ATKINS

High Speed Rail Strategic Alternatives Study

Strategic Alternatives to the Proposed 'Y' Network

February 2011

Contents

Section

List of Tables

List of Figures

Appendices

Glossary

Abbreviation	Definition
BCR	Benefit Cost Ratio
DECC	Department of Energy and Climate Change
ECML	East Coast Main Line
GDP	Gross Domestic Product
HS2	High Speed 2
IEP	Inter-city Express Programme
MML	Midland Main Line
NATA	New Approach To Appraisal
NMF	Network Modelling Framework
NPV	Net Present Value
PDFH	Passenger Demand Forecasting Handbook
PLD	PLANET Long Distance
PM	PLANET Midlands
PS	PLANET South
PVB	Present Value of Benefits
PVC	Present Value of Costs
RPI	Retail Prices Index
TEE	Transport Economic Efficiency
TPM	Trains per hour
TUBA	Transport User Benefit Appraisal
WCML	West Coast Main Line

Introduction

1.1 Background

Atkins was appointed by the Department for Transport (DfT) in August 2009, to consider road and rail improvement alternatives to the High Speed Rail proposition, being developed by HS2 Ltd. The main objective of HS2 Ltd at the time was to consider the case for new high speed services between London and the West Midlands. Atkins work reported in March 2010.[1]

In the intervening period HS2 Ltd has been examining options for extending the original HS2 proposals to the West Midlands through to Manchester and Leeds, the so-called 'Y'-shaped network. The Department, therefore, has been considering conventional rail alternatives to the proposed High Speed network currently under development by HS2 Ltd. The purpose of DfT's work is to understand whether there are conventional rail alternatives to the proposed 'Y' high speed rail network between London and Manchester and Leeds which could deliver additional long distance capacity and reduced journey times, and to assess their deliverability and value for money.

Atkins was subsequently re-engaged by the Department for Transport in October 2010 to estimate the cost of the alternatives identified by the Department, including both capital and operating costs, to undertake demand forecasting using the latest HS2 Ltd PLANET model, and to produce an economic appraisal of the alternatives.

This analysis of the 'Y' network Strategic Alternatives is the subject of this current report.

1.2 Purpose of the Report

This document forms the final study report for the examination of Strategic Alternatives to the proposed HS2 'Y' Network. The report outlines the interventions developed, examines the Capital and Operating Costs of the interventions, and then details the Economic Appraisal of the Alternatives.

1.3 Structure of the Report

The remainder of this report is structured in the following manner:

- Section 2 describes the Future Year Base Line;
- Section 3 outlines the description of packages of potential interventions being examined;
- Section 4 details the Demand Forecasting;
- Section 5 details the Capital and Operating Costs;
- Section 6 details the Economic Appraisal;
- Section 7 summarises the findings of the report and draws out conclusions from the work undertaken.

1 http://www.dft.gov.uk/pgr/rail/pi/highspeedrail/alternativesstudy/pdf/strategicoutline.pdf

2. Future Year Baseline

2.1.1 Introduction

The first step in forecasting the demand for the alternative interventions is to construct a future year scenario, against which the alternatives can be assessed. In line with the HS2 Ltd work on the proposed 'Y' network, two future year horizons have been examined: 2021 and 2043. The construction of future year models represent a Do-Minimum scenario, and the elements of supply and demand that make up this scenario are described in the remainder of this section.

The Do-Minimum scenario has been assessed using the PLANET Suite of Models, developed specifically for the HS2 Ltd study. The HS2 Ltd models have been used to ensure consistency between the appraisal of the proposed high speed rail scheme and the identified alternatives.

2.1.2 Supply

In developing the HS2 Ltd future year Do Minimum scenarios, committed or likely to be committed rail schemes were taken directly from the HS2 Ltd study. These were derived from a number of published sources including the Network Rail Strategic Business Plan, the TfL Business Plan, and the timetable and capacity enhancements included within the DfT's Network Modelling Framework (NMF) to 2019.

In line with the approach taken by HS2 Ltd, in order to achieve consistent forecasts from the Planet model for 2043 some additional ECML capacity was assumed in Scotland to address high forecast levels of crowding. This may result in some demand, and thus benefits, for the alternative scenarios potentially being excluded. The additional capacity was assumed in both the 2021 and 2043 models.

No additional uncommitted schemes were incorporated into the models beyond 2019, such that the future year rail networks are assumed to be consistent between 2021 and 2043.

Consistent with the approach taken by HS2 Ltd, a number of schemes were identified for inclusion in the Future Year Do Minimum scenarios. Of particular interest to this study are the following schemes:

- West Coast Main Line – station upgrade at Birmingham New Street and Bletchley re-modelling;
- West Coast Main Line – nine-car Class 390 units lengthened to eleven-cars;
- East Coast Main Line – Inter-City Express Programme and Thameslink Programme capacity increases with new rolling stock;
- Chiltern Line – capacity increase through train lengthening in the peaks;
- Midland Main Line – line speed improvements between St Pancras and Sheffield and Thameslink Programme capacity increases with new rolling stock; and,
- East Coast Main Line – infrastructure capacity provided by schemes to be delivered by Network Rail in the period to 2014.

2.1.3 Passenger Demand

Future year exogenous rail demand growth is inputted directly into the PLANET Modelling Suite. Exogenous rail demand growth is forecast using the industry standard Passenger Demand Forecasting Handbook (PDFH) 4.1, and recent GDP forecasts, that include the impact of the recession. Transport prices and population changes are taken from standard Department for Transport guidance and models.

The overall impact of the application of the exogenous growth is given in Table 2.1 below. This forecast is consistent with that used by HS2 Ltd.

Table 2.1 – Do Minimum Rail Forecast Demand

Model	2008 Trips	2043 Trips	% Growth in Trips (2008 to 2043)
PLANET South	1,549,812[2]	2,408,083[2]	55%
PLANET Midlands	34,436[2]	49,384[2]	43%
PLANET Long Distance	974,804[2]	1,562,615[3]	60%

This shows that strategic demand, as represented in the PLANET Long Distance model, is forecast to increase significantly, by approximately 60% between 2008 and 2043. Local demand increases are still noteworthy, with growth in PLANET Midlands and PLANET South forecast to be in excess of 40% between 2008 and 2043.

2.1.4 Rail Issues

In order to determine the forecast implications for both passenger volumes and crowding in the London to Manchester, Sheffield and Leeds corridors, analysis was initially undertaken using the HS2 Ltd PLANET Long Distance (PLD) model. Crowding is defined as a proportion of the total passenger numbers to seated capacity. The PLD model is an all day (16 hour) model.

The changes in long distance passenger volumes over the period 2008 to 2043 for the Do Minimum are shown in Figure 2.1 overleaf. In this analysis long distance is defined as trips on the inter-city services only (on the Chiltern Line this refers to services going to Banbury or beyond in a northbound direction, and those going from High Wycombe or beyond in a southbound direction).

2 Number of trips in 3 hour peak period
3 Number of trips in 16 hour all day period

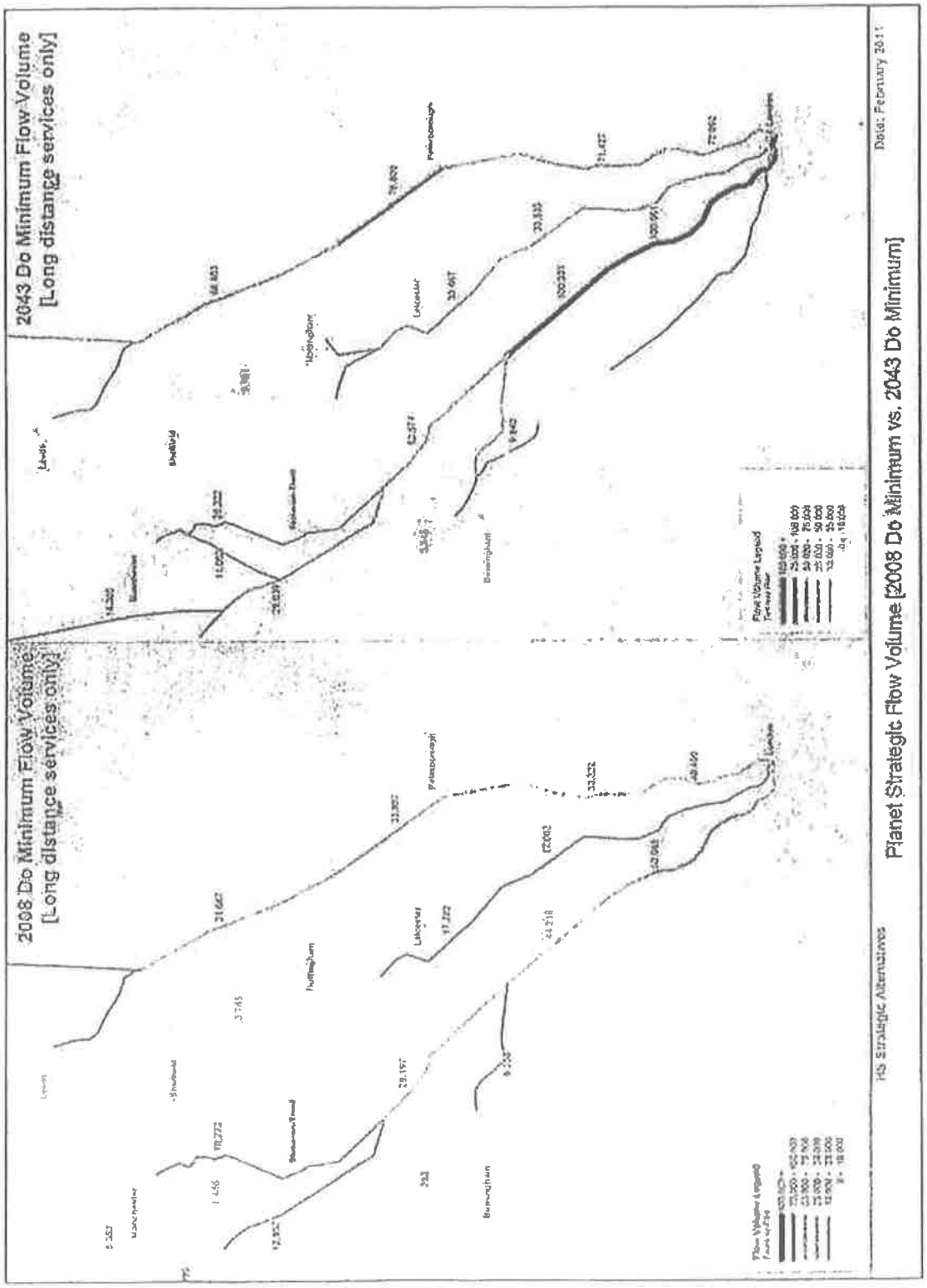

Figure 2.1 – HS2: PLD WC/MM/EC Long Distance Services Rail Passenger Volumes (two way)

A description of the impacts for the three major rail lines under consideration (West Coast Main Line (including the Chiltern Line), Midland Main Line and East Coast Main Line) is given in the remainder of this section.

2.1.4.1 West Coast Main Line (including the Chiltern Line)

- Demand on the WCML long distance services is forecast to increase by approximately 100% up to 2043, with forecast (two-way) daily passenger volumes on long distance services on the approach to London increasing from approximately 50,000 to 100,000 trips. This is considerably larger than the average rail growth of 60% shown in Table 2.1. However, it is noted that the PLD 2007/8 demand on the WCML does not include the effect of the higher service frequencies on some routes since the December 2008 timetable change. This has led to a significant increase in trips such that the base year modelled flows on this line are lower than current patronage figures; and,
- All day crowding levels on the approach to London are forecast to increase from approximately 57% to 75% between 2008 and 2043.

2.1.4.2 Midland Main Line

- Demand on the MML long distance services is forecast to increase by approximately 100% up to 2043, with forecast (two-way) daily passenger volumes south of Leicester increasing from approximately 17,000 to 34,000. This is again in excess of the average rail growth of 60% in strategic trips shown in Table 2.1; and,
- All day crowding levels south of Leicester are forecast to increase from approximately 39% to 59%.

2.1.4.3 East Coast Main Line

- Demand on the ECML long distance services is forecast to increase by about 115% up to 2043, with forecast (two-way) daily passenger volumes on long distance services on the section between Peterborough and Stevenage increasing from approximately 33,000 to 71,000. This is considerably larger than the average long distance rail growth of 60% highlighted in Table 2.1;
- All day crowding levels on the section between Peterborough and Stevenage are forecast to increase from approximately 54% to 66%.

3. Strategic Interventions

3.1 Introduction

This Chapter outlines the strategic rail interventions identified by DfT as potential alternatives to the proposed 'Y' high speed rail network between London and Manchester and Leeds. These interventions were identified taking into account the likely future year Do-Minimum situation, described in Chapter 2 of this document, industry planning documents, including Route Utilisation Strategies, and Atkins previous work on WCML and Chiltern Line upgrades.

Due to the geographic scale of HS2, few alternative interventions would be able, on their own, to deliver an equivalent level of functionality, whether in terms of journey time improvements or capacity enhancements. It was therefore considered more appropriate to consider packages of interventions.

The remainder of this chapter describes the rail interventions identified by DfT, in terms of the overall theme of the package and the individual works which would lie behind the theme. The outputs from each of the packages are then described, in terms of service frequency and journey times.

3.2 The Scenarios

In this section we detail the strategic rail intervention packages identified by DfT for analysis in the study. The packages can be summarised in outline below:

Table 3.1 – Rail Intervention Packages

Package	Description
Scenario A	Increasing long distance passenger capacity by extending length of existing long distance services, requiring works including platform lengthening, track remodelling and depot works to cater for longer trains and more vehicles
Scenario B	Increasing passenger capacity and enhancing long distance service frequency, requiring works to operate a higher frequency of services, including upgrades to stations and junctions, and additional tracks
Scenario C	Combined passenger capacity enhancement and reduced journey times on long distance services, including construction of some new alignments to bypass sections with low line-speeds and limited capacity

3.3 Scenario Deliverables

3.3.1 Introduction

An outline description of what each of the three scenarios deliver is provided in this section. The indicative train service patterns assumed for the modelling of each package are represented diagrammatically in Appendix A.

3.3.2 Scenario A

3.3.2.1 West Coast Main Line

This scenario assumes WCML intercity services are lengthened up to the effective limit for each branch on the route. This increases the seating capacity provided on the WCML on the approach to London by approximately 21%. It is proposed to operate two separate rolling stock fleets:

- 11 carriage trains are assumed to operate services to Liverpool;
- 14 carriage trains are assumed to operate services to Manchester, Glasgow and Birmingham.

3.3.2.2. Midland Main Line

Scenario A assumes that long distance diesel services operating on the MML are lengthened up to a maximum of 11 car trains. These interventions increase the seating capacity provided on the MML on the approach to London by approximately 16%.

3.3.2.3 East Coast Main Line

Scenario A assumes that all ECML intercity services are operated by 12-car IEPs. This increases the seating capacity on the ECML on the approach to London by approximately 31%.

3.3.3 Scenario B

3.3.3.1 West Coast Main Line

Scenario B assumes that the train service frequency on the WCML "fast" lines is increased as far as possible without the provision of six tracks. This is assumed to provide 16 trains per hour (tph) over the busiest section of the WCML: Euston – Ledburn Junction, with the following assumed service specification:

- Euston – Manchester: 4 tph "fasts;
- Euston – Birmingham: 4 tph "fasts";
- Euston – Liverpool: 3 "fast" trains every 2 hours;
- Euston – Glasgow: 3 trains every 2 hours;
- Euston – Chester/North Wales: 1 tph
- Euston – Milton Keynes – Northampton – Rugby: 4tph (fast):
  - 2 tph extended to Birmingham New Street;
  - 1 tph terminating at Rugby; and
  - 1 tph extended to serve stations along the Trent Valley route.

3.3.3.2 Midland Main Line

This scenario assumes a higher service frequency with electrification of the MML. An 8tph timetable is provided North of Bedford with the following assumed service specification:

- St Pancras – Derby – Sheffield: 2 tph (fast between London and Leicester);
- St Pancras – Nottingham: 2 tph (fast between London and Leicester);
- St Pancras – Leicester: 2 tph (calling at intermediate stations);
- St Pancras – Corby: 2 tph (calling at intermediate stations).

3.3.3.3 East Coast Main Line

Scenario B assumes a higher frequency long distance timetable on the ECML. A 10tph timetable is provided, with all rolling stock comprised of 10 car 125mph IEP sets. The assumed service specification is:

- London – Leeds: 3 tph (1 via Hambleton);
- London – Newcastle: 4 tph (with 2 tph extended to Edinburgh, and some services beyond);
- London – Sheffield: 2 tph;
- London – Hull / Lincoln: 1 tph (alternating).

3.3.4 Scenario C

3.3.4.1 West Coast Main Line

Scenario B is assumed to result in the WCML fast lines operating at maximum capacity. In Scenario C, in order to free up additional WCML capacity, the 'fast' WCML services between London and Birmingham are diverted onto the Chiltern route. Three WCML paths per hour are assumed to be released to provide other services.

The train service assumed on the WCML in Scenario C is similar to Scenario B, with the exception of the following:

- Euston – Birmingham services diverted to the Chiltern Paddington – Birmingham route;
- Euston – Liverpool service frequency increased to 2 tph "fasts";
- Euston – Glasgow service frequency increased to 2 tph "fasts"; and
- Euston – Warrington stopping service 1 tph.

This package includes infrastructure enhancements to enable the Chiltern route to maintain existing London – West Midlands journey times, safeguarding existing benefits for passengers.

3.3.4.2 Midland Main Line

This scenario assumes the higher frequency MML timetable is in operation, as in scenario B.

3.3.4.3 East Coast Main Line

Scenario C assumes a 12tph timetable on the ECML. This consists of the 10tph timetable provided in scenario B, with additional journey time savings, and an additional service operating between London and Nottingham at a frequency of 2 tph. A new alignment is assumed to by-pass Peterborough.

3.3.5 Summary of Journey Time Impacts

Whilst Scenario A delivers only increased capacity, both Scenarios B and C deliver journey time improvements between the key cities as well as capacity enhancements. The table below gives an illustration of the typical journey time savings which could arise from the interventions and which were included, as appropriate, in the PLANET modelling of each of the packages described in a later chapter of this document:

Table 3.2 – Typical Journey Times Impacts (in minutes)

Rail Service Group	Reference Case Journey Time	Scenario A	Scenario B	Scenario C
London – Birmingham New St / Moor St	85	85	76	73
London – Manchester	128	128	125	125
London – Nottingham	110	110	93	86
London – Sheffield	127	127	105	100
London – Leeds	118	118	118	115

The table above shows that Scenario B offers journey time savings on the West Coast Main Line between London and Birmingham, with approximately 9 minutes saved over the Reference Case journey time of 85 minutes. More modest savings of 3 minutes are made on journeys between London and Manchester. Sheffield and Nottingham benefit from significant journey time savings but Leeds journey times are unchanged.

In Scenario C, further savings are made on the journey time between London and Birmingham, with a saving of 12 minutes over the Reference Case time of 85 minutes. Scenario C also provides further reductions in journey times to Sheffield and Nottingham and some reductions to Leeds.

3.4 Scenario Components

The individual interventions assumed to be required to deliver Scenarios A to C are shown in the following table:

Table 3.3 – Rail Intervention Package Components

Package	Components
Scenario A	**West Coast Main Line/Chiltern Line** Longer platforms and associated enabling works at the following stations - Euston, Watford Junction, Milton Keynes, Nuneaton, Lichfield, Stafford, Warrington, Wigan, Preston, Lancaster, Oxenholme, Penrith, Carlisle, and Lockerbie. In addition the throat at Euston would need to be re-modelled, this would require land acquisition and property demolition Depot modifications for longer trains Power supply strengthening for overhead line equipment. **Midland Main Line** Longer platforms and associated enabling works at the following stations – Luton Airport Parkway, Luton, Bedford, Wellingborough, Kettering, Corby, Market Harborough, Loughborough, East Midlands Parkway, and Chesterfield **East Coast Main Line** Longer platforms and enabling works at the following stations – Peterborough, Grantham, Newark, Retford, Doncaster, Wakefield Westgate, York, Durham, Alnmouth, and Berwick. Additional infrastructure enhancements include: – Kings Cross throat re-modelling; – Depot modifications for longer trains; and – Power supply strengthening for overhead line equipment.
Scenario B	**West Coast Main Line/Chiltern Line** Infrastructure enhancements on the West Coast Main Line include: – Stafford area by-pass; – Grade-separation between Cheddington and Leighton Buzzard; – 3 new platforms at Euston Station; – 3 extra platforms at Manchester Piccadilly (with grade-separation at Ardwick); – 4-tracking Attleborough – Brinklow (including freight capacity works at Nuneaton) – Northampton area speed improvements; and – 4-tracking Beechwood Tunnel to Stechford. **Midland Main Line** Infrastructure enhancements on the Midland Main Line include: – Electrification from Bedford to Sheffield; – Freight loop facility between London and Bedford; – Re-instatement of 4-tracks between Bedford and Kettering; – Re-instatement of 2-tracks between Kettering and Corby; – Station area re-modelling at Corby;

Package	Components
	– Re-modelling and 4-tracking in the Leicester area; and, – Electrification and increased stabling capacity at depots. **East Coast Main Line** Infrastructure enhancements on the East Coast Main Line include: – Kings Cross: Throat re-modelling. Re-instatement of a third tunnel and 6-track approach; – 4-tracking Digswell – Woolmer Green; – 4-tracking Huntingdon – Peterborough – Peterborough area works: Werrington Flyover; – 4-tracking Stoke Junction – Doncaster; – Newark – provide flyover for Nottingham to Lincoln route; – Retford – works to address low speed turnouts and restrictive signalling; – Electrify and upgrade Retford – Sheffield; – Re-modelling and extra platforms at Doncaster; – Electrification of Hambleton Junction to Leeds;
	West Coast Main Line/Chiltern Line This package comprises the same infrastructure enhancements on the West Coast Main Line as in Scenario B, with the exception of the 4-tracking of Beechwood Tunnel to Stechford. In addition it comprises the following enhancements on the Chiltern Line: – Electrification throughout; – line speed increase to 125 mph maximum; – provision of extra platforms at Birmingham Moor Street; – Kenilworth (Leamington – Coventry) track doubling; – 4-tracking Tyseley – Dorridge; – Extended (freight) loop at Fenny Compton; – Banbury by-pass line; – Improvements at Princes Risborough; – New 2-track tunnel Saunderton – Seer Green (avoiding High Wycombe); – 4-tracking Seer Green – South Ruislip (Northolt Junction); and, – 2-tracking South Ruislip – Paddington via Park Royal and Old Oak Common **Midland Main Line** No additional works beyond Scenario B. **East Coast Main Line** As Scenario B, plus the extra infrastructure enhancements: – Grantham – Nottingham – electrify and upgrade; and, – Peterborough area – new 140 mph 15-mile electrified bypass line with grade-separations at each end.

4. Demand Forecasting

4.1 Introduction

The scenarios described in Chapter 3 have been assessed using the PLANET Suite of Models, developed specifically for the HS2 Ltd study. The HS2 Ltd models have been used to ensure consistency between the appraisal of the high speed rail scheme and the identified alternatives.

This chapter describes the demand forecasting undertaken for the three alternatives scenarios previously described.

4.2 Modelling of the Alternative Scenarios

4.2.1 Introduction

The timetables associated with the three alternative scenarios were coded into the model and run for the years 2021 and 2043.

This section shows the change in demand associated with the three rail scenarios, and then highlights the impact of the scenarios on capacity and crowding on the major routes under consideration.

4.2.2 Impact on Demand

The 2043 total modal transfer and the number of generated rail trips that are estimated to occur as a result of the proposed rail interventions, is summarised in Table 4.1.

Table 4.1 – Estimated 2043 Modal Transfer & Rail Trip Generation (trips per day)

	Modal Transfer from Air	Modal Transfer from Highway	Generated Rail Trips	Total Additional Rail Trips
Scenario A	2,788	1,439	7,641	11,868
Scenario B	6,023	6,084	24,320	36,427
Scenario C	6,998	6,934	27,018	40,950

Table 4.1 shows that, as expected, the amount of additional rail trips associated with each scenario increases from Scenario A to C. It also shows that there are significantly more additional trips in Scenario B than in Scenario A. This again is to be expected as Scenario B offers journey time savings in addition to more capacity. Scenario C shows an increase in additional trips over Scenario B, but this increase is fairly small as most of the improvements have already been made in Scenario B.

4.2.3 Impact on Capacity and Crowding

As a result of assessing each of the packages in the PLANET demand model, forecast additional capacity and crowding levels on the long distance services to London on each of the major lines under consideration were determined. A summary is given in Tables 4.2 to 4.4 below, for each of the lines under consideration.

4.2.3.1 West Coast Main Line and Chiltern Line

The forecast capacity and crowding impacts on the West Coast Main Line and Chiltern Line are given in Table 4.2 below.

Table 4.2 – Forecast Capacity & Crowding Impacts – West Coast Main Line and Chiltern Line

Rail Package	Long distance seated capacity (16 hour two way) to/from London Combined	% increase in seated capacity over Reference Case Combined	WCML load factor approaching London (16 hour two way) (% seats)	Chiltern load factor approaching London (16 hour two way) (% seats)
Reference Case (2043)	164,700	-	75	46
Scenario A (2043)	199,900	21	64	46
Scenario B (2043)	253,500	54	51	45
Scenario C (2043)	291,300	77	45	43

The modelling shows that the packages could provide significant additional long distance passenger capacity on the WCML and Chiltern routes ranging from an additional 21% of seated capacity in Scenario A where the trains are lengthened, through to an additional 77% of seated capacity in Scenario C.

Modelling also shows that by 2043, in the three scenarios, the all day load factor on WCML services to and from London is forecast to range between 45 – 64%. The levels in Scenarios B and C are broadly in line with the 2008 level of 57%. In all options the all day load factor on the Chiltern route remains at a similar level between 43% and 46%.

By comparison, if no further enhancements above those already assumed to be committed are undertaken on the WCML or the Chiltern routes, as assumed in the Do Minimum scenario, all day load factors are forecast to increase to 75% on the southern section of the WCML and 46% on the southern section of the Chiltern route.

4.2.3.2 Midland Main Line

The forecast capacity and crowding impacts on the Midland Main Line is given in Table 4.3 below.

Table 4.3 – Forecast Capacity & Crowding Impacts – Midland Main Line

Rail Package	Long distance seated capacity (16 hour two way) to/ from London	% increase in seated capacity over Reference Case	Load factor approaching London (16 hour two way) (% seats)
Reference Case (2043)	54,600	-	69
Scenario A (2043)	63,200	16	64
Scenario B (2043)	139,800	156	28
Scenario C (2043)	139,800	156	25

The modelling shows that implementation of the scenarios could result in significant increase in long distance seated capacity on the Midland Main Line. Scenario A offers an additional 16% of seated capacity, over and above the Reference Case, whereas Scenarios B and C offer some 156% of additional seated capacity.

Without the introduction of the interventions represented by the scenarios the daily load factor approaching London on the Midland Main Line is forecast to be at 69% by 2043, which will represent significant crowding. Scenario A has a modest impact on this figure, reducing forecast load factors down to 64%. In contrast, Scenarios B and C reduce load factors down to less than 30%, as in Scenario B, trips between Sheffield and London would be largely carried on the ECML, and in Scenario C trips between Nottingham and London would also largely be carried on the East Coast Main Line.

4.2.3.3. East Coast Main Line

The forecast capacity and crowding impacts on the East Coast Main Line is given in Table 4.4 below.

Table 4.4 – Forecast Capacity & Crowding Impacts – East Coast Main Line

Rail Package	Long distance seated capacity (16 hour two way) to/ from London	% increase in seated capacity over Reference Case	Load factor approaching London (16 hour two way) (% seats)
Reference Case (2043)	110,500	-	64
Scenario A (2043)	144,900	31	52
Scenario B (2043)	181,500	64	43
Scenario C (2043)	214,700	94	40

Implementation of the scenarios would result in significant increases in capacity on the East Coast Main Line. The train lengthening in Scenario A will result in an additional 31% of long distance seats on the route. This figure will then improve further to an additional 64% of seats in Scenario B and 94% in Scenario C.

In the absence of interventions, the daily two-way load factor is forecast to be at around 64%, which will represent serious crowding at key points in the day. Scenario A is forecast to reduce the load factor down to 52%. The implementation of Scenarios B and C then further reduce the load factor down to 43% and 40%.

Scenario C, despite adding a large amount of capacity to the East Coast Main Line, does not have a large impact on the load factor (reduces from 43% to 40%). This is mainly due to the London to Nottingham flows being carried on the East Coast Main Line in Scenario C.

5. Capital and Operating Costs

5.1 Introduction

The estimated costs of the scenarios are detailed in this section to inform the economic appraisal. These costs are still at an Order of Magnitude level due to the early stage of development of the interventions. Should any of the proposals be progressed the cost estimates would be refined as the packages progress through the design process.

The cost estimates for the Strategic Alternative scenarios have been undertaken by cost consultants, Faithful and Gould, who are part of the Atkins group of companies.

The remainder of this section lists the assumptions made in costing the proposed HS2 Y network alternative scenarios.

5.2 Capital Costs

5.2.1 Methodology

The high level capital cost estimates presented have been developed using a model containing a series of high level unit rates, consistent with those used by HS2 Ltd, to determine the costs for each location within each scenario. The unit rates are grouped into the main elements of work, namely:

- Trackwork alterations and new work including renewals, realignment of track and turn outs, and provision of new track, grade-separated crossings or loops;
- Structural alterations to bridges, viaducts, tunnels, roads, etc.
- Signalling alterations including reconfiguring, repositioning and associated work including telecoms;
- Power and Electrification alterations to suit, including realignment, plus new power requirements as appropriate; and,
- Platform extensions, alterations and associated and consequential work.

For each element the assumed quantum of work has been identified by DfT, in consultation with Faithful and Gould. Faithful and Gould has not undertaken any assessment as part of this study to determine how consistent the assumed quantums are with the proposed output specifications for each of the scenarios. The work scope has been scheduled, and from these schedules unit quantities have been assessed and applied to the unit rates to build up a base costs for each location.

To the base costs a series of percentage additions have been applied for management and project on-costs to arrive at a total 'all in' scheme cost per location. These location costs have then been summarised into a cost per scenario on all of the main inter-city routes being examined.

In preparing cost estimates, a benchmarking exercise has been carried out in tandem to validate the unit rates, with the outturn costs of other comparable route improvement schemes.

5.2.2 Estimate Parameters

To determine the work necessary at each location to accommodate that particular scenario, workshops were held with DfT. For each scenario the extent of work was determined, broken down into the following key elements of work:

- Trackwork;
- Structures;
- Electrification (Traction Power systems);
- Signalling, telecoms and control systems;
- Buildings, including platforms;
- Other electrical and mechanical systems; and,
- Contractors' preliminaries, and other project on-costs.

Beneath this level the main components of the physical works associated with the scheme itself are broken down.

The elements listed above are then linked to a unit rates file, and quantified to produce an overall base construction cost.

The template established also makes provision for the addition of other indirect costs associated with the management and execution of the works, namely:

- The cost of procuring or leasing land, as necessary, for either the permanent works or temporary requirements;
- Ancillary costs, including environmental works and landscaping;
- Provision of main power substations and enhancements to the national grid (as considered necessary);
- Design, Project Management and other fees, during implementation; and,
- Optimism Bias.

At this stage the majority of the items listed above have been determined on the basis of an applied percentage. Of these the largest item is Optimism Bias, which has been applied at 66% of the overall costs, to reflect this early stage in the project development. This is consistent with HM Treasury's Green Book guidance.

5.2.3 Estimate Exclusions

Whilst at this stage of the project development there remain a number of gaps in the information necessary to populate the capital cost in detail in all areas, we have endeavoured to make the estimate as complete as possible, minimising the number of excluded items. Those exclusions that do remain are detailed below:

- Potential property development, income or resale value;
- Local taxes;
- Development costs expended by the client to date;
- Costs associated with the client team including its duties, accommodation and services;
- Financing charges associated with borrowing or raising funds; and
- Future inflation to the implementation phase (Costs are based at Average 2009 prices).

5.2.4 Estimating Assumptions

At this stage of the scheme development a number of high level assumptions have had to be made with regard to estimate content, both in terms of quantities of work and the rates applied to them. These can be summarised as follows, and should also be read in conjunction with the estimate exclusions detailed above:

- All construction, maintenance and renewal prices are based at a common base date of an Average 2009 price;
- No consideration has been taken for any cost effect in programming and procurement arrangements and planning;
- Track work by location has been determined by desk top studies;
- The related structural works have been assumed to be kept to the minimum; and,
- Signalling works are assumed to be kept to a minimum and relate to moving and repositioning only, without major area reconfiguration or central control alteration.

If the schemes are progressed, and the estimates are developed further, then these assumptions will be challenged and addressed, although it is likely that a number of more detailed assumptions will still be required.

5.2.5 Capital Cost Estimate

The detailed capital cost estimate is given in Appendix B, broken down by the main inter-city routes being examined, and by scenario. A summary of the total capital cost of the three rail scenarios are given in Table 5.1 below.

Table 5.1 – Total Capital Costs, £ millions (2009 prices/values)

Package	Total Cost (£, millions)
Scenario A	3,516
Scenario B	13,085
Scenario C	23,802

Table 5.1 shows an increase in capital cost by scenario. Scenario A, has an overall cost estimated at £3.5 billion, this figure increases to £13 billion in Scenario B, and up to nearly £24 billion in Scenario C.

5.2.6 Rolling Stock

There are alternatives as to whether the rolling stock requirements for the three scenarios would be purchased, and thus treated as a capital cost, or leased, and thus incorporated into the operating costs. In implementing conventional improvement schemes of this nature the rolling stock is almost always leased, as it involves small numbers of additional trains being added to existing fleets. In this work, therefore, the central case figures assume that rolling stock is leased.

In the HS2 Ltd work on the proposed Y network the rolling stock is assumed to be purchased, and thus is treated as a capital cost. We have therefore also produced figures where the rolling stock is assumed to be purchased so that comparison with HS2 Ltd's analysis can be made.

The assumed capital costs of rolling stock were provided to Atkins by the Department for Transport.

The wider assumptions relating to the purchase of the rolling stock are consistent with those of HS2 Ltd, as follows:

- The initial investment costs were spread equally over a five year period, prior to the scenarios being implemented;
- All rolling stock was assumed to have a lifecycle of 35 years; and
- Optimism bias was added to the initial purchase cost at a rate of 18%, consistent with HS2 Ltd's assumptions.

The capital cost of purchasing rolling stock for the first time is given in Table 5.2 below.

Table 5.2 – Cost of purchasing rolling stock for the first time, £ millions, 2009 prices/values

Package	Total Cost (£, millions)
Scenario A	904
Scenario B	1,702
Scenario C	1,960

5.3 Operating Costs

Rail operating costs were estimated for each of the packages on an incremental basis. An estimate was made of the base costs for operating the West Coast Main Line, Chiltern Line, Midland Main Line and East Coast Main Line, in the Reference Case and in each of the three scenarios. The difference between the Scenario cost and the Reference Case cost was the figure carried forward to the appraisal.

The operating costs only included the variable elements of operating costs, as follows:

- Variable Track Access charges;
- Electricity and Diesel Fuel Costs;
- Staff costs, based on £ per train set;
- Lease costs of rolling stock;
- Insurance;
- Variable Overheads/Administration Costs; and
- Rolling Stock maintenance.

The assumptions underlying the estimation of the operating costs were consistent with those used by HS2Ltd. These include:

- Staff Costs used were current UK long distance operators' typical working hours, practices and costs.
- Electricity Costs were assumed to grow in line with the 2010 DECC electricity price index, equating to 91% growth in between 2010 and 2030 (with no further growth in later years)
- An Optimism Bias allowance of 41% was applied to all operating costs consistent with the approach taken by HS2 Ltd.

Lease cost assumptions for rolling stock were provided by DfT.

The incremental operating costs for each of the rail packages are given in 2009 prices, in the table below.

Table 5.3 – Operating Costs, £ millions, per annum, 2009 prices/values

Package	Total Cost (£, millions per annum)
Scenario A	236
Scenario B	578
Scenario C	706

The element of the annual operating costs that is related to the cost of leasing rolling stock for each of the three scenarios is given in the table below.

Table 5.4 – Cost of leasing rolling stock, £ millions, per annum, 2009 prices/values

Package	Total Cost (£, millions per annum)
Scenario A	116
Scenario B	294
Scenario C	333

Under a scenario where rolling stock is purchased, the annual operating costs for each of the three scenarios is the total annual costs (given in Table 5.3) minus the lease costs (given in Table 5.4). These costs are given in the table below.

Table 5.5 – Cost of Operations without rolling stock lease charges, £ millions, per annum, 2009 prices/values

Package	Total Cost (£, millions per annum)
Scenario A	119
Scenario B	284
Scenario C	373

6. Economic Appraisal

6.1 Overview

This section presents the results of the economic appraisal for the HS2 'Y' Network Strategic Alternatives rail packages of interventions, focusing on the benefits that will be generated for users and transport providers as a result of the interventions, and the costs associated with their provision. For each set of interventions, the following information is presented:

- Derivation of Scheme Costs, which describes the methodology for converting base costs into a present value of costs used in the economic appraisal;
- Derivation of Scheme Benefits, which provides a summary of the modelling packages used to assess the impact of the road and rail interventions, and the appraisal tools used to generate the present value of benefits; and
- Summary of Results, which presents summary economic statistics (PVB, PVC, NPV and BCR) for each of the three packages of interventions.

6.2 Derivation of Scheme Costs

6.2.1 Introduction

The costs associated with the packages of schemes are described in more detail in Chapter 5 of this document. This section below, highlights how these costs were converted into a present value of costs for use in the economic appraisal.

6.2.2 Capital Costs

NATA-based economic appraisal requires realistic and accurate scheme costs to be produced. The costs of transport schemes are an integral component of the scheme appraisal process, particularly where they are subsequently used to form decisions on scheme funding.

There are two main elements of a scheme cost estimate:

- The base cost, which is the basic cost of a scheme before allowing for risks;
- Adjustment for risk and optimism bias, which should cover all the risks that can be identified, and reflect the well-established and continuing systematic bias for estimated scheme costs and delivery times to be too low and too short respectively, and results in the risk and optimism bias-adjusted cost estimate.

Capital infrastructure costs for the three packages of rail-based interventions are presented in Table 6.1. These represent nominal capital costs, in 2009 prices, expressed in factor cost unit of account. The costs do not include an allowance for future inflation, to be consistent with the approach of HS2 Ltd.

Table 6.1 – Undiscounted Real Scheme Capital Costs (£m, 2009 prices and values)

	Scenario A	Scenario B	Scenario C
Base Costs	2,118	7,883	14,338
Risk & Optimism Bias	1,398	5,203	9,463
Total Scheme Costs	3,516	13,085	23,802

In order to be consistent with the appraisal assumptions of HS2 Ltd., we have also examined a scenario whereby the rolling stock fleet required to operate each package would be purchased. These costs are presented in Table 6.2. In accordance with the approach taken by HS2 Ltd, it is assumed the rolling stock fleet would be replaced every 35 years. A further allowance is included to account for the refurbishment of the rolling stock, approximately every 18 years.

Table 6.2 – Undiscounted Real Scheme Capital Cost of Rolling Stock (£m, 2009 prices and values)

	Scenario A	Scenario B	Scenario C
Total Cost	2,409	4,539	5,227

Table 6.3 presents the scheme capital costs, including both infrastructure work and rolling stock.

Table 6.3 –Total Scheme Capital Costs, including rolling stock purchase (£m, 2009 prices and values)

	Scenario A	Scenario B	Scenario C
Nominal Scheme Cost (2009)	5,925	17,624	29,029

6.2.3 Operating Costs

This section presents the operating costs included in the economic appraisal, which form part of the overall PVC for each package of rail options. The derivation of these costs has been described in Chapter 5, and is summarised in Table 6.4 below.

Table 6.4 – Rail Operating Costs included in the Economic Appraisal when Rolling Stock is Assumed to be Leased (£m, 2009)

	Scenario A	Scenario B	Scenario C
Nominal Operating Costs (2009)	25,624	60,312	74,577

In order to understand the impact of alternative rolling stock procurement arrangements, the economic analysis was also undertaken assuming that the additional rolling stock was purchased. Under this scenario, the capital costs for the scheme are still consistent with Table 6.1. However the cost of leasing the rolling stock was included in the overall operating costs, which are summarised in Table 6.5.

Table 6.5 – Rail Operating Costs included in the Economic Appraisal when Rolling Stock is assumed to be a Capital Cost (£m, 2009)

	Scenario A	Scenario B	Scenario C
Nominal Operating Costs (2009)	14,698	32,674	43,320

6.3 Derivation of Scheme Benefits

6.3.1 Modelling of Rail Schemes

The strategic alternative scenarios were assessed using the PLANET framework model, adopting identical assessment parameters to those of HS2 Ltd. This ensured that the approach to the assessment of the Strategic Alternative rail packages was consistent to that of HS2.

Model runs were undertaken for both 2021 and 2043, and an economic appraisal undertaken consistent with the approach taken by HS2 Ltd.

6.3.2 Economic Appraisal Results

The economic appraisal of the scenarios has been undertaken using a bespoke spreadsheet model, using outputs from the PLANET Strategic model in conjunction with economic parameters and formulae contained on the DfTs WebTAG Unit 3.5.6. The spreadsheet is based on conventional consumer surplus theory and is therefore consistent with the TUBA methodology recommended by DfT and used on the appraisal of rail-based packages described above.

The appraisal is based on the same 60-year appraisal period as for the proposed HS2 project. If a decision is taken to proceed with a high speed rail network, the HS2 Ltd working assumption is that the section of the proposed Y network from London to Birmingham would be open in 2026, with the remaining sections through to Manchester and Leeds opened in 2033. For the Scenarios, therefore, we have assumed that the works on the West Coast Main Line are undertaken for opening in 2026, with the works on the Midland Main Line and the East Coast Main Line undertaken for opening in 2033. The total appraisal period is therefore from 2026 through to 2092.

Annualisation factors consistent with those employed for HS2 Ltd, ensure that all 8,760 hours of the year are represented.

Summary economic statistics, assuming the rolling stock is leased are presented in Table 6.6 for all three rail packages. The full TEE tables for each package are presented in Appendix C, in Tables D1 to D3.

Table 6.6 – Economic Summary Statistics – Assuming Rolling Stock is Leased (£m, 2009 prices & values)

Economic Summary Statistic	Scenario A	Scenario B	Scenario C
PVB	2,190	10,916	11,853
PVC	5,078	11,558	21,392
NPV	-2,887	-642	-9,739
BCR	0.4	0.9	0.5

The range of benefits for each of the rail packages appears appropriate, with the major increase in benefits coming between Scenarios A and B. At a strategic level, the results are consistent with the changes in mode shift presented in the tables earlier in the document.

The results in Table 6.6 show that Scenarios A, B and C have negative Net Present Values, reflecting the fact that the Present Value of the Costs are higher than the Present Value of the Benefits. This manifests itself as a Benefit to Cost Ratio of less than one, which means that they are characterised as poor value for money schemes.

The economic results for the scenario whereby the rolling stock is assumed to be purchased are summarised in Table 6.7.

Table 6.7 – Economic Summary Statistics – Assuming Rolling Stock is a Capital Cost (£m, 2009 prices & values)

Economic Summary Statistic	Scenario A	Scenario B	Scenario C
PVB	2,190	10,916	11,653
PVC	3,773	7,694	17,072
NPV	-1,583	3,222	-5,420
BCR	0.6	1.4	0.7

The effect of assuming that the rolling stock is purchased is to decrease the present value of costs, as discussed already in Chapter 5. This means that under this scenario, the BCRs for the rail packages are higher than when the rolling stock is assumed to be leased.

In the situation where the rolling stock is purchased Scenarios A and C remain as poor value for money schemes. Scenario B, however, has a positive Net Present Value, and is reclassified as a low value for money scheme.

7. Summary and Conclusions

7.1 The Packages

Three rail scenarios were identified by DfT as Strategic Alternatives to the High Speed Y shaped network proposition. These scenarios comprised rail interventions grouped together as follows:

- Scenario A: Increasing capacity by extending the length of existing long distance services, requiring works including platform lengthening, track remodelling and depot works to cater for longer trains and more vehicles;
- Scenario B: Increasing capacity and enhancing long distance service frequency, requiring works to operate a higher frequency of services, including upgrades to stations and junctions, and additional tracks; and
- Scenario C: Combined capacity enhancement and reduced journey times, including construction of some new alignments to bypass sections with low line speeds and limited capacity.

These packages were costed, modelled and evaluated by Atkins, consistent with the approach taken by HS2Ltd. The outcome of this assessment work is summarised in this section.

7.2 Scenario A

Scenario A indicates that with infrastructure investment (in the region of £3.5 billion) the capacity of long distance services from London to the North could be enhanced through train lengthening.

Depending on the assumptions made in relation to rolling stock procurement, this package has an indicative BCR of between 0.5 and 0.6.

The proposed works would be disruptive to passengers. The extent of this depends on the scheme design and the scope of staging works, and has not been assessed in detail at this stage.

7.3 Scenario B

Scenario B indicates that with infrastructure investment (in the region of £13 billion) the capacity of the major rail lines from London to the North could be enhanced with additional long distance service frequencies.

Depending on the assumptions made in relation to rolling stock procurement, this package has an indicative BCR of between 0.9 and 1.4.

The proposed works would be disruptive to passengers. The extent of this depends on the scheme design and the scope of staging works, and has not been assessed in detail at this stage.

7.4 Scenario C

Scenario C indicates that with infrastructure investment (in the region of £24 billion) the capacity of the major rail lines from London to the North could be enhanced and journey time reductions of varying extent could be provided for long distance passengers.

Depending on the assumptions made in relation to rolling stock procurement, this package has an indicative BCR of between 0.5 and 0.7.

The proposed works would be disruptive to passengers. The extent of this depends on the scheme design and the scope of staging works, and has not been assessed in detail at this stage.