set up to enable HS2 Ltd to identify significant efficiencies from its programme. Its mission is to support the delivery of the required HS2 infrastructure solution by realising significant cost savings through embedding the right sponsor, client and supply chain behaviours and processes.

2.6.2 The objective of the programme is to identify and investigate opportunities that, if applied to HS2, could realise significant opportunity savings from the current baseline budget.

2.6.3 The ECP team's focus includes the following areas;

- Collaboration
- Implementation of Building Information Modelling (BIM)
- Offsite manufacturing

2.7 Value Engineering Initiative (VEI)

2.7.1 Alongside the Efficiency Challenge Programme, we have been looking at other ways of driving cost out of the scheme. Whereas the ECP has been looking at policy and strategy, the Value Engineering Initiative (VEI) looks more closely at materials, design and construction activities.

2.7.2 Three principal work streams are being progressed relating to VE and innovation. They are:

- creating the evidence base for the existing assumed savings and supporting the Phase One estimate by reviewing the VE registers across the areas;
- looking at a series of case studies that apply latest technology / innovation to HS2 infrastructure.
- constructing a modelling tool to develop a detailed parallel programme using the outputs from the case studies that will be used to calculate potential savings across the scheme.

3 Infrastructure capital cost estimate: Phase Two

3.1 Introduction

3.1.1 As illustrated earlier, Phase Two is at an earlier stage of development than Phase One. The Phase Two initial preferred route is going through consultation. The design is based on large-scale route alignment drawings and generic design assumptions, and consists of a relatively small number (250) of approximate rates (e.g. cost per km for tunnels, cuttings and embankments).

3.2 Base construction rates for asset types

3.2.1 The estimate has been prepared by an external cost consultant to provide independent cost estimation, drawing on its extensive cost database. This database is used annually to produce the industry-standard "Spon's Civil Engineering and Highway Works Price Book". The quantities are provided by the Phase Two PSCs.

3.2.2 For tunnels, the best available data for benchmarking rates at this point is provided by the British Tunnelling Society through the Infrastructure UK cost study work. This data enables tunnel length and construction approach to be reflected, particularly for tunnel boring methodology. Rates for each proposed tunnel are considered on an individual basis using the available data.

3.2.3 HS2 Ltd is carrying out a review of the HS2 Phase Two base rates against the current design standards used in Phase One. Where appropriate, market testing and/or benchmarking against other projects will also be used.

3.3 Construction base cost

3.3.1 To derive the base costs, the current rate set is applied to the scope defined by the engineering teams[13]. The quantities are provided by the Phase Two PSC engineering companies in a scope template that contains 250 design elements. This enables us accurately to reflect our understanding of the scope as it emerges. The quantities are reviewed and checked by the HS2 in-house engineering teams.

[13] High Speed Two Ltd, 2012. Options for phase 2 of the High Speed rail network, approach to design. HS2 Ltd, London. Available online at https://www.gov.uk/government/publications/options-for-phase-two-of-the-high-speed-rail-network-approach-to-design.

3.3.2 For the legs to Manchester and Leeds, we have used the routes published in the Route Engineering Reports[14].

3.4 Approach to indirect costs

3.4.1 As with Phase One, the Spending Round model uses indirect costs from a workforce plan model agreed by the HS2 Ltd Board and DfT.

3.4.2 This covers all the activities required to deliver Phase Two

3.5 Land costs

3.5.1 CBRE was engaged to undertake a land valuation exercise similar to that on Phase One, where it had estimated the overall property costs for the base proposition routes. As with Phase One, this assessment includes property, disturbance and resale values within the planned railway corridor. An update of this is being commissioned.

3.5.2 For the Spending Review we included a prudent uplift to the CBRE estimates (to reflect that Phase 1 land and property estimates were 25% higher following the design development work, but also made allowance for hardship and discretionary purchase (not in the Phase Two costs previously). These costs will, as with Phase One, become more definite as we move through the project lifecycle.

3.6 Approach to other cost elements

3.6.1 In line with our previous estimates, we have applied the following allowances to the Phase Two estimate:

- environmental mitigation in urban areas or areas of known environmental significance - 5% of base construction cost excluding utilities, in other areas 3% and in tunnelled areas 0%;
- surveys (ground and topography) - allowance of £150,000 per route kilometre;
- rail possession / isolation / safety management - 2% of base construction cost for route sections affecting existing railway; and
- train operating company compensation - 8% of base construction cost for route sections where our works would affect the existing railway.

3.6.2 Percentages are also applied to the rail and control systems costs for contractor training (5%), spares (1%) and testing and commissioning (1%).

[14] HS2 Ltd, 2013, Route Engineering Report, West Midlands to Leeds & West Midlands to Manchester

3.7 Efficiency Challenge Programme

3.7.1 To date, the ECP has been concentrating on Phase One. Once the Phase Two scheme has been through consultation, a thorough review will be carried out and then those applicable opportunities will be applied.

3.8 Value Engineering Initiative

3.8.1 To date, the VEI has been concentrating on Phase One. Once the Phase Two scheme has been through the proposed line of route consultation, a thorough review will be carried out and then those applicable opportunities will be applied.

3.8.2 Work has started with the Phase Two team to ensure that any tangible value engineering can be incorporated within the design. This will mean that the savings will be inherent in the base estimate.

4 Contingency

4.1 Introduction

4.1.1 All of the infrastructure costs referred to in the previous sections exclude any allowance for risk or contingency.

4.1.2 The level of contingency in an estimate recognises the uncertainty and risk that is inherent at any particular stage of a project, and provides a level of confidence that the estimate will not be exceeded.

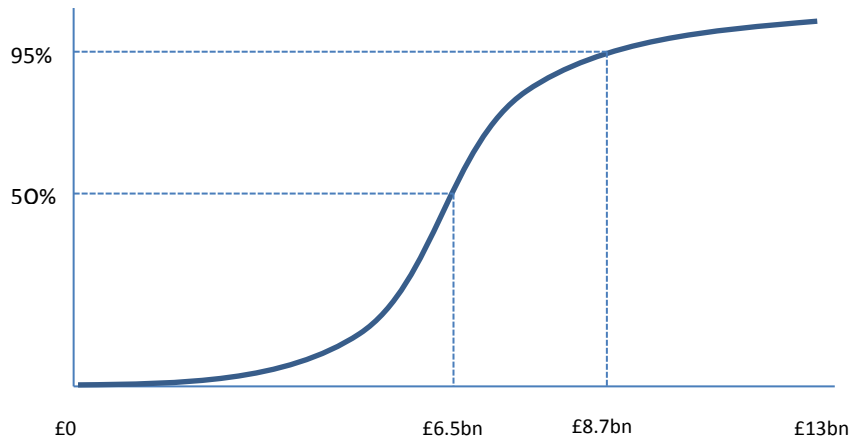
4.1.3 The source of this uncertainty and risk can be found in many areas but typically occurs in the following categories;

- programme;
- quality and safety;
- procurement & contracts;
- people and behaviours; and
- external influences.

4.1.4 HS2 Ltd recognises the financial benefits of the effective management of uncertainties and risk. It is committed to adopting a disciplined and rigorous approach to risk and contingency management that aligns with industry best practice and is independently assured.

4.1.5 The probability factor (or 'P' value) reflects the level of certainty of an 'out-turn' cost being achieved. This factor takes into account HS2 Ltd's exposure to changes or developments in the scheme, and the risks involved in the delivery of the scheme. Therefore, P95 reflects a higher certainty of an 'out-turn' cost being achieved, whereas a P50 value denotes a 50:50 chance of an 'out-turn' cost being achieved.

Figure 3: Illustrative risk S curve – indicative figures only



4.1.6 The above graph shows an illustrative S curve demonstrating how P50 and P95 values are read.

4.1.7 Reflecting the different stages of development we have used the following techniques to calculate an allowance for the two scheme phases.

4.2 Quantative Risk Analysis

4.2.1 HS2 Ltd's risk exposure is represented through a series of risk registers within the organisation.

4.2.2 A risk register is typically developed through a series of interviews, workshops and reviews. The registers list the threats or opportunities with a cost impact and a mitigation plan.

4.2.3 A threat in the risk register is characterised by a probability that the threat occurs and an impact (on cost, time, reputation) if it does. The cost impact is generally expressed as a range (for example, £5 million to £25 million) which represents the potential extra-over costs associated with the threat event. The threats are generally modelled as independent events, with covariance introduced between some related threats where it is deemed appropriate. The threat probabilities and cost impacts represent expert judgement relative to the allowance already included in the base cost estimate. The threats produce a range of costs.

4.2.4 A cost QRA model is created through a stochastic model. The model makes a distinction between threats and opportunities that may or may not occur and tolerance ranges associated with the status of the price estimation and design development. Both threats and tolerances represent uncertainty to the base cost estimate, but are best modelled separately within the model.

4.3 Optimism bias

4.3.1 There is a demonstrated, systematic, tendency for projects to be overly optimistic in the calculation of early estimates, that is they underestimate timescales and costs associated with a project.

4.3.2 The application of Optimism bias is intended to counter this.

4.3.3 The existing supplementary green book guidance[15] on optimism bias suggests that the upper bound on optimism represents a 'starting point' and the contributory factors to the optimism bias uplift are then assessed in terms of whether they are mitigated.

[15] https://www.gov.uk/government/publications/green-book-supplementary-guidance-transport

4.4 Phase One

4.4.1 As discussed in section 2 the design for Phase One has progressed from a high-level route appraisal to a full preliminary design and environmental statement sufficient to support the hybrid Bill process.

4.4.2 As the design and the estimate have become more mature so has the calculation for contingency. This maturity can be seen through the contingency estimations as part of the Baseline iterations. In January 2012 the P50 contingency estimation represented 66% of the base cost; it currently stands at 24%.

4.4.3 The revised contingency figures are therefore derived from a QRA only, which is in line with our expectations of forthcoming Treasury Guidance.

4.4.4 The risk register for Phase One was developed through a series of interviews and reviews, and informed by risk registers emerging from the Professional Service Contractors (PSCs). The Phase One risk register contains over 300 active threats with a cost impact and a mitigation plan. These are under continual review and challenge to gain assurance that risks are being effectively managed to provide value for money.

4.5 Phase Two

4.5.1 As illustrated earlier, Phase Two is at an earlier stage of development than Phase One.

4.5.2 Therefore Phase Two has estimated a higher contingency element which represents the greater degree of uncertainty.

4.5.3 For the base proposition routes outlined in the Route Engineering Reports, we have used values from our location-specific and programme-wide QRA, coupled with an appropriate additional provision for optimism bias.

4.5.4 A risk register for each leg of Phase Two was developed through a series of workshops. As with Phase One a QRA model was created using a stochastic model.

4.5.5 In line with the existing supplementary green book guidance[16] we have reviewed the optimism bias factors that contribute to calculation of the HS2 additional risk provision for Phase Two. The scored weightings recognise that this is Phase Two of the scheme; therefore, there is a different weighting of factors from that previously used in Phase One.

[16] https://www.gov.uk/government/publications/green-book-supplementary-guidance-transport

4.5.6 The factors that have been reviewed are as follows:

- Project Specific – design complexity has been reduced from 8 to 7 on the grounds that the design of the Phase Two contains nothing as intrinsically complex as Phase One; and
- External Influences – legislation/regulation has been reduced from 6 to 5 on the grounds that this is a greater risk for Phase One.

4.5.7 The detailed commentary that supports the optimism bias factor weightings for Phase Two is in Appendix B. This calculation results in an additional provision of 33%[17] added to the total estimated scheme cost for Phase Two.

[17] The 33% is not applied to all elements within the cost model and therefore the net effect is an uplift of 32%

5 Rolling stock capital cost estimate

5.1 Introduction

5.1.1 There are two types of rolling stock proposed for the HS2 service provision:

- Services operating only on the HS2 network use a 'captive train';
- Services operating also to and from the conventional network are called 'classic compatible'.

5.1.2 All train sets are of 200 m length. Two units can operate coupled together as 400 m trains.

5.2 SR2013 submission

5.2.1 The Spending Round model used the August 2012 Economic Case figures for rolling stock, as the work described in this section was concluded and validated after the submission.

Table 2: Calculation of upper bound figure in SR2013 for the Full Network

Item	Nr	Cost (£m)	Total (£m)
Captive (200m sets) base cost	92	26.3	2,420
Classic-compatible (200m sets) base cost	64	39.5	2,528
Classic-compatible (260m sets) base cost	15	51.3	770
Total base cost at 2011			5,718
Captive (200m sets) @ 18% risk			436
Classic-compatible (200m sets) @ 40% risk			1,011
Classic-compatible (260m sets) @ 40% risk			308
Total risk provision at 2011			1,755
Total at 2011 prices			7,473

Source: HS2 Ltd

5.2.2 Consistent with making long-term provision in the public finances at a high level of certainty, the figure of £7.5 billion will be retained as the long-term funding envelope for rolling stock, providing a high level of confidence that rolling stock requirements can be met within this funding envelope.

5.3 Most likely cost of rolling stock

5.3.1 A complete review of the rolling stock requirement was carried out in June 2013, covering the cost of procuring the rolling stock, and the relevant application of optimism bias (OB). These proposals result from a detailed technical review which assessed the current inputs and assumptions against the best evidence available. There are three areas of change incorporated:

- revised composition of rolling stock fleet;
- revised estimated purchase price of the rolling stock; and
- revised optimism bias.

5.3.2 We have used these revised figures as our most likely rolling stock costs within the Economic Case.

5.4 Revised composition of rolling stock fleet

5.4.1 Since August 2012 a draft Circulation Plan has been produced. This document sets out to provide a possible solution for running the given train service patterns, taking account of economic aspects, to determine the fleet size for the different vehicle types. This is based on the identified operational fleet size, stabling facilities and maintenance activities that need to be investigated. The maintenance activities will be in accordance with the Fleet Asset Management Plan.

5.4.2 We have used the revised fleet numbers taken from the draft Circulation and Stabling Plan, which includes six operational reserve trains and 13 trains in maintenance. The 5% contingency is to cover any changes in the base numbers as a result of changes to the inputs.

Table 3: Revised rolling stock numbers for the Full Network

Item	Number	Contingency	Total
Captive (200m sets)	77	4	81
Classic-compatible (200m sets)	94	5	99
Classic-compatible (260m sets)	0	0	0
Total rolling stock numbers	171	9	180

Source: HS2 Ltd

5.4.3 The '260m trains' previously included in calculations have been removed as a service offering and substituted by 200m services. The above numbers reflect this.

5.5 Revised estimated purchase price

Captive trains

5.5.1 In our recent review HS2 Ltd has analysed recent tender awards of comparable procurement deals, and has conducted market soundings. It has confirmed that our previous assumption of £26.3 million trainset cost for the captive train fleet is reasonable. We have benchmarked our price against:

- Alstom AGV NVT New Trains;
- Bombardier Zefiro380 China;
- Bombardier Zefiro V300 TrenItalia;
- Siemens Velaro RENFE;
- Siemens Velaro Deutsche Bahn;
- Siemens Velaro Eurostar; and
- Hitachi Javelin.

Classic compatible

5.5.2 For the classic-compatible trainsets all manufacturers have stated that the recurring construction cost of each classic-compatible trainset will not be significantly higher than that of the captive trainsets. On completion of the design and set-up of manufacturing, the differences between the two train types that would affect the per-trainset cost (as opposed to the up-front cost) are expected to be very small. Additional systems may be needed, such as classic network pantographs, classic signalling systems and additional deployable door steps. This is catered for using a 15% uplift to the captive trainset price. Some factors could make the classic-compatible trains less expensive, such as the reduced material for the smaller car body – these factors have not been included.

5.5.3 The revised purchase price does not assume that the same supplier will supply both fleets. If the contract for both fleets were awarded to a single supplier, further price reductions could be expected.

5.5.4 Previously, design costs had been rolled into the cost per trainset. However, further review has concluded that the design difference is better represented as an up-front development cost which does not fluctuate significantly with fleet size. We have allowed £420 million for the design, the set-up for manufacturing a new train, and the tooling costs for a new production line.

5.5.5 The new estimate is based on:

- the rolling stock design consuming 1 million engineering hours (a pessimistic assumption, as this would normally deliver a new design);
- the 15 key train sub-systems requiring an average of 100,000 sub-supplier engineering hours each;
- an allowance for project management, procurement, manufacturing set-up hours, both in the rolling stock supplier and in the sub-suppliers; and
- approximately £50 million tooling costs for new production lines (rolling stock manufacturer and sub-supplier).

5.6 Revised optimism bias

Captive trains

5.6.1 The analysis of recent tender awards and the market sounding exercise found that the highest contract awarded was £29 million in 2008 (£30 million in 2011 prices). To reflect this upper bound we have therefore used a 15% optimism bias allowance on top of the £26.5 million, giving a total proposed figure of £30.48 million per trainset.

Classic compatible

5.6.2 The better understanding we now have of the costs of the classic-compatible trainsets means that we have reduced the optimism bias to 20%. Our reasoning is that once the different types of stock are designed, the cost of manufacture will not differ greatly. A similar quantity of materials and a similar time will be required for both fleets.

5.6.3 We have estimated the per-trainset price of the classic-compatible to be £4 million higher than the captive (equivalent to 15%) to account for differences in sub-supplied items due to differing technical requirements for the classic-compatible fleet. This value is considered to be pessimistic, given that there are no changes identified for the classic-compatible trains that would introduce significant cost.

5.6.4 We have also added a 100% optimism bias to the design costs of the classic-compatible rolling stock to allow for the uncertainty in phasing timing, the procurement route and design approval, testing and commissioning risk of the British-specific design. We would expect to revisit this percentage once the procurement strategy on rolling stock is confirmed.

5.6.5 These changes reduce the rolling stock cost to £6.9 billion, including contingency of around£1.3 billion.

Table 4: Revised purchase price calculation

Item	Nr	Cost (£m)	Proposed OB	Cost inc OB (£m)	Total (£m)
Captive (200m sets) base cost	81	26.5	15%	30.48	2,469
Classic-compatible one off Design Allowance	1	420	100%	840	840
Classic-compatible (200m sets) base cost	99	30.5	20%	36.6	3,623
Total base cost at 2011					
Total at 2011 prices					**6,933**

Source: HS2 Ltd

5.7 Summary of changes

5.7.1 The tables below demonstrate the changes in each of the elements.

Table 5: Rolling stock numbers

Item	August 2012	Proposed	Movement
Captive (200m sets)	92	81	(11)
Classic-compatible (200m sets)	64	99	35
Classic-compatible (260m sets)	15	0	(15)
Total Rolling Stock numbers	171	180	9

Table 6: Purchase price

Item	August 2012	Proposed	Movement
Captive (200m sets) base cost	26.3	26.5	0.2
Classic-compatible (200m sets) base cost	39.47	30.5	(8.97)
Classic-compatible (260m sets) base cost	51.3	N/A	
Classic-compatible one-off Design Allowance		420	420

Table 7: Levels of optimism bias

Item	August 2012	Proposed	Movement
Captive (200m sets)	18%	15%	(3%)
Classic-compatible (200m sets)	40%	20%	(20%)
Classic-compatible (260m sets)	40%	N/A	
Classic-compatible one-off design allowance		100%	100%

Table 8: Summary of changes

Item	August 2012	Proposed	Movement
Captive (200m sets)	2,857	2,469	(388)
Classic-compatible (200m sets)	3,539	3,624	85
Classic-compatible (260m sets)	1,077	N/A	(1,077)
Design		840	840

Source: HS2 Ltd

6 Renewals

6.1.1 Recognising that the HS2 business case is evaluated over a 60-year period, the assumptions outlined in Table 9 have been applied to derive renewal costs for relevant infrastructure assets and trains.

Table 9: Renewal interventions for infrastructure assets and rolling stock

Asset type	Assumption made
Infrastructure	
Permanent way	Full replacement by end of 30 and 60 years, each taking four years 25% spend each year
Switches and crossings	Full replacement by end of 30 and 60 years, each taking four years 25% spend each year
OHLE	Renew 50% each by year 15, 30, 45 and 60, each taking two years
Power supply	Renew 50% each by year 15, 30, 45 and 60, each taking two years
Signalling	Renew 50% each by year 15, 30, 45 and 60, each taking two years
Communications	Renew 50% each by year 15, 30, 45 and 60, each taking two years
Stations	40% renewal by year 40 taking four years
Earthworks	No renewal in evaluation period
Retaining walls	No renewal in evaluation period
Structures	No renewal in evaluation period
Tunnel	No renewal in evaluation period
Tunnel Systems	Renew 50% each by year 15, 30, 45 and 60, each taking 2 years
Depot / stabling	50% renewal by year 35 and 70 taking three years
Depot Systems	Renew 50% each by year 15, 30, 45 and 60, each taking 2 years
Rolling stock	
Captive and classic-compatible trainsets	Renewal by year 35 spread in line with initial expenditure phasing

Source: HS2 Ltd

7 Operating costs

7.1 Introduction

7.1.1 Since the previous Economic Case was published, we have carried out a detailed review of our operating cost unit rates. Our underpinning assumptions are set out below. These rates have been applied for both phases.

7.1.2 The review covered:

- rolling stock maintenance;
- traction power;
- train crew;
- infrastructure maintenance;
- Network Rail charges;
- variable overheads and admin costs, insurance;
- station staffing, maintenance and utilities; and
- classic line savings.

7.1.3 For each of these cost elements, HS2 Ltd has reviewed the evidence on which our current inputs and assumptions are based, and provide more up-to-date data where possible.

7.2 Rolling stock maintenance

7.2.1 We carried out market research and analysis of publicly available contractual information of major train manufacturers to ascertain the correct level of maintenance cost for our rolling stock.

Captive set maintenance

7.2.2 Following the review of cost information, we found that our previous estimate for maintenance cost was still accurate. Simply updating the GDP deflator used to put the cost into 2011 prices changed the unit cost by £0.02 to £2.97 per kilometre travelled for a 200m captive train.

Classic-compatible set maintenance

7.2.3 The classic-compatible trains may be more expensive to maintain than the standard captive fleet because they will run on the classic network. The design and quality of classic track imposes additional pressures on the rolling stock.

7.2.4 Our review highlighted that our previous calculation of an additional 25% premium over the maintenance cost of a captive set was too conservative. We found that the maintenance activities over and above what was needed for the captive sets would be additional wheel turning, more frequent replacement of wheelsets, and possibly the maintenance of additional systems such as classic signalling. Taking these into account and leaving an extra 12% allowance for any additional maintenance needs, we have estimated a maintenance cost of £3.50 per kilometre travelled for a 200m classic-compatible set.

Maintenance cost growth

7.2.5 All rolling stock maintenance costs are up-rated in real terms by Retail Price Index (RPI) in line with industry-standard conditions for maintenance contracts. As on our demand and benefits side, the GDP projections used are based on the Consumer Price Index; to maintain comparisons, we use an index of RPI projections adjusted by the GDP deflator growth, as this will allow us to work in constant prices.

Optimism bias

7.2.6 We have been conservative in our unit cost estimates by not including the efficiency gains which are likely to be realised through more intensive use of automated inspections and condition-based monitoring enabled by newer technology. Furthermore, we have been conservative in building in a cost premium for classic-compatible sets, going well beyond the quantified additional costs that were identified by manufacturers.

7.2.7 This is why we apply 15% OB on captive set maintenance and 20% on classic-compatible maintenance. Both of these rates are lower than before, reflecting the greater maturity and substantial upside risks of our reviewed unit cost estimates. The classic-compatible unit cost is subject to a higher level of OB than the captive, because of the slightly higher uncertainty around the additional costs imposed by running our reference train on the classic network.

Table 10: Summary of rolling stock maintenance costs

Maintenance cost of HS2 reference train	Previous estimate	Current estimate
200m captive	£2.95 per unit-km	£2.97 per unit-km
Optimism bias on captive train maintenance	41%	15%
200m classic-compatible set	£3.68 per unit-km	£3.50 per unit-km
Optimism bias on classic-compatible train maintenance	41%	20%

7.3 Traction power

7.3.1 Previously, we had estimated that a 200m-long set would consume 28 kilowatt hours per kilometre whilst running on HS2. We have updated

this assessment to reflect greater maturity in the energy consumption assessment, which is based on analysis using industry-recognised tools and comparison against wider evidence and calculations. Based on a set of conservative assumptions on speed, average number of stops during the journey, and power supply losses, we now estimate that the energy consumption of our reference train will be 24.97 kilowatt hours per kilometre on HS2 track.

7.3.2 In the case of classic-compatible services running on the classic network, our previous modelling assumed 14 kilowatt hours per kilometre. Based on more conservative assumptions which are consistent with the revised estimate for the captive electricity consumption, and using the technical specification of our reference train, we have updated this figure to 15.27 kilowatt hours per kilometre.

Optimism bias

7.3.3 The modelling assumptions provide a relatively conservative estimate of energy consumption, as further energy improvements are achievable through emerging technologies and more efficient driving styles than the current standard style. Furthermore, traction power supply losses are assumed to make up 7% of energy consumption, whereas Network Rail reports that losses represent between 1.5% and 5.3% of total traction energy consumption.

7.3.4 On the other hand, these estimates are specific to HS2's current reference train, which is a relatively light Alstom AGV. If a heavier train were selected during the procurement process, the energy consumption would be higher. However, heavier trains with conventional seating configurations are also likely to have around 10% greater seating capacity.

7.3.5 Due to this source of uncertainty, we use an OB of 10% on the electricity cost estimates.

Table 11: Summary of traction power modelling

Energy consumption of HS2 reference train	Previous estimate	Current Estimate
200m set on HS2 track	28.0 kWh/trainset-km	24.97 kWh/unit-km
200m set on classic track	14.3 kWh/trainset-km	15.27 kWh/unit-km
Optimism bias	41%	10%

Source: HS2 Ltd

7.4 Train crew

Driver and conductor costs

7.4.1 Previously, in order to ensure that HS2 and the strategic alternatives were comparable, HS2 used the staffing assumptions provided by Atkins for Pendolino trains.

7.4.2 During our review of the cost inputs and assumptions, HS2 has contacted high speed train operators to find out about staffing requirements specific to high speed operations. The 394m Alstom Eurostar trains require a minimum of three staff on board to operate the train safely. Therefore, any additional staff must generate enough ticketing or on-board revenue to be commercially viable.

7.4.3 Through discussion with the Italian Nuovo Trasporto Viaggiatori (NTV) operator, we found that 200m NTVs are operated with five staff on board with a mix of operational and retail/customer service activities, indicating that any staff above this level would not make commercial sense for NTVs.

7.4.4 Taking the evidence in the round, we assume a total of five staff on board 200m HS2 trains, increasing to seven staff on board 400m trains. We continue to assume that 50% of service staff costs are covered by on-board revenues.

7.4.5 Even though we assume the cost of only five on-board staff per 200m train in our estimate of HS2's operational costs, this is not to say that there will only ever be up to five staff on board. However, any additional staff will need to be self-financing, either through ticketing or on-board revenues.

7.4.6 All staff costs are up-rated in real terms by average earnings index projections from the Office for Budget Responsibility (OBR). As on our demand and benefits side, the GDP projections used are CPI-based; to maintain comparisons, we use an index of earnings growth projections adjusted by the GDP deflator growth, as this will allow us to work in constant prices.

Optimism bias

7.4.7 As we now use staffing assumptions which are based on currently running high speed services, and particularly because the assumptions are based on current staffing of our reference train, we have lowered the optimism bias to 30%.

7.4.8 Although we may be sure about the number of safety-critical staff that are needed on board each service, these staff are also likely to have more bargaining power, enabling their wages to grow faster than

average earnings. It is because of this uncertainty that we have a relatively high level of optimism bias on safety-critical train crew costs.

7.4.9 Furthermore, the number of revenue-generating staff deployed on board will ultimately be a commercial decision. Although we know the current staffing level of high speed trains, uncertainty remains around the total number of revenue-generating staff required.

7.4.10 Finally, as we estimate staff costs on a per-kilometre basis, rather than through a full staff diagram exercise, there is still some uncertainty around the number of staff diagrams needed in total. We expect that this information will become available soon, and we will again adjust optimism bias accordingly.

Table 12: Summary of train crew figures

Train staffing	Previous estimate	Current estimate
Number of safety-critical staff on each train	1 driver per train, 1 train manager per 200m unit, 1 cleaner per 200m unit	1 driver per train, 1 train manager per train, 1 service staff per train
Optimism bias on safety-critical staff	41%	30%
Number of revenue-generating staff on each train	5 service staff per 200m unit for journeys of over one hour, 2.5 service staff per 200m unit for journeys of under one hour	2 service staff per 200m unit
Optimism bias on revenue-generating staff	41%	30%
Real inflation -staff costs	1.5% real inflation per year for driver costs	Real cost inflation in line with OBR's average earnings projections for all staff

Source: HS2 Ltd

7.5 Infrastructure maintenance

7.5.1 HS1 is our closest comparator on the cost of operating and maintaining high speed infrastructure. Our source suggests that the unit cost of maintaining HS1 infrastructure is £94,730 per single track kilometre, per annum. This is the same estimate as before; it comes from Network Rail's New Lines Strategic Business Case. Unlike previously, however, it is expressed per single track kilometre, rather than per route kilometre, and the GDP deflator used to express the figure in 2011 constant prices has been updated.

Optimism bias

7.5.2 There are two main differences between HS1 and HS2, which may limit this cost's applicability to HS2.

7.5.3 First, HS1 is a much smaller network. Therefore, a relatively high proportion of costs are likely to be fixed overheads, which would not scale up with the number of track kilometres. However, without further information on what is included within overheads, it is impossible to be sure that these will not vary at all with the size of the network.

7.5.4 Second, HS1 experiences a much lighter train frequency - and therefore overall tonnage - than we expect HS2 to experience. As HS2 services are planned to be much more frequent, the level of infrastructure maintenance needed may be more intense than that currently undertaken on HS1.

7.5.5 It is because of these uncertainties that a 41% level of optimism bias is applied to the annual cost of operations and maintenance.

Infrastructure manager head office

7.5.6 The operation and management of HS2 infrastructure is likely to require a head office function that currently does not exist within the rail industry.

7.5.7 Therefore, we have now included an estimate of these head office costs. It is based on the average projected outturn costs of HS1's head office function from the Office of Rail Regulation's review of HS1 costs. As these are projected costs based on experience from previous years' outturn costs, we apply an OB of 20% to this cost element.

Table 13: Infrastructure manager office costs

	Previous estimate	Current estimate
Infrastructure manager head office	-	£7.5m per year
Optimism bias	-	20%

Source: HS2 Ltd

7.6 Stations

Station maintenance and utilities

7.6.1 The previous estimate of the cost of station maintenance and utilities came from Network Rail's New Lines Programme Strategic Business Case from 2009. It based its estimate on the qualifying expenditure and Long Term Charge data for a typical intercity station.

7.6.2 HS2 now has more detailed data on the Long Term Charge for all stations, and the Qualifying Expenditure for the 18 stations managed by Network Rail. Given this more detailed data, we have calculated the average Long Term Charge and Qualifying Expenditure per platform for the Network Rail managed stations.

Optimism bias

7.6.3 The new estimate is substantially higher than the current estimate, as Network Rail stations tend to be large interchanges, housed in buildings that date from the 19th century. As HS2 stations such as Toton and Meadowhall will be newbuilds on land which is not in a prime urban location, these maintenance and utility costs will be large overestimates. For other stations, we still expect that this will be an overestimate because newly built HS2 stations will be designed with ease of maintenance and energy efficiency in mind. This is why we now use a lower, 20% optimism bias.

Table 14: Station maintenance costs

	Previous estimate	Current estimate
Estimate of station maintenance and utilities	£124,764 per platform per annum	£286,473 per platform per annum
Optimism bias	41%	20%

Source: HS2 Ltd

Station staffing

7.6.4 A number of inputs and assumptions are needed in order to estimate the cost of HS2 station staff. For each station, this includes:

- the number of staff needed for each station, by function, worked out by the number of platform islands, ticket windows and turnaround cleaning teams; and
- a basic salary, inclusive of overtime/Sunday pay.

7.6.5 Taken together, this information will allow us to calculate the annual costs of staffing on all nine stations for the full network.

7.6.6 Adding in the staff pensions and national insurance on-costs uplift of 18.5%, direct overheads rates of 17%, and staff cost growth index in line with average earnings growth, these estimated costs give a comprehensive picture of station staff costs which is comparable with all other staff costs in the model.

Optimism bias

7.6.7 As we have now included a number of staff on-costs in line with train crew costs, we have lowered the rate of OB on this cost element to reflect the increased maturity of the estimate.

7.6.8 On the other hand, as the commercial structure of future stations is not decided and station staffing is a commercial decision, there is still a relatively high amount of uncertainty around the final station staffing costs. This is why the rate of OB remains high at 30%.

Table 15: Station staffing costs

	Previous assumption	Current assumption
Station staff on-costs	NI allowance of 11.5% and pension allowance of 10%	NI and pension allowance of 18.5%, and an additional 17% allowance for direct overheads
Station staff cost growth	There is no real staff cost growth	Staff costs grow in line with real average earnings
Optimism bias	41%	30%

Source: HS2 Ltd

7.7 Network Rail charges

7.7.1 Network Rail charge rates and rolling stock insurance cost rates are needed for both the estimation of the cost of HS2 services on Network Rail infrastructure, and the cost change of the impact of classic services resulting from released capacity changes. The following charge rates are required:

- capacity charge rate per train mile, split by service group;
- the variable track access charge (VTAC) per vehicle mile;
- electrification asset usage charge per vehicle mile; and
- rolling stock insurance cost per train mile.

7.7.2 As with other classic line costs per train/vehicle mile, an average National Rail charge per vehicle/train mile is averaged across agreed stock types, and applied to classic line mileages on this basis.

7.7.3 For HS2 services, an average capacity charge over the services in the Phase One and Phase Two timetables will be calculated based on the mix of service groups into which they fall. The VTAC charge rate for a Pendolino per vehicle kilometre is used as a proxy for the charges that HS2's reference train would incur. The same electrification asset usage charge and insurance costs per train/vehicle kilometre are used for HS2 services as for classic line services. All of these are applied to HS2 annual train/200m unit kilometre data to give annual cost estimates.

Optimism bias

7.7.4 The marginal impact that HS2 trains will have on the classic network is likely to be smaller than the current charge rates that we are using to estimate these costs. However, as there is uncertainty around whether the charging structure will change over the appraisal period, we apply a relatively high level of optimism bias at 30%.

7.8 Train operating companies: operating costs

7.8.1 Since the previous Economic Case, we have changed the way in which TOC operating costs for HS2 and the classic network TOCs are calculated within the operating costs model. Previously, this cost line was calculated by simply taking a percentage of train crew staff costs and rolling stock insurance. Our new method is based on the expenditure of current train operators.

7.8.2 This method will more than double the annual allowance for TOC operations and give us more reliable and accurate estimates of HS2 TOC costs and the change in classic line TOC costs for economic appraisal.

7.8.3 The new estimate includes:

- an estimate of fixed costs based on the average fixed costs per TOC observed across long-distance operators. This includes legal, professional and industry association costs, plus sales and marketing and some head office costs;
- an estimate of ticket commission costs based on the average net commission level as a percentage of TOC revenue observed across long-distance operators;
- an estimate of head office staff costs based on the average number of head office staff per TOC relative to the number of trainsets managed. Over the basic salary, we add all of the on-costs and overheads as discussed earlier, and apply the average earnings growth index in line with all other staff costs; and
- an estimate of non-staff catering cost, based on the average catering cost per passenger observed across long-distance operators. In line with catering staff costs, it is assumed that 50% of catering costs are recovered by on-board revenues.

7.8.4 Adding these elements together gives the total cost of operating HS2 trains, together with the net cost of ticket commissions on HS2 and the classic network. This is the best method to use given the information we have, because we know that TOC costs are linked to a number of variable activities. Commissions have a closer link to revenues, and the number of head office staff is likely to be better determined by the supply of services across the network than by the number of passengers who actually board the trains. Therefore, this method uses the cost drivers that are most likely to determine HS2 train operation expenditure, given the data available.

Optimism bias

7.8.5 As the proposed method for calculating TOC operating costs is based on existing TOC expenditure, and the most relevant drivers of that expenditure that we have data for, we can use a relatively low level of optimism bias of 20%.

7.9 Classic line savings

7.9.1 When HS2 is operational, there will be changes in the services provided on the classic network. As HS2 will provide high capacity long distances services, fewer of these will be needed on the classic network. Furthermore, the vacated train paths can be more efficiently used for more commuter services.

7.9.2 This switch to fewer long distance services and more commuter services on the classic network will result in cost savings on the classic network as a result of HS2. Most of these are calculated by estimating the number of train and vehicle km saved by the changes to classic line services split out by stock type, and multiplying by the cost per km of operation. The elements of costs covered include:

- Rolling stock lease;
- Rolling stock maintenance;
- Electricity;
- Diesel;
- Driver;
- Train manager;
- Other on-board staff;
- TOC overheads and administration;
- VTAC;
- Electrification asset usage charge;
- Capacity charge; and
- Rolling stock insurance.

7.9.3 The changes in vehicle or train-km are outputs from the Planet Modelling Framework. The unit costs of operating are derived from cost input rates from current annual operational costs and current annual train mileage advised by DfT.

7.9.4 The only exception to this method is the estimate of TOC overheads and administration costs, which are based on fixed costs, head office staff

costs and catering costs per passenger derived from existing TOC management accounts. Previously, this used to be estimated as 15% of staff and rolling stock insurance costs.

7.9.5 In order to be consistent with HS2 cost estimates, all classic line staff costs now grow in line with the Average Earnings Index projections, and maintenance costs grow in line with RPI. The inflation indices from electricity and diesel costs have also been updated to reflect more recent projections.

Optimism bias

7.9.6 Previously, a 41% rate of OB (with 18% for lease costs) was applied to classic line savings, in line with WebTAG's requirement to apply OB on the net cost of a scheme. However applying OB to cost savings increases the amount of cost savings estimated, thereby going against the purpose of OB, which is to increase overall costs in order to counteract the tendency to be optimistic about future costs. This is why OB is no longer applied to our estimate of classic line savings.

Appendix A: Cost estimates

Table 16: Phase One cost estimate[18]

	Cost £m	
Item	**P50**	**P95**
Contracts & delivery team	1,150	1,150
Construction		
Tunnels	2,910	2,910
Civil engineering	3,390	3,390
Stations	2,545	2,545
Depots and stabling	720	720
Railway systems	1,560	1,560
On-network works	480	480
Land and property	1,630	1,630
Corporate overheads	1,265	1,265
Total construction cost[19]	**15,650**	**15,650**
QRA derived construction risk	3,750	5,750
Additional scheme risk provision	N/A	N/A
Total	**19,400**	**21,400**

Source: HS2 Ltd

[18] Figures are rounded to the nearest £5m

[19] These costs are slightly higher than those used in the Economic Case for HS2 as they include the spending in 2012/13. As this spending has already occurred these are sunk costs, and are therefore not included in economic appraisal, in line with WebTAG 3.5.9

Table 17: Phase Two cost estimate[20]

	Cost £m	
Item	**P50**	**P95**
Contracts and delivery team	1,960	1,960
Construction		
Tunnels	1,030	1,030
Civil engineering	4,170	4,170
Stations	545	545
Depots and stabling	130	130
Railway systems	2,190	2,190
On-network works	inc	inc
Land and property	1,400	1,400
Corporate overheads	1,050	1,050
Total construction cost[21]	**12,475**	**12,475**
QRA derived construction risk	3,030	5,240
Additional scheme risk provision	3,485	3,485
Total	**18,990**	**21,200**

Source: HS2 Ltd

[20] Figures are rounded to the nearest £5m

[21] These costs are slightly higher than those used in the Economic Case for HS2 as they include the spending in 2012/13. As this spending has already occurred these are sunk costs, and are therefore not included in economic appraisal, in line with WebTAG 3.5.9

Table 18: Full network cost estimate[22]

	Cost £m	
Item	**P50**	**P95**
Contracts and delivery team	3,110	3,110
Construction		
Tunnels	3,940	3,940
Civil engineering	7,560	7,560
Stations	3,090	3,090
Depots and stabling	850	850
Railway systems	3,750	3,750
On-network works	480	480
Land and property	3,030	3,030
Corporate overheads	2,315	2,315
Total construction cost[23]	**28,125**	**28,125**
QRA derived construction risk	6,780	10,990
Additional scheme risk provision	3,485	3,485
Total	**38,390**	**42,600**

Source: HS2 Ltd

[22] Figures are rounded to the nearest £5m

[23] These costs are slightly higher than those used in the Economic Case for HS2 as they include the spending in 2012/13. As this spending has already occurred these are sunk costs, and are therefore not included in economic appraisal, in line with WebTAG 3.5.9

Appendix B: Optimism bias factors for Phase Two

Contributory Factors to upper bound OB (%)			Capital Expenditure 66%	Proposed weighting	Reasoning
Procurement	Complexity of contract structure	N/A at this stage	-	-	Unchanged. Standard public sector procurement anticipated.
	Late contractor involvement in design		-	-	
	Poor contractor capabilities		-	-	
	Government guidelines		-	-	
	Dispute and claims occurred		-	-	
	Information management		-	-	
	Other (specify)		2	-	No additional issues identified at this stage.
Project Specific	Design complexity	e.g. design being built in difficult conditions	8	7	10% route in tunnels; significant viaducts; open line of route zero complexity, Phase Two is less complex than Phase One. There are no stations such as Euston or Old Oak Common that added to the complexity of Phase One.
	Degree of innovation	New-generation design, unusual site conditions requiring innovation	9	-	None of the technologies identified are unproven and the core systems underpinning our specification are available now. Phase Two is also an extension of the application of the technologies used for Phase One. The issues are therefore not innovation issues for Phase Two - more design complexity which is reflected above and also in link specific construction risks. We have considered our initial approach to construction - no aspects of scope were identified requiring novel construction methodologies. Ground condition risks are addressed in the QRA.
	Environmental impact	Contamination, noise pollution, impact on wildlife	5	2	Alignment has been optimised to reduce impacts; environmental allowance (up to 5%) is already included in base price; route-wide ground condition and contamination risks are included in the QRA figure. Weighting reduced to reflect work already undertaken, but some element of risk remains hence reduced weighting.
Client Specific	Inadequacy of the business case	Output specifications not clearly defined, number of services were not anticipated, oversight in facilities required, full range of stakeholder needs not identified and included	35	10	Phase Two of the project will benefit from the work carried out to deliver Phase One. The infrastructure will benefit from the operations concept work, which has highlighted areas where additional work is required to ensure that the infrastructure reflects the proposed levels of service for Phase Two, i.e. the size of the rolling stock depot and the technical capability of the route (specified to support up to 18 tph for which we have undertaken extensive work to validate the technical feasibility of sustaining 18tph; maximum design speed of 250mph specified). The proposed routes and specification have been subject to wide review during the past year, resulting in numerous route amendments which have been incorporated within the proposed alignment to address potential stakeholder concerns; the risk of subsequent changes to the specification and parts of the route has been significantly mitigated (although not eliminated).
	Large number of stakeholders	Different public sector parties have different interests in project, approvals takes longer due to number of parties involved	-	2	Active stakeholder management strategy already being implemented, risk reduced but still exists.
	Funding availability	Difficulties in obtaining financial backing, additional funding available later causing scope change	5	5	Weighting unchanged.
	Project management team	Inexperienced project delivery team; inadequate drawing review before construction	2	2	In line with Phase One experience, it is assumed that an experienced Development Partner will be engaged on Phase Two at earliest stage possible to work with HS2 in specifying and then managing design contracts. Engineering design framework contracts would be activated immediately following the Development Partner's arrival to provide sufficient scale and quality of engineering design resource, including appropriate design checks. Weighting not amended at this stage.
	Poor project intelligence	Insufficient ground investigation, detailed design based on insufficient site information, insufficient surveying of existing conditions	9	9	Provision made for surveying / ground investigation commencing during 2015, not appropriate to have undertaken it prior to confirmation of preferred alignment. Note that the route-wide QRA includes allowances for ground conditions and buried services. Weighting retained.

Contributory Factors to upper bound OB (%)			Capital Expenditure 66%	Proposed weighting	Reasoning
Environment	Public relations	Local community opposition, environmental protests	-		
	Site characteristics	Protected wildlife within site, underground streams to protect, archaeological findings	5	3	Strategic level appraisal has been undertaken and used to inform alignment development, work continues throughout subsequent stages mitigating the impact of this risk. Route-wide risks already include some provision for archaeological finds and rework associated with environmental impact assessment. Weighting reduced to reflect mitigation and provision in QRA.
	Permits / Consents / Approvals	Parliamentary Bill required, difficulties in obtaining planning permission, appeals to SoS	-	-	Active stakeholder engagement across all parties and potential constituencies on-going; however, this will remain a major risk for the time being
	Other (specify)		-	-	We have considered the risks of schedule delay arising from difficulties in obtaining approvals or progressing works on site due to issues arising with consultees or other stakeholder objections and made provision in our QRA.
External Influences	Political	Opposition by major political party, impact on sensitive constituencies, lacks support from key political stakeholders	-	-	Active stakeholder engagement across all parties and potential constituencies on-going however this will continue to remain a major risk for time being
	Economic	Change in market demand, causing changes in funding priorities, stock market crash	3	3	Weighting retained (but no PFI assumed)
	Legislation / Regulations	Change in required standards	8	5	On-going risk due to long-term nature of project; however, slow rate of change of TSIs and active participation in TSI forum (UIC) already on-going, so risk partially mitigated. As a risk, this is greater for Phase One, as it will set the parameters and standards by which the whole project will be built. Any change in standards after the commencement of works on Phase One would therefore be harder to apply to Phase Two, as it could create a system imbalance. In addition, our active participation within the UIC will further help to mitigate the impact of any changes to standards
	Technology	Unanticipated technological advancements, computer virus, limits in technology	8	2	Day 1 technology assumptions for our core sub-systems (such as train technology) are conservative; technological advancements should present opportunities rather than negative impacts in this context. Our business-critical computer-based systems will be specified and subsequently operated with high degrees of firewall protection and security. We have made provision in our QRA for technology-related risks such as obsolescence. The potential impact on Phase Two may be lower than for Phase One, as we are extending Phase One - Weighting not changed
	Other (specify)		1	-	No additional issues identified at this stage.
				50	
				33.0	% additional risk