High-Speed Rail Development Programme 2008/9

Principal Consultant

Final Report

9 October 2009

Version 5.7

Contents

Appendices

1 Introduction

1.1 The Study

This report details the conclusions from a study to develop a strategy for a UK high-speed rail network. The study was planned to comprise five stages as detailed below, with an additional stage being introduced during the course of the study:

- Workstream 1 – Determine the starting point for the study by evaluating relevant work already completed elsewhere, including an open call for further relevant material.
- Workstream 2 – Determine the Guiding Principles of the high-speed rail network using the principal categories such as national and local policy, target markets and technical considerations, in consultation with various stakeholders.
- Workstream 3 – Create and document assessment and appraisal methodologies through development of a strategic business case model, incorporating a ridership forecast model which can later be applied to route and network options; identify, at strategic level, the full economic benefits, assess capital costs, evaluate environmental impact, evaluate CO_2 emissions; use these models to generate performance indicators for options.
- Initial Network Scenarios - Assess some overall networks to give early indications of the appropriate strategy and guide the subsequent workstreams.
- Workstream 4 – Define and evaluate high speed rail (HSR) route and service options for the five corridors addressed in the study (see Figure 1.1 for a high-level representation of the five corridors). Define the options utilising the Guiding Principles determined in Workstream 2 and stakeholder feedback, and identify key technical, physical and political constraints; this learnt significantly from the results of the Initial Network Scenario study. Evaluation of the options via application of tools developed in Workstream 3.
- Workstream 5 – Using output from all other Workstreams, define an overall network development strategy, including one or more possible long-term network specifications; phasing; the overall case for the national network based on benefits delivered; and the level of investment. Workstreams 4 and 5 are undertaken simultaneously, and can be considered to be 2 parts of a single workstream: Workstream 4/5.

This report describes the conclusions drawn from Workstream 4/5, making reference to the conclusions of the earlier workstreams, in particular the Initial Network Scenarios workstream, where relevant.

Figure 1.1 The 5 corridors studied in the High Speed Rail Development Programme

1.2 Study Approach

This section sets out the approach used in the High Speed Rail Development Programme, and particularly for Workstream 4/5, in which HSR scenarios are both defined and evaluated.

Definitions

Before embarking on a description of the study approach, we define a number of concepts:

- Corridors
- Linkages
- Routes
- Scenarios
- Service Patterns

The five Corridors, presented in Figure 1.1, are deliberately broad 'areas of interest'. They are

1. London – Northern England (western)
2. London – Northern England (eastern)
3. London – Bristol and South Wales
4. Transpennine
5. Northern England to Scotland

It is important to distinguish Corridors 4 and 5 as dependent corridors, i.e. HS lines in these corridors would not realistically be built without lines in at least Corridor 1 or Corridor 2 being built as well. We also note that whilst there is a degree of interdependence and interaction between Corridors 1, 2, 4, and 5, Corridor 3 can be considered almost entirely in isolation. Corridor 3 includes consideration of the West of England.

With the exception of Corridor 5, we are considering the different options for building a single new HS **Line**. We refer to these lines as:

- High Speed – North West (HS-NW) Corridor 1
- High Speed – North East (HS-NE) Corridor 2
- High Speed – South West and Wales (HS–SW) Corridor 3
- High Speed – Transpennine (HS-TP) Corridor 4

We will also refer to the existing Channel Tunnel rail link as High Speed – Channel Tunnel (HS-CT). Corridor 5 would be served by HS-NW, HS-NE or indeed both lines.

Within each corridor and between corridors the desired HSR **Linkages** must be identified. A Linkage is made up of two end-points that will be served by HSR rolling stock, via newly built high-speed tracks, and/or as an onward service from the HSR network to the classic line.

Within each corridor there are a number of potential **Routes** that a high speed line can take; on some corridors where capacity is less critical there is the possibility of upgrading to remove particular bottlenecks or increase speed. The finding that the most pragmatic approach to constructing new HS lines is to follow existing railway and motorway corridors wherever possible means that the number of Routes we can consider within a corridor is kept to a manageable number.

A **Scenario** is a possible end-state of the network. A Scenario therefore comprises one or more Routes or upgrades. In WS4/5 we have tested the business case of a total of 12 Scenarios plus some smaller variants to determine the relative merits of each ultimate outcome. A scenario includes both a set of infrastructure and a **Service Pattern** - the set of train services one is likely to run on the infrastructure in that scenario, including services that run on from this infrastructure to the classic and HS1 network.

Major Steps in the High Speed Development Programme

Table 1.1 sets out the major steps of the study. It is important to bear in mind that these steps are not necessarily sequential, but rather later steps may lead to modifications in conclusions from earlier ones.

Table 1.1 Major steps of the High Speed Rail Development Programme

Review of existing material on high speed rail in UK context	Ensure we learn from previous work and do not unnecessarily repeat previous studies.
Definition of the Guiding Principles for high speed rail in the UK	As mentioned above, the aim of Workstream 2 was to identify the Guiding Principles that should orient the strategic choices for HSR in the current study. These Guiding Principles are summarised in Table 1.2 below.
Develop appraisal model	This model included demand and revenue forecasting, cost modelling and economic appraisal. It outputs a wide range of economic and other indicators that assist in selecting between options.
Identification of high-level network Scenarios	A preliminary set of possible network shapes, all of which must respond favourably to the Guiding Principles, is defined. Each Scenario is made up of a number of Routes, which are broad definitions of the infrastructure to be built.
Appraisal of high-level network Scenarios	To identify key issues and guide the subsequent work, especially detailed scenario definition.
Identify issues that need resolving	Following the high level scenarios, identify a number of issues that need resolving through further scenario tests.
Specify the remaining scenario tests	These need to be specified as detailed in the following tasks.
The following steps are undertaken for each of a number of scenarios	
Definition of required Linkages	The HSR links that are of value are defined.
Identify required infrastructure	Identification of the infrastructure that will deliver the linkages.
Select preferred infrastructure options	A reasoned evaluation of the various infrastructure options leads to a selection of the preferred options.
Define service patterns	Service patterns consistent with the required infrastructure, and that reflect the requirements of the Guiding Principles are defined.
Demand forecasts	The demand forecasts and load factors are determined based on the infrastructure and service patterns. Nonetheless, they may also lead to modifications in infrastructure (eg construction of extra platforms)) or service patterns (eg to respond to excess demand).
Business Case and complete assessment	A complete Business Case and assessment is carried out on the Scenarios.
Recommended scenario	
Define the overall HSR Network	Using results of the various scenarios, we define an overall scenario including appropriate phasing.

1.3 The Guiding Principles for High Speed Rail Development

The Guiding Principles for high speed rail development in Britain, as defined in Workstream 2, are presented in Table 1.2.

These guiding principles inform the high-level decisions made in the current study when defining network scenarios and corridor options.

It is not the purpose of this study to necessarily identify the 'optimum' ultimate solution, although we do recommend a network that we consider to best meet the objectives of the guiding principles, more importantly, this study aims to provide decision makers with an evidence base upon which to decide which solutions are the best to develop.

Table 1.2 Guiding Principles for High Speed Rail development

1. Capacity	**HSR routes need to be located such that they provide additional capacity for the national transport system where there is forecast to be unmet demand on the long-distance routes, and create high-value capacity relief on the existing rail network.**
■	HSR routes need to provide additional capacity into the centre of the major cities they serve, particularly where the inter-urban rail network is operating at, or close to, capacity.
■	HSR networks need to be planned so that they create additional commuting capacity where there is forecast to be a capacity short-fall on current plans.
■	Freight network capacity released on the main lines needs to be matched by suitable availability of paths to reach terminals, ports and to cross London.
2. Sustainable Economic Competitiveness	**HSR needs to serve places which are capable of stimulating economies to achieve growth, recovery and wider productivity benefits, and to stimulate and support a sustainable pattern of development.**
■	HSR needs to access city centres and to have high-quality stations where large-scale regeneration and high development densities are considered desirable, or where existing demand is intense.
■	Cities so served need to have complementary city-region and regional development plans across the relevant sectors so that HSR has a material economic impact.
■	The effect of HSR needs to be such that the locational disadvantages of northern and western cities are reduced and pressure from long-term development in the southeast relieved.
■	The overall HSR service offer needs to be perceived to offer a step-change in quality, with faster journeys offering an advance in accessibility and a level of reliability that fosters investor confidence.
3. Whole Journey	**HSR has to be planned to address the whole journey, as identified in TaSTS/DaSTS, to make it an attractive, lower carbon, alternative to car use.**
■	HSR services will have to offer safe and secure, attractive, reliable and substantially reduced journey times, able to attract travel not only to and from city centres but across wider catchments and across social and income groups.
■	To create a connected rail-based alternative across a wide set of destinations, there is a need to have HSR stations serve as hubs, connected conveniently into feeder rail and other public transport services.
■	There will have to be substantial provision for road-based access modes, including cycle and private car, at HSR stations, planned from the outset to minimise overall carbon emissions.
■	Parkway stations will only be considered if they do not detract from the ability to achieve the objectives set in relation (a) to city centres and (b) to achieving an overall reduction in carbon.
4. Modal Switch - Aviation	**HSR needs to attract travellers away from short-haul aviation to/from major international hub airports in order: to free-up runway capacity for more valuable longer-distance services; and/or reduce carbon emissions; and/or to provide suitable HSR services for regions that have lost air services and are not well connected to international hub airports .**

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- To be an acceptable substitute for international inter-lining traffic, access from HSR to air terminals has to be as attractive and convenient, including security and ticketing issues, as from a flight.
- HSR has to be able to offer journey times that will compete effectively with air and win significant route market share.
- HSR has to be able to match effective airline frequency. The capacity of an HSR train is much higher than a typical domestic aircraft; this means either the air passenger flows are large or the HSR service not only serves the airport market but also other destinations, and/or a series of cities that can be attractively served by a single airport service.
- To address the near-continent short-haul market, HSR services will need to be capable of direct operation over the HS1 route and onwards over the expanding European high-speed rail network.

5 An Integrated Network for All	**HSR needs to be planned as a system, developed in a staged programme, properly integrated with other transport facilities to maximise its value, with complementary measures identified as necessary, to ensure a comprehensive (nationwide) spread of benefits that has relevance and appeal across all social groups and types of traveller.**

- There will have to be a long-term national strategy with a phased flexible implementation approach.
- To ensure the long term benefits of HSR are secured for the cities, regions and devolved nations, the delivery of HSR should be supported by complementary planning and economic development measures
- The benefits of freeing capacity on existing main lines and local networks need to be demonstrated for communities that may not be directly served by HSR.
- The HSR long term network strategy needs to address all of the English regions and the devolved nations.

2 Corridor Status Report

This section contains a brief overview of the current situation in the 5 corridors. A detailed analysis is provided in Appendix A.

2.1 Overview of Corridors

Section 1.1 and Figure 1.1 above present an overview of the 5 corridors.

2.1.1 Economic and Demographic Conditions

The design and construction of a high speed rail network in Great Britain will take many decades. It is thus important to examine economic and demographic conditions not only today, but in the future.

Population and employment trends until 2025 are examined based on published sources such as TEMPRO; thereafter the forecasts consist of extrapolating these trends into the future for inclusion in the demand forecast and business case models. It should be noted that these are trend-based forecasts that do not take account of ambitions to grow regional economies more quickly, as described in regional strategies and the Regional Economic Strategies of the Regional Development Agencies, which HS rail could itself help facilitate.

Table 2.1 shows the broad population and job growth trends predicted for the regions and Scotland.

Table 2.1 Growth in population and number of jobs from 2007 to 2025 in the 5 Corridors and in all of Great Britain[1]

[1] TEMPRO Dataset 5.4

	Population (millions)			Jobs (millions)		
	2007	2025	% increase	2007	2025	% increase
London	7.4	8.6	16%	4.4	5.2	17%
South East	8.2	9.3	13%	4.4	5.1	16%
West Midlands	5.3	5.8	10%	2.7	3.0	9%
North West	6.8	7.5	10%	3.4	3.6	8%
Corridor 1	**27.7**	**31.2**	**13%**	**15.0**	**16.9**	**13%**
London	7.4	8.6	16%	4.4	5.2	17%
East	5.6	6.6	18%	2.8	3.2	14%
East Midlands	4.3	5.0	16%	2.2	2.5	13%
Yorkshire and Humber	5.1	5.8	14%	2.7	3.0	13%
North East	2.5	2.6	5%	1.3	1.3	2%
Corridor 2	**24.9**	**28.6**	**15%**	**13.4**	**15.2**	**13%**
London	7.4	8.6	16%	4.4	5.2	17%
South East	8.2	9.3	13%	4.4	5.1	16%
South West	5.0	5.9	17%	2.7	3.1	15%
Wales	3.0	3.2	8%	1.4	1.6	8%
Corridor 3	**23.6**	**27.0**	**14%**	**13.0**	**15.0**	**15%**
Yorkshire and Humber	5.1	5.8	14%	2.7	3.0	13%
North East	2.5	2.6	5%	1.3	1.3	2%
North West	6.8	7.5	10%	3.4	3.6	8%
Corridor 4	**14.4**	**15.9**	**11%**	**7.3**	**7.9**	**9%**
Scotland	5.1	5.3	5%	2.6	2.7	6%
North East	2.5	2.6	5%	1.3	1.3	2%
North West	6.8	7.5	10%	3.4	3.6	8%
Corridor 5	**14.4**	**15.4**	**7%**	**7.2**	**7.6**	**6%**
Great Britain	**58.2**	**65.6**	**13%**	**30.6**	**34.3**	**12%**

The expected growth in each corridor is generally near that of the British average. Scotland, Wales, the North East and Wales, however, expect relatively low growth, whereas the growth in the South West and the East will be particularly high. It is notable that in comparing Corridors 1 and 2, the stronger growth is expected in the latter of these, i.e. on the eastern side of England. Corridor 5, the Anglo-Scottish link, is the corridor with the lowest overall expected population and employment growth.

2.2 Passenger Travel Market

This section examines in broad terms the passenger travel market in the 5 Corridors. The modes studied are car, air and rail.

The coach market is considered to be irrelevant to the high speed rail study because coach travellers are unlikely to find high speed rail attractive. Their major reasons for choosing coach would preclude their choosing high speed rail in the future. Those who currently choose coach:

- do so for the low monetary cost (traded off against potential time savings if using rail)
- prefer point-to-point journeys (journeys which would involve interchange if using rail)

Coach has thus been omitted from this study, except for coach to Heathrow where it often provides the fastest mode of public transport; the transfer from this mode is treated in the same way as transfer from rail in other contexts.

Workstream 2 identified the importance of designing a high speed rail network that would maximise abstraction from both air and car. Figure 2.1 below offers an overview of 2007 demand on key itineraries, from city centre to city centre, where rail is currently the dominant mode..

Two important East-West itineraries are not included in this graphic: Manchester-Leeds, 46 million trips, of which 93% were made by car, and Edinburgh-Glasgow, 80 million trips, of which 90% were by car.

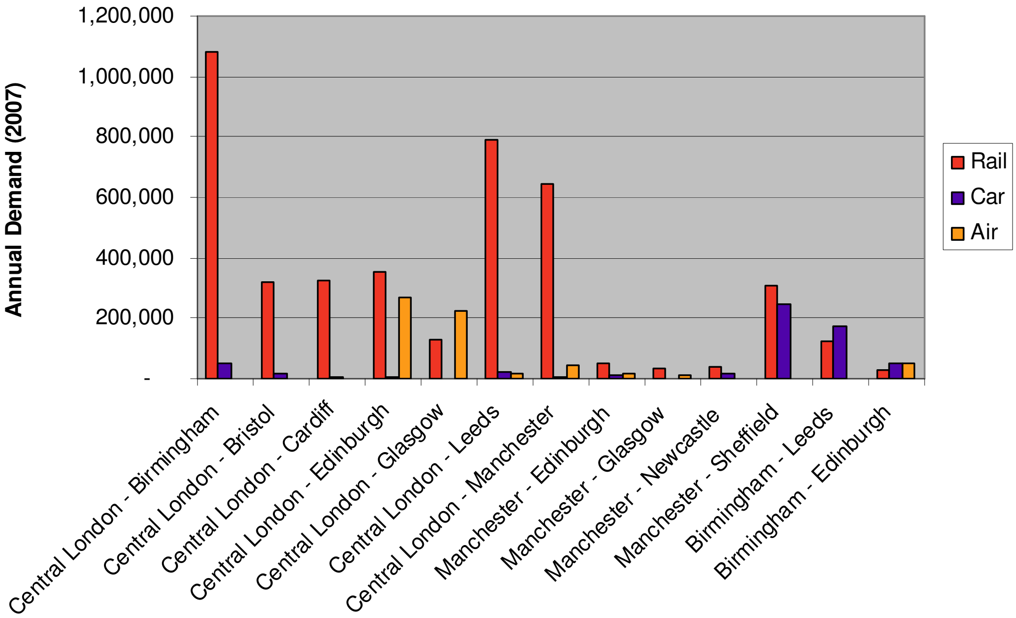
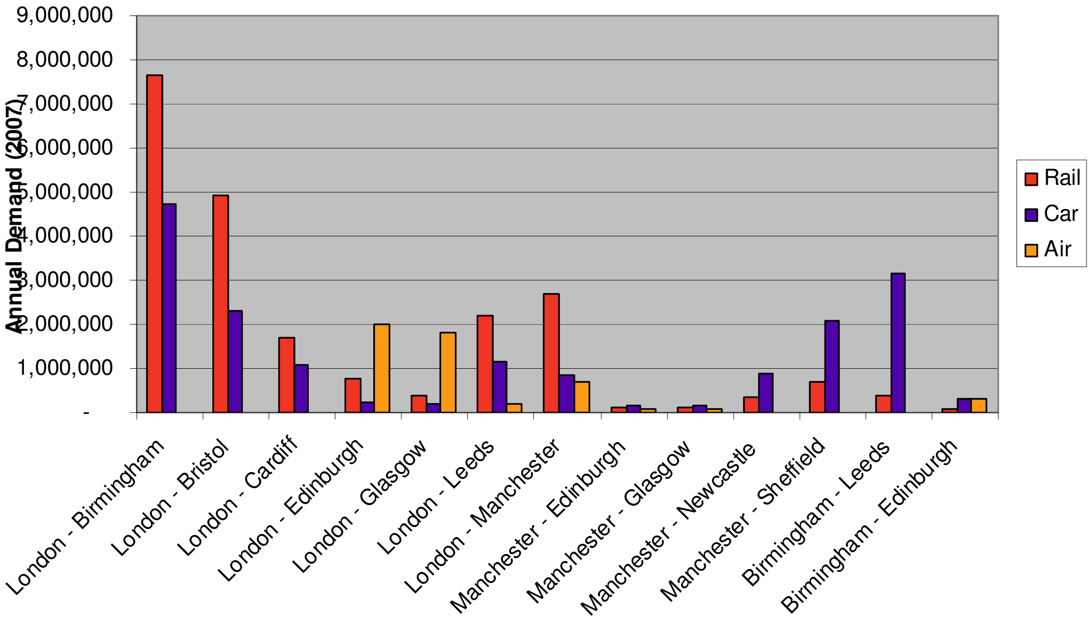


Figure 2.1 2007 demand between city pairs, between HSR catchment zones[2] - demand from city centre to city centre

Whereas Figure 2.1 shows demand between the centre of the listed cities, Figure 2.2 shows how these mode shares differ when comparing demand from both the cities and their associated city regions, showing rail to be less competitive over these wider areas.



[2] The demand is for the city centre to city centre, defined as the area covered by the relevant city council (London is Westminster, City of London, Islington and Camden.) . Rail demand is sourced from the demand forecasting tool MOIRA. Car demand is sourced from the DfT National Travel Model. Air demand is sourced from the Civil Aviation Authority. Note that air demand regards customers travelling from city centre. For example, 0.44 million people took a flight to travel between Greater London and Greater Manchester, whereas more people actually took Manchester-London or London-Manchester flights, but with other ultimate origins or destinations.

Figure 2.2 2007 demand on key itineraries, between HSR catchment zones - demand from cities, including surrounding city regions

Travel times by mode are shown in Table 2.2; these exclude access/egress times. In order to encourage modal shift towards high speed rail, journey times must be competitive, in particular with regards to air travel.

Table 2.2 Travel times by mode. Times are typical advertised times – selected journeys may be significantly faster, e.g. London – Glasgow by rail can be as fast as 4hr 10min.

Itinerary	Rail travel time	Air travel time	Road travel time
London - Manchester	2hr 10 min	1 hr 6 min	4 hr
London - Birmingham	1hr 25 min	n/a	2.5hr
London - Bristol	1 hr 50 min	n/a	2 – 2.5 hr
London - Cardiff	2 hr 10 min	n/a	2.5 – 3 hr
London - Edinburgh	4 hr 40 min	1 hr 20 min	7+ hr
London - Glasgow	4 hr 40 min	1 hr 20 min	7+ hr
London - Leeds	2hr 25 min	n/a	3.5 hrr
London - Newcastle	3hr 10 min	1 hr 12 min	~5 hr
Birmingham - Manchester	1 hr 25 min	n/a	1.5-2 hr
Edinburgh - Glasgow	50 min	n/a	1 hr

2.3 Rail Infrastructure and Services in the 5 Corridors

This section outlines the current situation on the five corridors, as well as existing plans for their upgrades. The current service patterns and the restrictions on capacity they bring are also considered.

2.3.1 London to the North West

The primary rail link between London and the North West is the 645km West Coast Mainline (WCML), which has recently undergone a lengthy and thorough £10bn upgrade which has seen speed increases from 177km/h to 200km/h, the introduction of tilting trains, removal of major bottlenecks (Rugby, Nuneaton) and the addition of extra tracks to portions of the route. This has made it possible to reach Manchester and Liverpool in just over 2 hours, and Birmingham in 1hr20min. The modernisation has also increased the clearance on the entire route to W10-gauge, making the route the most important freight and container rail link between the South East, the North and Scotland. Many important freight terminals, such as Daventry, Rugby, Trafford Park and Garston are located along the route. According to Network Rail's Route Plan for the WCML, freight depots across the route could generate up to 30% growth in freight traffic by 2019.

The route today is continuously four-track between London Euston and Rugby (133km). From there the Birmingham and Coventry branch diverges. The route has long three- and four-track sections from Rugby up to Preston (a further 204km). From Preston the route is two-track with passing loops for freight trains. At Carstairs (599km from London) the route splits, with one branch continuing to Glasgow Central via Motherwell, the other, more lightly used, to Edinburgh. The other main junctions on the route are:

- Colwich Junction (where the Stoke-on-Trent branch splits),
- Crewe (where the Manchester and North Wales routes diverge),
- Weaver Junction (branch to Liverpool), Preston (branch to Blackpool),
- Carlisle (Junction of Settle & Carlisle Line, Cambria and Newcastle lines).

The premier long-distance operator on the WCML is Virgin Trains (VT). Following the introduction of their Very High Frequency timetable in December 2008, VT now operate the following service pattern throughout most of the day:

- 3 trains per hour (tph) between London and Birmingham New Street (1tph extended to Wolverhampton),
- 3tph between London and Manchester (2x via Stoke-on-Trent, 1x via Crewe), and
- 1tph each to Liverpool, Glasgow and Holyhead.

Additionally, there are 14 trains per day between Birmingham and Scotland, ending alternately at Edinburgh or Glasgow. All these services are provided by relatively new Class 390 Pendolino and Class 221 Super Voyager tilting trains, built 2000-2004.

Other long-distance services using the WCML are Cross Country and Transpennine Express. Cross Country operate a 2tph service between Manchester and Birmingham New Street (via Stoke-on-Trent, Stafford and Wolverhampton), from where trains run either to Reading, Hampshire and Dorset, or Bristol, Devon and Cornwall. Transpennine Express operates:

- 7 trains per day between Manchester and Central Scotland (mainly to Edinburgh, with some services to Glasgow),
- 1tph between Windermere / Oxenholme and Manchester Airport, and
- 1tph between Blackpool and 1tph between Blackpool and Manchester Airport.

Local services on the southern half of the route are provided by London Midland, with the following service pattern:

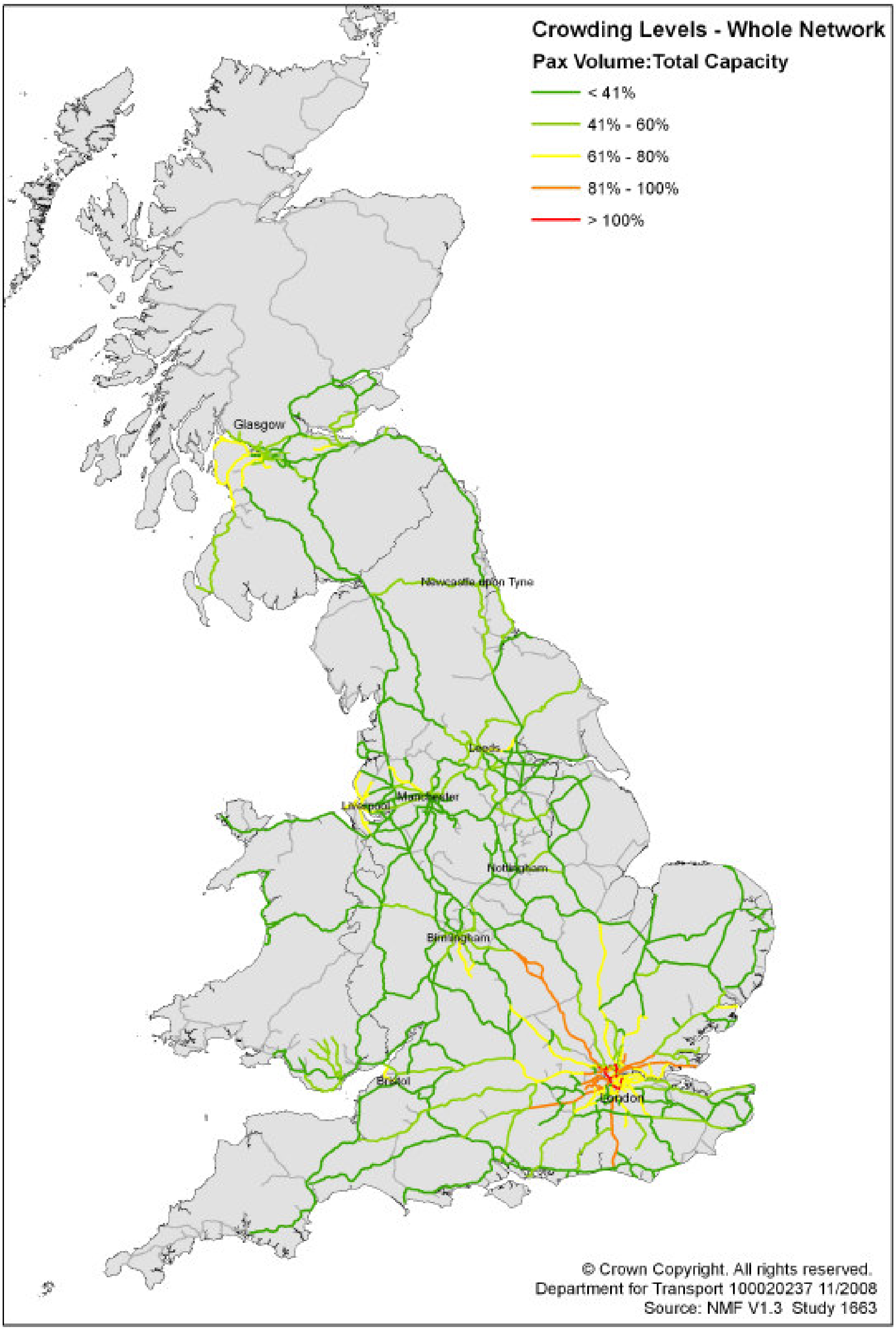
- 1tph London Euston to Crewe via Northampton, Stafford and Stoke-on-Trent
- 6tph London Euston to Milton Keynes, Northampton and Birmingham New Street (stopping and semi-fast)
- 3tph Birmingham New Street to Northampton
- 2tph Birmingham New Street to Liverpool

Local services on the northern half of the route are provided by Northern Rail, with the following service pattern:

- 2tph Liverpool – Wigan and 1 tph to Blackpool
- 1tph Blackpool – Preston - Manchester- Buxton
- 1tph Blackpool – Preston – Blackburn – Leeds

Despite the recent upgrades to infrastructure at the southern end of the route, the WCML will soon be struggling to provide enough capacity for passengers wishing to travel. Figure 2.3 shows projected crowding levels in 2024/2025.

Figure 2.3 Loading levels in the 3-hour morning peak period, 2024/25[3]



[3] Source: Department for Transport, *Britain's Transport Infrastructure: High Speed Two*, January 2009.

Despite the route having four tracks on most of the stretch between London and Manchester, there is an inherent conflict between the needs and objectives of the different groups of train service. On one hand, improvements to long-distance services have meant that passenger numbers have risen from 13m in 1997 to 23m in 2008[4], some of which reflect a mode shift from air, and will keep on growing with a more frequent service and fewer weekend closures. On the other hand, the Government has planned thousands of new homes in the Milton Keynes area as part of its Sustainable Communities Plan[5], which will add more rail commuters into London. This will create severe problems on the southern half of the route, where the slow lines have to accommodate the stopping patterns of both the slower all-stations services, freights, as well as the faster semi-fast services to the Trent Valley and beyond.

Further north, Birmingham New Street and Manchester Piccadilly are amongst the busiest stations in Great Britain, outside of London. They are currently running at close to capacity in terms of train movements and are struggling to keep up with the growth in passenger numbers.

2.3.2 London to the North East

The corridor from London to Yorkshire and Tyne & Wear is today served by two main lines. The East Coast Mainline (ECML) runs out of London Kings Cross, to Peterborough and by-passes Sheffield to the east via Doncaster, where the branch to Leeds diverges. The mainline runs further North to York, Darlington, Durham and Newcastle, and then on to Edinburgh Waverley. Most of the route up to York lies on flat terrain, with 200km/h running on most of the route, using electric non-tilt trains built at the beginning of the 1990s, and some diesel HSTs and newer diesel units. Further north from Darlington the line is somewhat twisting, but speeds upwards of 160km/h can be achieved on most stretches.

The line is the main connection between London, Leeds, York, Newcastle, and Edinburgh. It is four-track between London and Welwyn Garden City (32km), with two tracks over Welwyn Viaduct, a major pinchpoint on the route. Adding two additional tracks here would be a major infrastructure cost. From there, it is four-tracked until Connington (111km from London), where the line again narrows to two tracks for 10km. From then on, the line passes Peterborough and continues as either a three or four track alignment till Stoke Junction (161km from London), where it turns to a two-track alignment for most of the way to Edinburgh. Besides the two-track section over Welwyn Viaduct, the capacity constraints on the route are:

- Hitchin Junction, where 'down' trains from London to Cambridge have to cross both 'up' lines at grade as they leave the ECML – the peak period trains on this route are especially heavily loaded and the junction is one of the constraints to providing additional capacity,
- The two track section over Stilton Fen south of Peterborough,
- Peterborough station itself, especially with the planned extension of Thameslink services to this point and the possibility of the need to create new junctions to facilitate the use of the GN/GC Joint Line for north-south freight movements.
- Newark Level Crossing – a flat diamond crossing with the Nottingham to Lincoln line, where trains have to slow down from 200 to 160km/h,
- Doncaster area junctions (including Shaftholme)
- York and Newcastle stations – busy stations with very slow approaches,
- Leeds station – an extremely busy station with a complicated layout and 6 tracks approaching from the west and only 2 from the east.

The key services, operated by the East Coast franchisee, are:

- 2tph London to Leeds
- 1tph London to Edinburgh (some extended to Inverness, Aberdeen and Glasgow), and
- 1tph London to Newcastle (some extended to Edinburgh).

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[4] Source: 2008 Rail Industry Monitor

[5] Source: Milton Keynes Partnership. http://www.miltonkeynespartnership.info/future_plans/index.php.

The ECML is also used by two open access long-distance operators, with a third due to start by the end of the year. Hull Trains runs 7 services a day to Hull, while Grand Central runs 4 trains a day to Sunderland via York and Eaglescliffe, and now has approval to launch a Bradford service too under the name Grand Northern. Other long-distance operators are:

- Transpennine Express: 3tph from Liverpool and Manchester to Scarborough, Middlesbrough and Newcastle
- Cross Country Trains: 2tph from the South and South West via Birmingham New Street – Leeds/Doncaster to Newcastle and Edinburgh

Local services out of London (Kings Cross and Moorgate) are operated by First Capital Connect, with up to 10 services per hour serving locations such as Peterborough, Kings Lynn, Cambridge, Hertford, Stevenage or Welwyn Garden City. These services are one of the longest-distance commuting services in Britain, and have widely varying stopping patterns to cater for both the long and shorter-distance markets. Further to the North, Northern also operates local services around Leeds, Teesside and Tyne & Wear.

The ECML is also a very important freight artery, carrying containers from the Haven ports to Yorkshire and the North East, as well as coal and other traffic. There are also plans for gauge enhancements to the East Coast Main Line and to link in the major East Coast ports in the North by 2014 which will attract further freight traffic. Due to the existing capacity constraints, freight from the London area is diverted via the Hertford Loop, but most freight trains join the route at Peterborough.

The East Coast Route Utilisation Strategy (RUS)[6], published by Network Rail, forecasts approximately 20% growth in the number of passengers using the long-distance services out of Kings Cross between 2006 and 2016, with West Yorkshire stations growing at twice that rate. Partly due to the capacity constraints in serving the London commuter market, the RUS only foresees an 11-26% growth during that time for stations to Peterborough and Cambridge. Despite the recession, what is already a busy route will become even busier over the next decade.

The single biggest infrastructure investment currently planned for the ECML will be the connection of the southern end of the route to the Thameslink tunnel as part of the Thameslink modernisation programme. A total of 24tph is scheduled to run through the tunnel from 2015 onwards, with ten of these destined for the ECML. Together with platform lengthening on the route, this should contribute towards the alleviation of some crowding issues, and will free up platforms at Kings Cross. However, it may take up further capacity on the fast lines, shared between Peterborough/Cambridge services and long-distance services. A further major investment for the route will be the introduction of the new Super Express Train on the route by 2015, that will shorten journeys times from London to Leeds by 10 minutes and from London to Edinburgh by 12 mins, while also increasing capacity per train by around 20%.

A constraint to increasing the speed of long-distance services on the ECML is the (irregular) stopping pattern of these services. While the route by-passes large cities like Leicester, Nottingham and Sheffield, the operator is bound to make calls at smaller stations en-route, such as Grantham, Newark and Retford. The irregularity of the stops is a further significant constraint for services, and a standard clockface timetable with a higher number of paths than today has been under consideration for some time now.

Furthermore, Leeds is a very capacity-constrained station, with either station throat at capacity despite the station's recent modernisation and remodelling. Plans for electrifying the so-called 'electric horseshoe' (electrifying between Hambleton Jn and Leeds) would have enabled ECML services to run straight back to London without needing to reverse at Leeds, thereby increasing the efficiency of rolling stock use. However, these plans are difficult to implement without increasing capacity through Leeds Station.

The Midland Mainline (MML) runs out of London St Pancras, towards Leicester, Derby and Sheffield, also serving Nottingham via a branch. The route only permits 177km/h running until Derby, with limited scope for 200km/h between Derby and Sheffield. Though somewhat smaller, the stations of Wellingborough, Kettering and Market Harborough (between London and Leicester), have East Midlands Trains as their only service provider.

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[6] East Coast Route Utilisation Strategy. Network Rail 2007. http://www.networkrail.co.uk/browse%20documents/rus%20documents/route%20utilisation%20strategies/east%20coast%20main%20line/east%20coast%20main%20line%20rus.pdf

The route is electrified and four-tracked as far as Bedford (Sharnbrook Jn, 91km from London), with three tracks to Kettering (119km from London) and two tracks to Leicester. Approximately half of the route from Leicester onwards is three or four-tracked, owing to large numbers of freight trains utilising the infrastructure.

The main long-distance operator on the line is East Midlands Trains, which operates 5tph out of London:

- 1tph to Corby, semi-fast
- 2tph to Nottingham, one fast, one semi-fast
- 1tph to Derby
- 1tph to Sheffield (some extended to Leeds)

Semi-fast trains are trains that call at smaller stations between London and Leicester.

The northern part of the route (Derby – Sheffield) is also used by Cross Country trains, which operate 2tph between the South, South West, Birmingham and the North East and Scotland. Both East Midlands Trains and Cross Country operate a mix of 1970s diesel HSTs and newer (built from 2000 onwards) Class 220, 221 and 222 units.

The London commuter market is catered for by First Capital Connect, which runs trains as far as Bedford. These trains continue through the Thameslink tunnel to London Bridge and Brighton, and to Sutton. There are two service groups:

- 4tph Bedford – Brighton (utilising fast lines and slow lines), more intensive in the peak
- 4tph Luton – Sutton (stopping train, slow lines), more intensive in the peak

In the Midlands, East Midlands Trains, Northern Rail and Cross Country run the following local and long distance services on the MML:

- 1tph Liverpool – Norwich (uses MML between Sheffield and Clay Cross Jn)
- 1tph Nottingham – Matlock
- 2tph Nottingham – Birmingham (1tph extended to Cardiff)
- 1tph Nottingham – Leeds (uses MML between Sheffield and Clay Cross Jn)
- 1tph Birmingham – Stansted Airport (uses MML between Wigston North Jn and Syston South Jn)

The MML is also an important freight route, with Ratcliffe-on-Soar power station lying on the route, and other power stations in the vicinity. A combination of these flows leads to the railway being capacity-constrained for much of its length. Coupled with relatively low top speeds on the route and a number of speed restrictions through intermediate stations between Leicester and Bedford, this makes the route one of the more unattractive intercity routes in Great Britain.

2.3.3 Anglo-Scottish

The straight-line distance from London to Glasgow is around 560km, and to Edinburgh around 540km. Such long distances have led to air being the preferred mode for travelling from London to Scotland. The hilly topography of the north of England causes the rail journey times on both the WCML and the ECML to be around 4h20min – 4h30min, despite both routes being modernised over the past three decades. This is well above the 3 hours typically considered to be competitive with air. This is also why both routes only have 1tph each between London and Glasgow / Edinburgh – a marked contrast with the 3tph to Manchester on the WCML or 2tph to Leeds on the ECML – both markets, where rail commands a majority of the market share.

The current stopping pattern is equally significant in determining the long journey times on the route, caused by the need for those trains to serve intermediate markets. On the WCML, the Glasgow services usually run non-stop between London Euston and Warrington Bank Quay. From then on, however, they become the main London link for places such as Wigan, Preston, Lancaster and Carlisle. Despite the curving nature of the route through the difficult topography of the Lake District and southern Scotland, a line speed of 125mph (with some short sections of 100, 115 and 120mph) is achieved using a tilting mechanism, with the most significant speed constraints being through stations such as Carlisle and Carstairs. Moreover, these services have to share tracks with a host of slower services (Transpennine, VT Birmingham – Scotland services), as well as freight trains, in particular many coal trains between Glasgow and Carlisle. The additional station calls and the need to accommodate other services make the typical London Glasgow journey time around 4h20min much slower than the record of 3h55min set by a VT Pendolino in 2006.[7]

The East Coast route may be slightly less capacity constrained at the north end of the line, however, it too has constraints preventing Scottish services from being faster. The main reason is again the requirement to serve intermediate stations, such as Grantham, Newark and Retford on the southern half of the route, and Darlington, Durham, Alnmouth, Berwick and Dunbar on the northern half. Whilst these stations are not very large markets per se, there is no capacity to introduce separate, semi-fast services for them, as is current practice on the MML, for example.

There have been proposals on both the WCML and the ECML to introduce speeds higher than 200km/h on their portions. However, whilst the rolling stock running on both routes is capable of around 230km/h (as is some of the signalling on the ECML), these plans have not materialised. This is because safety considerations require running upward of 200km/h to be controlled by in-cab signalling, which was proven to be too costly to install given the speed benefits it would achieve. It is in any case unlikely, that any upgrade of the current infrastructure would significantly increase the competitiveness of the journey times between London and Scotland to an extent, where rail would become the preferred mode of travel rather than air.

2.3.4 Transpennine

The Transpennine (TP) corridor is composed of two routes. The North TP route runs between Manchester Piccadilly and Leeds via Stalybridge and Huddersfield. The South TP route runs between Manchester Piccadilly and Sheffield via New Mills. Both routes have a low top speed due to their topography, and both are significantly gauge-constrained due to the number of tunnels they pass through.

The North TP route is much busier than the South. Transpennine Express provides the main service on the route, offering 4tph between Liverpool and Manchester Airport to Leeds, Hull, York, Scarborough, Middlesbrough and Newcastle, with an intermediate call at Huddersfield. Northern takes up the rest of the capacity with various local services calling at other stations on the route. Despite the relatively high frequency of the service, platform length and rolling stock constraints make it difficult for the current timetable to cope with the demand. The capability of the network also does not currently deliver a 60mph average journey time for passengers. Network Rail have committed to implement improvements to decrease the journey time through the core section (Manchester to Leeds) from the current 55 to around 40 minutes. Also, the Government has committed to electrifying the route from Liverpool to Manchester, which will lead to a cut in journey times on that section to 30 minutes. Further benefits may also be realised from the Manchester Hub Study, which is looking to resolve the complex capacity and reliability issues around the Manchester area.

The South TP has 2 fast tph, however, at uneven intervals. This is because both trains serve different purposes. One of these is the Transpennine Express running between Manchester Airport and Cleethorpes via Stockport, Sheffield and Doncaster. The other is the East Midlands Trains service between Liverpool and Norwich via Manchester, Stockport, Sheffield, Nottingham and Peterborough. The other train running through the route is an all-stations Northern Rail service. The journey time for the faster services is around 50 minutes from Manchester to Sheffield. As with the North TP, benefits may also be realised from the Manchester Hub Study.

2.3.5 Great Western

The Great Western Mainline (GWML) out of London Paddington is probably the busiest portion of railway in Great Britain not yet fully electrified. The Mainline serves a host of destinations in the West and South West of England (Bristol, Exeter, Plymouth, Cornwall, Oxford, Worcester, Gloucester), and South Wales (Newport, Cardiff and Swansea), as well as many suburban destinations and Heathrow Airport. The route is four-track all the way from London past Reading (where services to Exeter, Devon and Cornwall branch

[7] Virgin Train Breaks Speed Record. BBC News. http://news.bbc.co.uk/1/hi/scotland/glasgow_and_west/5369808.stm

off) to Didcot Parkway (85km from London), where it branches out into two two-track routes. One goes to Oxford, carrying services to Worcester. The other carries the bulk of the services to Swindon (where the line to Cheltenham branches off), and further to Wooton Bassett Junction (where services to Bath and Bristol Temple Meads branch off). From there the line continues to Bristol Parkway, through the Severn Tunnel, and onward to Newport, Cardiff and Swansea.

There are also some freight flows: aggregates traffic between Somerset and Acton; Avonmouth Docks traffic; and some between England and Wales, plus limited other flows. The section between Reading and Oxford is a major freight route for trains from Southampton towards the North.

The route is today electrified from Paddington to Heathrow Airport, however, all long-distance services are today served by diesel HST trains, with smaller units running on local services.

The main operator on the route is First Great Western (FGW), which runs the following long-distance services:

- 2tph to Bristol Temple Meads via Bath
- 2tph to Cardiff via Bristol Parkway (with 1tph onward to Swansea)
- 1tph to Exeter and Plymouth via Reading and Westbury (with some trains extended to Cornwall)
- 0.5tph to Cheltenham and Gloucester
- 1tph to Worcester and Hereford via Oxford
- 2tph to Oxford (1tph extended to Moreton-in-Marsh)

Cross Country trains also operates on sections of the route between Reading and Oxford (services from Reading and Bournemouth/Southampton to the North), between Bristol Temple Meads and Bristol Parkway (services from Devon and Cornwall to the North), and between Cardiff and Severn Tunnel Junction (services to Birmingham and Nottingham).

Local services out of Paddington are operated by First Great Western, Heathrow Express and Heathrow Connect as follows:

- 4tph Heathrow Express to Heathrow non-stop
- 2tph Heathrow Connect to Heathrow calling all stations
- 2tph FGW to Greenford
- 2tph to Oxford (semi-fast)
- 2tph to Reading

FGW also operates local trains around the Bristol area, while Arriva Trains Wales operates local services around Newport, Cardiff and Swansea.

The GWML is a very busy railway, however, it does benefit from a relatively new and efficient Integrated Electronic Control Centre (IECC) at Slough, which controls the busiest section from Paddington to Heathrow Airport. The main pinchpoints on the route are Reading Station, and the Severn Tunnel, which are full to capacity.

The GWML will undergo three significant changes within the next decade. One will be the electrification of the route from Heathrow Airport Junction through to Swansea and Bristol Temple Meads. Scheduled for completion by 2018, it will reduce the travel time to Swansea by around 19 minutes, and also increase capacity with new trains. The second major project is the remodelling of Reading station. Due to its complex layout, a lack of platform faces and the numbers of conflicting moves generated by various different passenger and freight services, Reading station has been the biggest generator of delays on the line. By major reconstruction of track and platforms, along with installing two flyovers, capacity and reliability will improve.

The third important project will be the construction of Crossrail. The scheme involves the construction of an east-west rail tunnel underneath London, to enable high-frequency local trains to run between

Heathrow and Maidenhead in the west to Stratford, Shenfield, Canary Wharf and Abbey Wood in the east. This will free up some terminal capacity at Paddington.

These three schemes together will be as important to the GWML as the route upgrade was to the WCML. They will reduce journey times quite significantly, and will increase the capacity and reliability on the route overall. However, not all the capacity issues will be addressed. While the route is already four-tracked till Didcot, there are significant conflicts from there to Wootton Bassett Junction, between the fast, slow and freight services, which carries the majority of traffic coming from the east on just two tracks. Hence, an extra pair of tracks to the west of Didcot would have the potential to bring in significant benefits.

2.4 Planning Issues/Objectives

The UK Government has made specific commitments to tackle climate change, support national and regional economic growth and develop transportation. The Climate Change Act commits to quantified objectives (an 80% reduction in carbon emissions by 2050)[8], the UK Government national transport objectives are primarily set out in the publication 'Towards a Sustainable Transport System[9]' (TaSTS), published in October 2007, which presents the government agenda to tackle transport congestion and improve transport networks whilst satisfying the twin objectives of both economic growth and reduction of carbon emissions.

In November 2008, the Secretary of State for Transport issued a formal consultation paper entitled "Delivering a Sustainable Transport System[10]" (DaSTS).

The objectives set out in this paper were integrated into the guiding principles for high speed rail formulated in Workstream 2: Strategic Choices. The sequence of objectives set out by the DfT are the following:

- Maximising the overall competitiveness and productivity of the national economy, including here the regional economic impact and reduction in congestion;
- Reducing transport's emissions of CO2 and other greenhouse gases;
- Contributing to better health and longer life-expectancy, including safety and security;
- Improving quality of life for transport users and non-transport users;
- Promoting greater equality of transport opportunity.

In Scotland, Scottish Transport Appraisal Guidance sets out the framework for appraising transport schemes against the Scottish Government's Purpose, which is 'to focus the Government and public services on creating a more successful country, with opportunities for all of Scotland to flourish, through increasing sustainable economic growth'.

A discussion of the impact of regional and national planning documents on high speed rail is presented in Appendix A.

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[8] Department for Environment Food and Rural Affairs (November 2007), Climate Change Act 2008, http://www.defra.gov.uk/ENVIRONMENT/climatechange/uk/legislation/.

[9] Department for Transport (October 2007), Towards a Sustainable Transport System, http://www.dft.gov.uk/about/strategy/transportstrategy/tasts.

[10] Department for Transport (November 2008), Developing a Sustainable Transport System, http://www.dft.gov.uk/about/strategy/transportstrategy/dasts.

2.5 Findings from regional workshops

Regional workshops were carried out as part of the High Speed Rail Development Programme in order to identify local stakeholders' objectives and concerns regarding HSR. Key findings are presented in the table below.

Workshop findings	Comments
In general, though good links with London are for most a top priority, participants stressed the importance of providing excellent cross-country links, as well.	This finding is in line with the Guiding Principle regarding comprehensive benefits.
A rapid link (3 hours or less) must be created between London city centre and Scotland. In Scotland the speed of the link is more important than freeing up rail capacity.	
An improved Transpennine link is justified by current transport demand (rail and car) and a need for greater capacity.	
Participants hope that local and cross-country services can be improved thanks to capacity release on the classic network due to a switch of long-distance services to the new HS.	Capacity release is a major issue on the WCML and ECML throughout England, but is less of an issue for Scotland and the Great Western Corridor.
In general, city centre locations for HSR stations were favoured over parkway-type stations. In large part this is because stakeholders believe that regeneration benefits can be obtained primarily via city centres, and not from new development zones. The importance of city centres as opposed to the classic concept of regeneration or development areas is underlined by the current economic crisis.	The WS2 report provided evidence that regeneration benefits were generally stronger with city centre stations.
HSR should probably serve more than one station in London, so as to put less pressure on one station, and in order to better serve different parts of London.	
Concern was expressed that a large-scale HSR project could be detrimental to classic rail users, either because their services would disappear, or because funds for infrastructure maintenance would be shifted towards the HSR and away from the classic lines.	In fact, HSR is expected to improve local services: by shifting long-distance services from the classic to the HSR, new capacity will be created on the classic lines that can be used for additional local services.
HSR must absolutely be integrated with local planning initiatives.	

2.6 Core objectives for high speed rail

The core objectives for high speed rail in the five Corridors have been determined on the basis of the guiding principles, stakeholder input at the workshops, and current transport challenges.

These core objectives are presented in Table 2.3.

Table 2.3: Objectives for high speed rail

Guiding Principle	Core Objectives
Capacity	Relieve southern WCML London to Carlisle, ECML London to Morpeth and Dunbar to Edinburgh, GW from Didcot to Wootton Bassett, southern MML.
	Relieve M1/M6, M40, M11, M62, M4
	Create new terminal and approach capacity in London, Birmingham, Manchester and Leeds
Economic Competitiveness	Serve Birmingham, Manchester, Newcastle, Leeds, Edinburgh, Glasgow, Nottingham, Bristol, Sheffield and Liverpool city centres
	Accommodate Milton Keynes/South Midlands and Cambridgeshire growth via relieving WCML, ECML and West Anglia route
	Strengthen regional connections to Heathrow as an international gateway
Whole Journey	Attract travellers from private car by making the rail service much faster, considering the whole journey from origin to destination including access and egress.
	Ensure that stations served have good connections
Reduce domestic and cross-channel aviation	Abstract the majority of London – Scotland air demand by providing rail journeys of less than 3 hours to Edinburgh and Glasgow
	Serve interlining market Manchester – Heathrow and if possible Scotland – Heathrow
	Create new service Birmingham – Heathrow, and introduce direct HSR services from Birmingham to near continent, an alternative to Birmingham - Schiphol etc flights
	Create HS-CT to Heathrow link, to serve Heathrow – Paris/Brussels interlining market
Integrated Network	Enable through running from classic network to HS, e.g. Bristol to Manchester
	Use released rail capacity to improve service in other areas (e.g. intermediate services along WCML)

3 Network Scenarios: Initial Network Testing

3.1 Objective of Initial Network Testing

As a prelude to the detailed consideration of different elements of a high speed rail network, it was considered valuable to explore a number of radically different potential networks. The objective was not to seek to identify an optimum scenario by this method, but to identify strengths and weaknesses of different approaches. This would then enable the remainder of the evaluation to be focused on answering clearly defined questions.

Four networks have been chosen to demonstrate contrast in approach. The intention is to maximise what can be learned from them, rather than to create optimised networks. Our interest therefore is only partly concerned with the overall economic performance of each of the networks, and the focus is just as much on the 'story' behind it, including:

- what constraints does each network place on the service patterns that can be run?
- what level of infrastructure will be required to carry the level of services needed to meet demand, e.g. how many platforms will terminal stations require, will some sections of route need to be four-track rather than two?
- what do different components contribute to the overall performance of a network? (Note that we can disaggregate cost into individual sections of infrastructure and benefits into particular flows or service groups.)
- what can be done with the classic network, and how does that contribute to overall performance?

These questions set the parameters by which the four scenarios are appraised against GG21's five guiding principles.

3.2 Strategic Choices and Design Criteria

The four scenarios have been defined as follows:

- Scenario 1 (reverse) **S network**
- Scenario 2 (reverse) **E network**
- Scenario 3 **Y network**
- Scenario 4 **H network**

Each Scenario represents a possible final state of the network. In each scenario, the network comprises a series of High Speed lines linking the major cities of the UK. We have identified a set of potential high speed links, each broadly following an existing Motorway or rail corridor. These are shown in Figure 3.1.

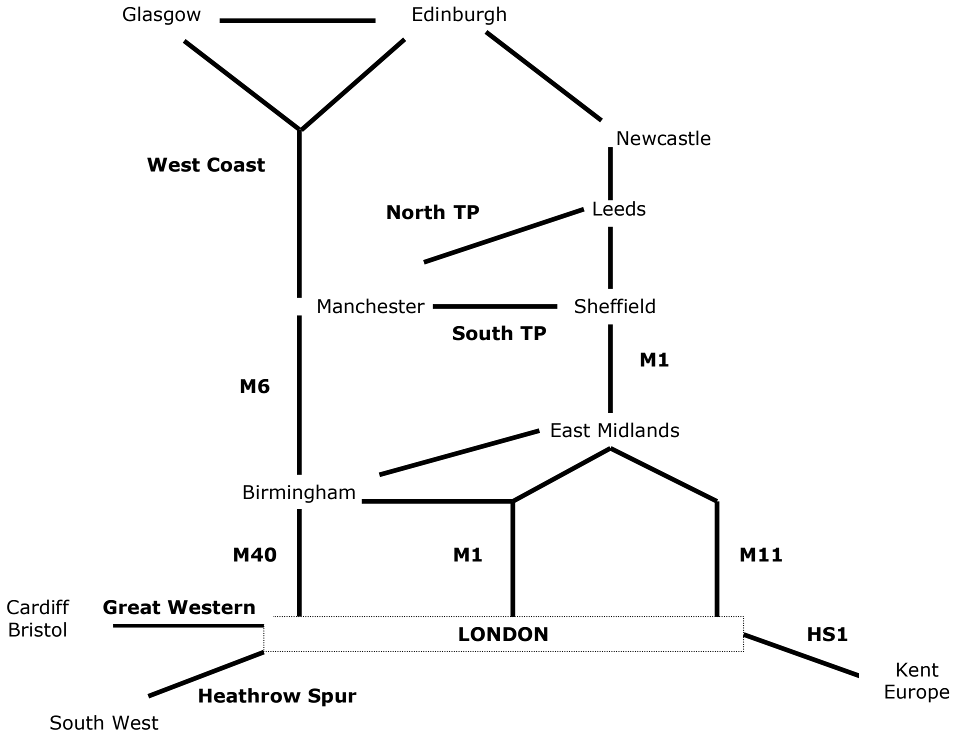

Figure 3.1 High Speed Network Components

In some cases the HS line is assumed to be an upgrade of the existing classic line in the corridor. Further, in some scenarios, HS trains are assumed to run on to specific sections on the Classic network to allow certain stations to be served that are not directly on the HS network. There are essentially two dimensions to the network definitions: firstly, the overall shape of the network between London and Scotland (as characterised by the letter shapes), and, secondly, a series of additional linkages to places which add value such as Heathrow, HS1 and the Great Western Main Line.

Three broad types of station have been considered. In the 'S' scenario, all intermediate stations are assumed to be dedicated new HS through stations located directly on the main line. These are assumed to serve city centres, so may need to be located underground. In the other scenarios, the HS lines are not assumed to penetrate city centres: instead cities are served by spurs, at existing or currently redundant or under-utilised stations. The only stations on the main line are parkway style stations, often located at Airports to take advantage of their existing highway and public transport connections.

Scenario 1 – Reverse 'S'

An outline map of this Scenario is shown in Figure 3.2.

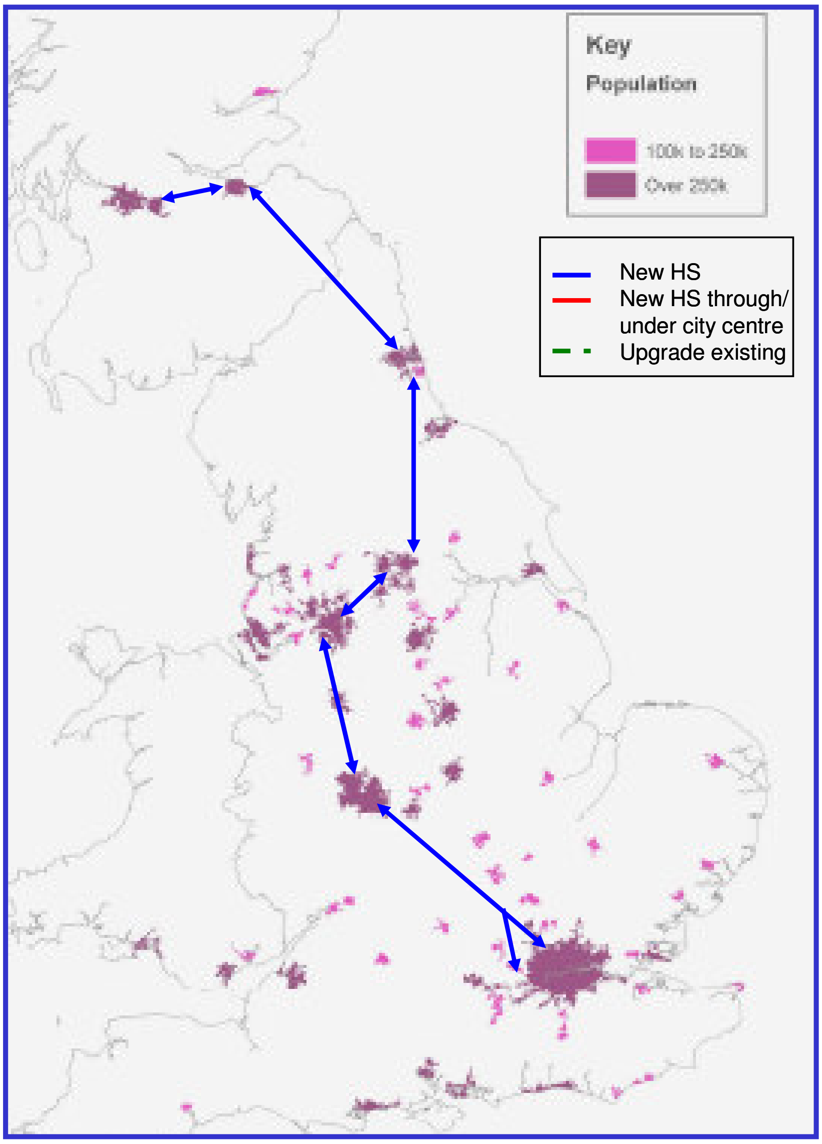

Figure 3.2 Network Map: Scenario 1 'Reverse S'

Reverse S is a single, self contained North-South High Speed Line (HSL) running London – Birmingham – Manchester – Leeds – Newcastle – Edinburgh – Glasgow, with stations running through (or under as necessary) city centres. The key features are:

- 2 track line between London and Birmingham via M40 corridor
- High Speed line running through or under city centres
- All stations except Glasgow would facilitate through services
- A single branch providing a link from the north into Heathrow

Scenario 2 – Reverse 'E'

An outline map of this Scenario is shown in Figure 3.3.

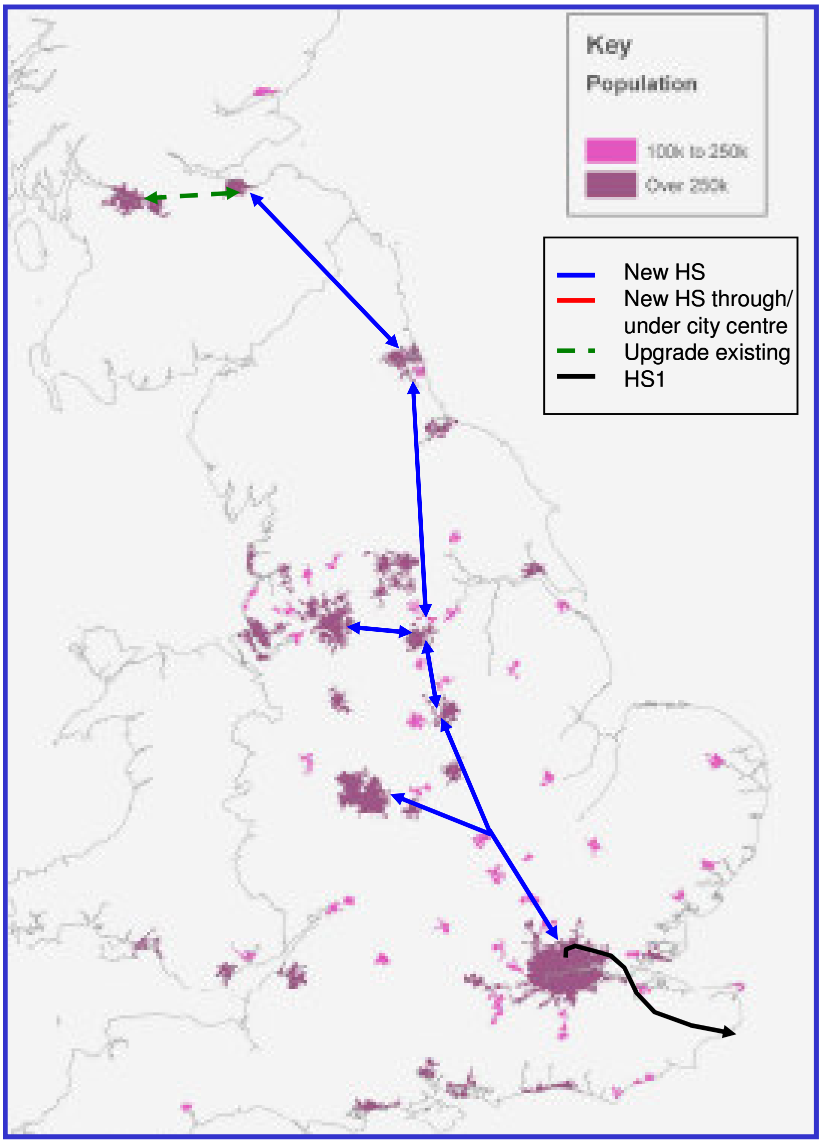

Figure 3.3 Network Map: Scenario 2 'Reverse E'

Reverse E is an easterly focused HSL in the M1 corridor serving London - East Midlands Parkway (EMP) – Newcastle - Edinburgh with an upgrade beyond to Glasgow. The key features of Reverse E are:

- 2 line track between London and Birmingham spur following an M1 alignment
- Branches to Birmingham and to Sheffield and Manchester via Trans-Pennine
- Spurs on the classic network to Derby, Nottingham and Leeds
- The Trans-Pennine link is between Manchester and Sheffield
- Connection to HS1 and Europe just north of St. Pancras

Scenario 3 – 'Y'

An outline map of this Scenario is shown in Figure 3.4.

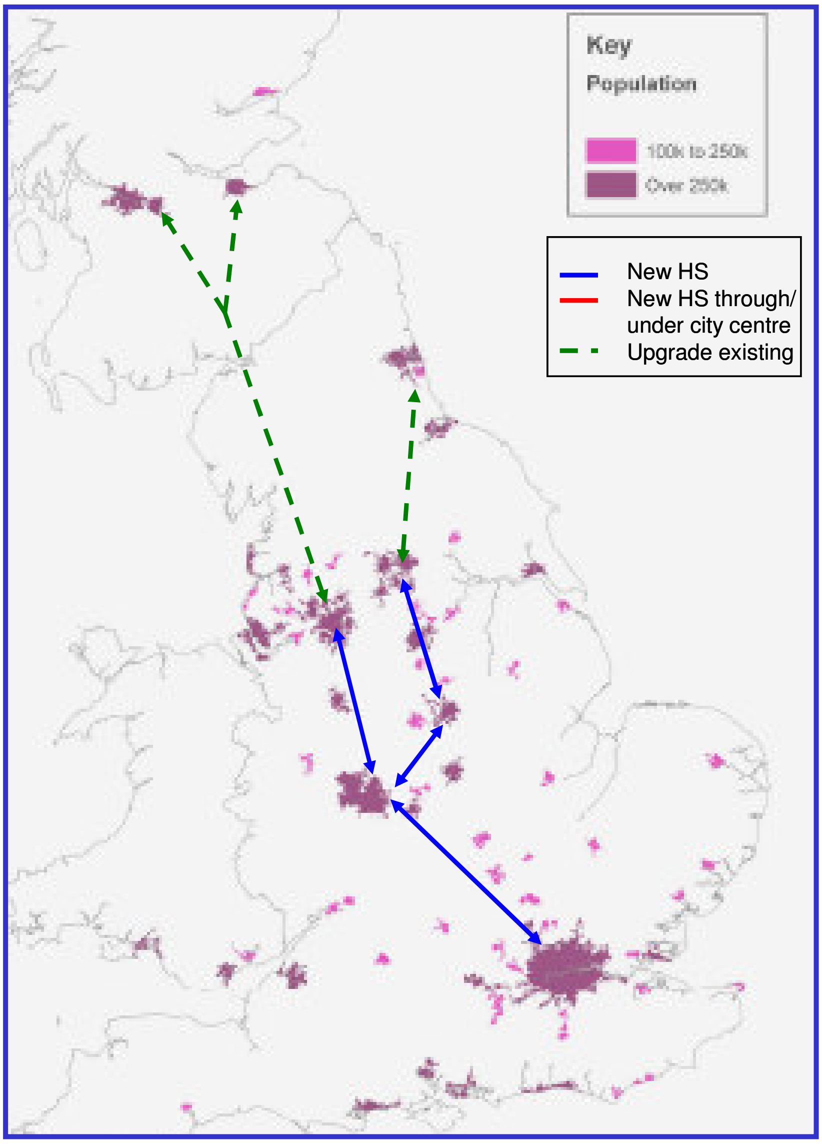

Figure 3.4 Network Map: Scenario 3 'Y'

Scenario Y comprises a four track HSL from London splitting at Birmingham International Airport (BIA) into a western HSL to Manchester followed by an upgrade of the West Coast Main Line (WCML) to Scotland; plus an eastern trunk route from BIA running as HSL to Leeds through East Midlands Parkway, and on to the existing East Coast Main Line (ECML) north to Newcastle. The key features of Y are:

- 4 track between London and Birmingham International following a M40 alignment
- spurs off the HSL to Birmingham, Derby, Nottingham and Sheffield
- link to the classic network near Crewe serving Liverpool, North Wales, North West and Scotland
- link from the north to the classic network serving Birmingham New Street and the South West
- no Trans-Pennine link or line between Edinburgh and Glasgow

Scenario 4 – 'H'

An outline map of this Scenario is shown in Figure 3.5.

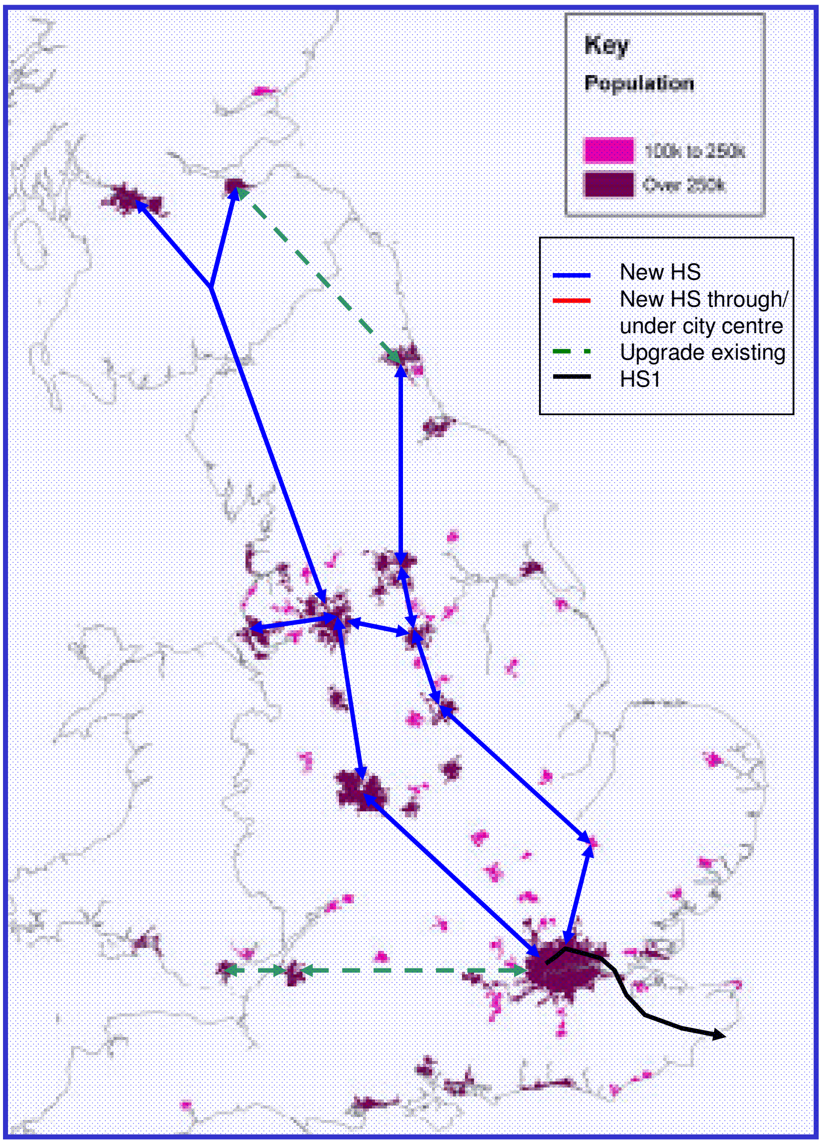

Figure 3.5 Network Map: Scenario 4 'H'

Scenario H comprises a new western HSL running London – Birmingham International – Manchester International Airport – Edinburgh/Glasgow, and a new eastern HSL running Liverpool Street – Stratford – Stansted – Nottingham – Newcastle then on an upgraded ECML to Edinburgh. The key features of H are:

- 2 track western HSL between London and Birmingham International following M40 alignment
- 2 track eastern HSL between London and Nottingham following M11 alignment
- The Trans-Pennine link is between Liverpool – Manchester International Airport – Sheffield
- Spurs to Birmingham, Manchester and Leeds
- Great Western Main Line (GWML) upgrade Cardiff – Bristol Parkway – LHR/Paddington
- All additional London connections provided: LHR connected to new western and eastern HSLs and to HS1; Western and eastern HSLs also connected to HS1; LHR also connected to South Western Main Line (SWML)

The HSR components at GG21 corridor level can be summarised as follows:

Table 3.1 Scenario Components

Scenario	Corr. 1 West Coast	Corr. 2 East Coast	Corr. 3 South West	Corr. 4 Trans-Pennine	Corr. 5 Anglo-Scottish	London area connectivity
1 'S'	Yes, but south only	North only	No	North	East, via Bham	LHR from north
2 'E'	No	Yes via M1 corridor	No	South (central M'chester)	East	HS1
3 'Y'	Yes, but North is upgrade	E Mids and Yorkshire branch from BIA	No	No	No	No
4 'H'	Yes	Yes via Stansted	Yes	South (MIA)	West, East upgrade	HS1, LHR with connection to GWML, SWML

3.3 Conclusions from the Initial Network Scenarios

Capacity into London

The analysis showed that a single two track railway north from London was unlikely to provide sufficient capacity to meet demand for high speed rail; indeed, there is a significant risk that such a railway would be at capacity almost from the day construction finished. The final network needs therefore to consist of four tracks north from London (plus probably two tracks west).

Four-track alignments versus two twin track alignments

A clear cost advantage to one or other approach could not be identified. The benefits are clearly context specific: if a distinctly different second corridor is developed as part of a twin-track approach, then there is the potential to serve more markets than a single four-track route, or to serve some markets more directly. However, four-track alignments might offer potentially greater operational resilience, as two tracks can be taken out of use during off-peak periods for maintenance or emergencies, while still maintaining a (reduced) level of service to the rest of the network.

The choice between these two alternatives is more likely to be dictated by practical issues such as whether or not terminal locations in London can be identified that can accommodate the 16 or more platforms that a four track alignment will require, and where sufficient onward connection capacity by other modes (LUL, Crossrail etc) can be provided. Moreover, as we demonstrate in Appendix C, while it is possible to undertake a phased construction whereby one pair of tracks is built substantially before a second, the only practical way to do this is to undertake all civil works in the first phase. This means that around 75% of the cost of construction will fall in the first phase, with the remainder in the second.

Balance of demand between Eastern and Western routes

If two distinct HS corridors are developed between London and Northern England (one to Manchester and one to Leeds/Newcastle), then the western route will need to serve the major flows of Birmingham and Manchester, plus several smaller flows such as Liverpool and the North West, which together gives greater demand than the flows of Sheffield, Leeds and Newcastle on the Eastern route. If the best economic case suggests Scotland should be served by the westerly route, this will add further to demand on the western route while leaving the eastern route with capacity to serve intermediate markets. If an M11 alignment is used, there may be the opportunity to use the capacity that would be created to serve Stansted and East Anglia, as we have done in the 'H' scenario, or it may imply that the need to build the eastern line is less urgent and can be constructed later.

London terminal

It would not be appropriate for this study to be definitive regarding London terminals. However, we have undertaken analysis to assess the feasibility of suitable central London termini. There appears to be at least one option that does not require a major building project or involve significant tunnelling or bridgework. This should have capacity equivalent to that of a double track HSR, but not a four-track HSR. Consequential changes to the underground network might be needed, but there are known schemes (not yet committed) that would make this feasible. To provide either a second central London terminus, or a single terminus for a four track HSR would be significantly more complex and expensive; however, there are some possible locations.

Another way to provide HSR capacity in London at lower cost is the use of stations outside central London. Any such station would require a range of high capacity rail (heavy or underground) links to a variety of destinations in central London, in particular major existing termini for onward connections. There is a location in east London that is worth further investigation.

On the west side of London, Heathrow Airport provides a well-connected hub; the development of Airtrack creates further important surface public transport linkages. Closer to London, there are locations with available space, but they do not appear to have the same range of onward connections, even if they can be connected to Crossrail.

The cost advantage of any option not directly serving central London needs to be traded-off against the additional access time penalty to central London and other important destinations. For example, we have analysed an alternative to our preferred Central London station located in the west of the city that would rely on Crossrail to provide the necessary linkages to other parts of London. In this scenario, demand for HS services was on average about 11% lower compared to the scenario based on the use of a central London station due to the additional time penalty. Overall, our assessment is that the value of a terminus in central London is very substantial, and costs have to be very large not to make this preferable.

Corridors

London to Midlands

From London to the Midlands, we have considered three distinct corridors, one following the M40, one along the M1 and one the M11.

Of these, our analysis to date indicates that the M40 has a distinct cost advantage, due to the availability of the 'GW/GC joint' railway corridor to provide an efficient, surface level route out of London that can exploit our currently-preferred central London terminus site.

We have not been able to determine a clear cost advantage to one or other of the two other corridors, and this will be highly dependent on the choice of London terminal.

Midlands to Northern England and Transpennine

From the Midlands to northern England we have considered two corridors: a westerly one from the Birmingham area following the M6 towards Manchester, and a central one following the M1 corridor serving the East Midlands, Sheffield, Leeds, and potentially onward to Newcastle.

It is possible to develop networks that serve all of Manchester, Leeds and Newcastle using only one of these corridors if it is combined with a Transpennine route. If the westerly corridor is developed, a northern Transpennine route can be used to link across to Leeds and Newcastle, though this compromises journey times to these cities. By contrast, the easterly corridor can be combined with a southern Transpennine route to serve Manchester, although there is still a 15 minute journey time impact to this city.

Both Transpennine routes would be challenging to construct, and compromises in line speeds will be necessary if costs are to be contained at a sensible level; furthermore, the relatively short Transpennine distances mean that the value of 300 kph compared to, say, 200 kph is fairly modest. (Note that we have incorporated these lower line speeds in our analysis and the journey times referred to in the previous paragraph.) Prima facie, there will also be significant environment constraints that will need to be considered in the development of a Transpennine route, especially on the Southern route if it passes through the Peak District National Park.

If a two-corridor approach is taken to the midlands to northern section of the country, then the Transpennine will not be required to serve key London flows, and will be purely providing non-London intercity links. From the analysis, it appears that the incremental cost and benefit of a full high speed Transpennine link performing purely this kind of role is unlikely to pass value for money assessment, not least because of the greater cost per kilometre of the Transpennine route.

The case could be stronger if this route could also perform one or more of the following functions:

- enabling a linkage from the northern part of the eastern HSL to Heathrow Airport, if providing this link in the London area proves too costly or infeasible
- similarly, enabling a linkage from the northern part of the western HSL to HS1, if providing this link in the London area proves too costly or infeasible
- providing a substantially improved link from the northern part of the eastern HSL to Manchester Airport (the regional airport for the whole of north England)
- providing additional capacity for freight (although Transpennine is not the largest of railfreight corridors at present)
- enabling further non-HS services to be operated
- providing new links into the Peak District National Park, as an alternative to car access. This might be most effective in combination with some form of car use restraint in this area to reduce car traffic in the Park.

Northern England to Scotland

The route options for this section again comprise two routes, eastern and western, mimicking the two main existing classic routes.

In conjunction with a reasonably direct HS route from London to the north west of England, a new HS line on the West Coast route can provide journey times of around 2hr 30min to both Edinburgh and Glasgow if non-stop, or 2hr 40 mins with one stop, making the route highly competitive with air.

By comparison, an East Coast route serves Glasgow via Edinburgh, so there is a difference in journey times to London from the two cities. The best times are achieved in combination with a direct M1 route from London to Leeds, then A1 to Newcastle, giving 2hr 23min to Edinburgh (non-stop), and a little over 3 hours to Glasgow; again a stop adds about 10 mins to these times. These are again in the range needed to be competitive with air, although that to Glasgow is on the threshold. These times would be significantly slower and less competitive if the route to Leeds is via Manchester.

We have considered the alternative option of the Anglo-Scottish routes being upgrades. While this may seem to be a less attractive option than building a new HS line, in that it delivers less competitive journey times (3 hours may still be achieved from London to Edinburgh and Glasgow, provided the full HSR goes as far north as Carlisle, for example), it could potentially avoid significant cost. In particular, upgrading certain, lightly-used sections of route might be a possibility.

As part of the East Coast options we have included two versions of the route between Edinburgh and Glasgow: a new HS line running from Edinburgh to Glasgow would be costly to build but deliver a journey time of just under half an hour. Alternatively, a cheaper option is to develop the existing route via Carstairs as an upgraded route, including a Carstairs bypass. We estimate journey times in the order of 35 minutes for this route, which would serve Glasgow Central rather than Queen Street. A variant of this second option would incorporate it into a network where Scotland is served via a West Coast route. In both cases, this would be a significant improvement over the existing 50 minute journey time between Waverley and Queen Street, but note there are separate plans to reduce this time.

Heathrow

We have tested two approaches to serving Heathrow: a single branch enabling HS services to serve the airport, and a wider scheme that creates a station at Heathrow that enables a wider range of linkages to be created, including links to, HS1, Great Western, and South Western Main Lines as well as the north-south high-speed lines. In both cases, the incremental business case for building the links was strongly positive provided there is capacity on the HSLs to run the additional trains.

In the former scenario, around 13m passengers p.a. would use the Heathrow Station, whereas in the second one the figure rises to around 20mppa. Creating a direct service from Heathrow to the Great Western route enables a significant market to South Wales and the West that is currently dominated by car and coach to be tapped. Around half of the demand using the Heathrow station is traffic related directly to the airport, with the remainder using Heathrow as a regional hub to access to rail network from the wider south east.

We only considered at this stage a link direct into Heathrow, and not a remote hub. To address the latter the additional interchange both for air passengers and for those making onward journeys by public transport to the local catchment area would need to be taken into account.

Further work needs to be done to understand the full benefits of a Heathrow connection, including what further traffic can be gained if HS services are assumed to replace domestic flights, rather than compete with them, as has been assumed here. (Note that our economic assessment does not assume a specific reduction in flights, it does include the benefit of reduced carbon output due to passengers switching from air to HS at the average level of carbon use per air passenger.)

Great Western

At this stage, we tested an upgrade to the GW route, rather than a complete new line, to understand its potential contribution to a UK-wide network. However, it looks as though this scheme provides substantial benefits (PV £12bn over a 60-year period) and is therefore worthy of further investigation, including upgrading sections or even the whole route to HS.

As noted above, its incorporation in the Heathrow hub network enables it to capture a significant airport access market. In addition, around 2.2m additional passengers can be captured through new links to an East Coast HS route, and HS1 to Kent and Europe, by travelling through or interchanging at Heathrow.

Intermediate Stations

Our preliminary tests include three different approaches to provide intermediate stops:

- serving city centres with through stations, which generally need to be new underground structures
- serving cities centres using existing or redundant infrastructure, generally on spurs rather than through routes
- parkway stations, often exploiting Airport as existing transport hubs

The first of these are an extremely expensive approach, as they will typically need to comprise:

- four platforms and
- two through lines, plus
- a lengthy four track approach from both directions to enable stopping trains to slow without losing paths for non-stopping trains following.

These are required to ensure that capacity on the main HS line is not compromised. Even with this, it will probably be necessary to reduce line speed to 230km on the through lines (for capacity reasons, but also for safety of passengers on platforms in underground stations) with this arrangement.

This station format will work best where all trains are calling at the station as an intermediate stop, i.e. no trains are terminating. This type of service pattern works most efficiently in situations where demand in either direction is 'balanced' so that when a train stops at the station, the number of alighting passengers is similar to the number of passengers boarding, and the load factor of the train is maintained.

Overall, networks with a 'trunk' and 'branches' tend to be more cost effective, as in most cases we have been able to find potential alignments for the branches that can use surface level approaches to cities, taking advantage of existing or redundant infrastructure.

As one of the Greengauge 21 guiding principles is to promote city centre regeneration, we have not tested Parkway-style stations as the dominant mode of access to the network. However, we have incorporated stations in the tests where there seems to be opportunity. These are largely at Airports, not so much as a means of access to the airport, but rather to take advantage of the existing road and public transport networks that exist at these locations. It is worth noting that where both city centre and Parkway stations are provided, the city centre station is always significantly more utilised.

In this mode, they act in a generally complementary manner to city centre stations, providing access to the HS system from a wider catchment, without causing unproductive levels of abstraction from the city centre stations. For example, one can compare the 'Y' and 'H' scenarios, where there is a similar level to Manchester city centre, but 'H' has the additional benefit of a parkway style station at the airport. In 'Y', the total Manchester demand is 14.2m journeys per annum, compared to 16.7 across the two stations in 'H'. The majority of passengers in 'H' continue to use the city centre station (10.1m) while the remaining 6.6m use the Parkway. A similar split is seen between central Birmingham and a parkway station, and Newcastle Central and Washington.

Use of Classic Network for HS services

As is common in France and Germany, it is possible for services to be run through from the High Speed network to serve destinations on the existing classic network. Though this may save the cost of building new HS line or upgrading classic line to HS standards, there are a number of limitations that this places on the type of rolling stock that can be used.

The stock must be built to British loading gauge, which constrains it to being single deck. Unit length is also restricted by existing platforms lengths: up to 320m is possible at most existing UK platforms, but to allow coupling of trains on the HS network, we have assumed 200m.

This avoids potentially excessive costs of rebuilding existing alignments, and perhaps most significantly, stations. This solution will in general only be appropriate for secondary destinations, or as an interim measure before demand has built up. Our scenarios have shown that on flows to major cities (Birmingham, Manchester, Leeds, Newcastle, Edinburgh and Glasgow), the extra capacity afforded by a 1000-seat UIC gauge unit will ultimately be required.

Value for Money

The initial network tests were done on a preliminary version of the forecasting model. A number of modifications were made subsequently, so the results of the initial network tests, while consistent with each other, are not consistent with subsequent analysis. The most important caveat that must be made of the Initial Scenarios is that the effect of the recession was not been taken into account in the demand forecasts; the revenue and economic benefits (and hence BCR) are somewhat higher than they could eventually expect to be as a result.

All schemes tested had BCRs in the range 1.6 to 2.0 when appraised as traditional projects; using the DfT 'funding' BCR, they are in the range 2.0 to 2.8. Ideally, a BCR of 2 or more would probably be required to secure funding under normal departmental guidance. Further refinement of both the analysis and of the scheme itself is required which will modify the above BCRs, including the need to consider the Wider Impacts (previously referred to as Wider Economic Benefits). Issues include:

- more detailed engineering analysis of infrastructure costs, to find scope for cost reduction
- optimising the routes served and the timetable
- optimising the size of the rolling stock fleet to match demand over the evolution of the network
- creating a better optimised network through taking the best elements from the ones tested so far
- inclusion of Wider Impacts.

The following summarises the conclusions that can be drawn from this phase of the study:

- there is sufficient demand to cities north of London to require four tracks
- No clear conclusion could be drawn on the merits of a single 4-track alignment vs two 2-track alignments; but subsequent analysis has shown the single 4-track option to be unattractive
- The western corridor has more demand than the eastern corridor, and additional flows are needed to make good use of an eastern corridor
- A central London terminal for one line can be provided relatively cost-effectively, and options are available for an additional terminal for a second north-south line
- Heathrow provides a good location in addition to other London terminals due to both the airport and its transport connectivity, but it will be significantly strengthened if trains can run beyond Heathrow to locations south
- There is good case for constructing HSR infrastructure to the central belt of Scotland; the choice between west and east coast routes is not clear and there may be merits in providing both
- A Transpennine route provides some desirable linkages, but not clear whether a business case can be made if it relies on high speed train services alone
- An upgrade to the GW route to South Wales and the South West looks viable, but the extent of high speed looks uncertain
- The prime network is best with city centre stations served by branches off the core HS route; parkway stations in addition can offer value, especially where these add to public transport accessibility as well as car
- There is a clear case for extensions from the HS network on to the classic network to distribute the benefits of high speed across the country.

Resolving the outstanding issues and undertaking more detailed analysis of the different elements of the network formed the basis of the next stage of work.

4 Issues addressed by Corridor and Network Studies

4.1 Building on the initial network scenario study

The initial network scenario strategy provided considerable insight into the likely shape of the appropriate high speed rail network for Britain. However, it could neither answer all the potential questions, nor could it provide a sufficient evidence trail. To do this a structured set of scenarios designed to address the specific issues was needed.

The specific issues that had been raised and not fully resolved by the initial network scenario study were:

- Which is the best first route to be built?
- Which is the best way to serve Scotland?
- What is the best way to provide a route from London to the north east - 4-tracking an M40 route; M1 route; M11 route?
- Confirm the value of serving Heathrow
- Confirm the value of providing link to HS-CT
- What is best Transpennine route and does it add value?
- What is the best route/ strategy to the west (South Wales and Bristol/ South West)?

4.2 Utilising other evidence

In addition to the results of the initial network scenario study, there are a number of other studies that will inform these issues, notably:

- A specific analysis undertaken by SYSTRA-MVA into the costs of alternative routes to Scotland; the full study is included in Appendix E
- SYSTRA-MVA study into costs of 4-tracking (Appendix C)
- SYSTRA-MVA comparison of the merits of M1 corridor vs M11 corridor, including London termini (Appendix G)
- SYSTRA-MVA study of options and costs of various linkages in London area (Appendix F)
- A separate Greengauge 21 study for the Welsh Assembly Government into options for serving south Wales

4.3 Costs of Routes to Scotland

The SYSTRA-MVA study found that the cost from London to Scotland of the East and West Coast routes are comparable, although the cost north from Manchester on the west coast is significantly higher than north from Newcastle on the east coast due principally to the longer distance. However, in terms of journey times from London, there is little difference for Edinburgh, but Glasgow is significantly longer via the East Coast. In response to a suggestion at a workshop, a direct route from Newcastle to Glasgow (with branch to Edinburgh) was also considered, but this proved to be the most costly; it provides no journey time benefit over the West Coast route, unless there is a requirement to go via Newcastle.

There are also issues regarding phasing and the ability to get early benefits to Scotland that may influence the choice of route in favour of the West Coast.

Both routes provide some opportunity for re-use of the existing alignment, subject to there being limited demand for residual classic or freight services. In reality, the benefits of such re-use may be small or non-existent in the longer term, as one of the priorities of HSR is to increase capacity, whereas mixed use of capacity by HS trains and other trains actually reduces overall capacity. But clearly, there is substantial scope for the two main lines to be used on an interim basis, which might extend over a considerable period of time.

Three scenarios were developed to ensure that the different realistic choices to Scotland were fully evaluated.

4.4 Serving the second corridor north from London

The initial work indicated that the single best route north from London was likely to be the M40 corridor, as a result of a relatively cheap rail corridor within London to a feasible central station site. The focus is then on the best second route that would serve the north east from London. A specific scenario test has been developed to consider the merits of the West Midlands and North West route as the initial route.

It may appear initially attractive to consider the option of 4-tracking a route out of London on the M40 corridor as a way of saving costs. However, analysis of the costs shows savings much less than might be expected. While construction in open country of a 4-track route costs less than that of two 2-track routes, certain elements of a 4-track alignment cost twice that of 2-track (eg tunnels, viaducts); other elements such as junctions can cost more than twice. There is a also a genuine concern that loading all HS passengers on a single terminus in London would have major impacts on the onward distribution (especially by LUL) and provides a single risk point in the network.

The overall cost of a 4-track route is estimated as 1.8 times that of a 2-track route. Against this, however, much of the 4-track route would need to be built as part of the initial build to prevent major possessions being required subsequently and the implied disruption this would imply. The requirement to construct a significant element of the infrastructure earlier than needed for demand purposes worsens the NPV, and if the second route is needed more than about 7 years after the first route then it is better even on cost grounds (taking into account the discount rate) that it be constructed as a stand-alone route. Furthermore, constructing the first phase as a 4-track route will lead to a later implementation of the first phase of the network.

In addition utilising a different route allows other destinations to be served. We have therefore concluded that the eventual network should not have a 4-track solution; it is worth noting that nowhere is there currently a 4-track high speed rail network.

The choice between an M1 and M11 corridor for a HSR line to serve the east side of the country is less clear cut. Provided the M11 corridor can terminate in London at a cost-effective station site, then it will be cheaper than accessing via the M1 corridor. It also provides opportunities to serve additional destinations in East Anglia; however, the M1 corridor is shorter and provides faster journey times to the north. Because of the junctions it will provide with the ECML, the M11 route also provides better phasing opportunities.

As a result it was decided to undertake a specific scenario test to inform the analysis of corridor choices.

4.5 London linkages

An engineering analysis of the potential linkages that can be created in the London area was undertaken. This was particularly to identify which routes could be linked (at what cost) to Heathrow and to HS-CT. This ensured that a realistic service pattern was included in each of the scenarios, along with appropriate costs.

Heathrow can readily be accessed from the M40 corridor, but is much more difficult from the M1 and M11 corridors. There are theoretical options to access Heathrow from the M1 and the Great Western, but this is slow and requires a link from the Great Western lines to the new Heathrow station, and, since this section of the Great Western will be operating very close to capacity, may entail the creation of two additional tracks in any event. From the M11, it should be possible to access via Stratford, HS-CT and its linkage to the M40 corridor and thence to Heathrow.

HS-CT can be accessed from most routes. We have identified at least one option for each of the M40, M1 and M11 corridors, although in each case the work involved is fairly complex, reflecting that inevitably such linkages need to be created in somewhat constrained sites.

4.6 Serving South Wales and the South West

The GG21 study for WAG identified which sections of the Great Western route from London would be capacity constrained in the future (after planned improvements such as Reading Station modernisation). The work on Heathrow also showed the potential from linkages with Great Western flows.

This led to a staged strategy based on part new line, part upgrade and electrification for this route which was incorporated into one of the scenarios. Essentially new line is built from Didcot to Bristol Parkway, plus a new link (the 'Western Connection') into Heathrow. This provides the required capacity benefits and journey time benefits partially through the higher speeds but also through removal of intermediate stops in the fastest trains.

4.7 Transpennine

The upgrade being considered by Network Rail to the north Transpennine corridor (Manchester to Leeds) would provide much of the benefit of a full HSR. The difficult terrain implies achieving a 300kph railway across the Pennines will be very expensive. Because of the short distance between the major cities, its benefit would be limited. There is therefore unlikely to be any business case for a new HSR on the northern corridor, but an upgraded existing line could carry HSR services with little time disadvantage.

The southern corridor is different in that new linkages can be provided, including those with Manchester Airport, and there is less opportunity to speed up journey times without construction of a significant element of new build. Thus, if a case can be made for a Transpennine HSR corridor, it is more likely to be on the southern route (Manchester Airport to Sheffield) and this is what was included in the scenario tests.

4.8 Scenario development

To ensure that the different issues were addressed in a consistent way and that conclusions were not biased by other issues, the range of scenarios needed to:

- Ensure that each of the above issues could be addressed either within a single scenario, or in most cases by considering the difference between two or more scenarios
- Provide, in so far as possible, consistent service patterns where the infrastructure permitted; however, where capacity was limited, some scenarios resulted in substitution of trains
- Exclude (at this stage) the implications of phasing (otherwise this might unduly influence the choice of eventual network strategy) – the implications of phasing were considered as an overlay where this was significant in the choice between options; furthermore, a full phasing study would be undertaken on the final selected scenario

The various scenarios and how they address the different issues are described in the following chapter. The evaluation of these scenarios, and in particular the different elements that need to be taken into account in judging between them, are described in Chapter 6.

5 Scenarios Tested

5.1 Overview

This Chapter provides a description of a series of Scenario tests undertaken in order to establish a preferred network strategy that meets the guiding principles and provides a good business case. The tests work on an incremental basis to assess the value of different potential elements of a national High Speed rail network.

The results of these tests are provided in Chapter 6, while the preferred network is developed into a detailed proposal in Chapter 7.

For each scenario, we describe:

- the specific network elements it is intended to test
- infrastructure assumptions
- High Speed service patterns assumptions
- resulting changes to classic services: comprising reductions in Intercity services and additional passenger and freight services operated using the capacity released from these services.

For the purpose of these scenarios, it was assumed that the whole scenario could be constructed and services run from 2021. This was done to avoid phasing assumptions influencing the comparison between the scenarios. The eventual network scenario (number 10) builds on the best elements of the earlier scenarios and also includes a phased development.

5.2 Scenario Tests

The following table summarises the scenario runs and, through the key decisions taken based on the appraisal results, the elements of the network they are designed to test.

The first test provides a starting point that is similar to (but broader than) the scope of analysis of the government company, HS2. Other than for the first scenario, each scenario is designed to be an incremental test against at least one other scenario to enable a particular issue to be addressed.

Table 5.1 Description of Scenarios

No.	Scenario description	Investigation points
1	London/Heathrow/HS-CT – Birmingham/Manchester (HS-NW)	Value of HS-NW: a high speed line between London and Birmingham/Manchester
2	Extend HS-NW to Edinburgh/Glasgow via W coast	2 vs. 1: Scotland connection
3	Remove HS-CT link from no.2	3 vs. 2: Value of HS-CT connection

4	Remove Heathrow from no. 3	4 vs. 3: Value of serving Heathrow
Decision Point 1: Confirmed value of HS-CT and Heathrow Links		
5	Add HS-NE route from London to Leeds/Newcastle via M1 corridor to no.2	5 vs. 2: Value of separate HS-NE route to Leeds/Newcastle
6	Extend Sc. 5 by adding HS-NE route to Scotland	6 vs. 5: HS-NE to Scotland *in addition* to HS-NW
7	Remove HS-NW north of Manchester	7 vs. 5: HS-NE to Scotland *instead of* HS-NW
Decision Point 2: Identified both HS-NW and HS-NE as preferred way of serving Scotland		
A	As Scenario 6, but with HS-NE following M11 corridor and terminating at Stratford	A vs 6: Value of M11 corridor for HS-NE vs. M1.
Decision Point 3: M11 selected as corridor for HS-NE to be taken forward		
8	Add Transpennine to best of above	8 vs. A: Transpennine
9	Add Great Western route to best of above	9 vs. 8 Great Western
Decision Point 4: Transpennine and Great Western elements confirmed as elements for Final network		
B	London to Leeds only via M11	Standalone: value of HS-NE only as first route to inform phasing
Decision Point 5: HS-NW selected as preferred first phase route		
10	Optimised preferred Network Scenario based on above choice	Final network scenario

5.3 Infrastructure

The infrastructure assumed in each scenario is detailed in Appendix H.

In each case the infrastructure assumed comprises the following elements:

- New HS alignments, including bridges, viaducts, tunnels and junctions; these comprise the routes outlined in Table 5.1
- New stations and station upgrades; new or major upgrades are identified (in relevant scenarios) to take UIC gauge trains at London, Birmingham, Manchester, Glasgow, Sheffield, Leeds, Edinburgh, Heathrow; Parkway style stations are identified at Birmingham, Manchester Airport, Stansted, Cambridge, East Midlands, Tees Valley/Washington, Edinburgh Airport
- Connections to the existing classic network, to allow through running of services wherever appropriate.

Appendix H also provides details of infrastructure costings.

5.4 HS Service Patterns

For each scenario, a standard hour service pattern has been developed for services running on the HS infrastructure.

The detailed service patterns for each scenario are included as Appendix I.

We distinguish between two distinct groups of services:

- High Speed Only Services: These services operate exclusively on HS infrastructure and assumed to be operated by the highest capacity UIC gauge Duplex units. These services service generally serve the highest-volume flows radiating from London.
- Services running through onto to the Classic network, operated by lower-capacity British-gauge[11] high-speed units. These services comprise four subgroups:
  - Non-London services, running between cities on the HS network and providing linkages through to parts of the classic network, to a large extent replacing the existing Cross Country and Transpennine network.
  - Services from London to cities where HS infrastructure is not available, such as Liverpool, Derby, Bristol, Cardiff and York.
  - Services running in an interim phase of a scenario, for example on the west coast north of Manchester prior to the full HS network being constructed; such trains will need to be tilt enabled if they are not to lose time.
  - Services serving Heathrow, running through from HS-NW and HS-NE to destinations on the classic network such as Bristol, Cardiff, Bournemouth and Gatwick Airport, plus also through to Stratford International, stations in Kent, and on to Europe through the Channel Tunnel.

The operational cost of having two separate rolling stock fleets could be minimised by selecting designs with a high degree of commonality. In principle, traction and running gear could be similar for the two fleets, with differences limited to bodywork.

The service patterns are developed from those tested in the Network Scenarios described in Chapter 3.

Using this as a starting point, the patterns have been developed to balance two requirements:

- maximising the benefits of services by providing as many direct linkages between destinations as possible
- ensuring a strong business case through efficient use of rolling stock: i.e ensuring that train capacity is not under-utilised, nor that excess demand is crowded-off unnecessarily.

[11] We use the term 'British gauge' here in reference to the W6A loading gauge that rolling stock would need to be compliant to in order to operate on all British main lines.

5.5 Changes to Classic Services

The following table outlines the changes to Classic services assumed in each scenario.

Table 5.1 Changes to Classic Services

Scenario	Changes
1	3tph WC London – Birmingham/Wolverhampton reduced to 2tph, with additional stops at Milton Keynes or Northampton to serve commuter markets
	3tph WC London – Manchester reduced to 2tph (both via Stoke), with additional stops in Trent Valley
	1tph WC London – Glasgow/Edinburgh curtailed to Lancaster with additional stops. Additional HS services provide replacement facilities for stations on Northern WCML
	1tph WC London – Chester –North Wales: replaced by HS service
	1tph WC London – Liverpool: replaced by HS service
	2tph XC South Coast/South West – Birmingham – Manchester: replaced by service running on HS Birmingham – Manchester
	New services using released capacity:
	2tph new services London – Milton Keynes – Northampton
	1tph additional local service on Coventry – Birmingham – Wolverhampton corridor
	Additional freight services on WCML south of Manchester
	2tph new skip stop service Birmingham - Manchester
2	As Scenario 1, plus
	1tph WC London to Glasgow/Edinburgh retained to serve intermediate markets on northern WCML, with additional stops.
	1tph TP Manchester Airport – Edinburgh re-routed to Windermere; Manchester – Edinburgh replaced by HS services.
	Additional freight services on WCML north of Manchester
3	No further changes
4	No further changes
5	As Scenario 2, plus
	2tph EC London to Leeds: additional stops introduced to serve intermediate markets. London to Leeds market served by HS services.
	2tph EC London to Newcastle and Edinburgh: additional stops introduced to serve intermediate markets, Newcastle – Edinburgh reduced to 1tph. London to Newcastle and Edinburgh markets served by HS services.
	Additional stops introduced in some existing GN suburban services, where capacity relieved by the additional EC stops.
	2tph MM London to Nottingham: more stops south of Leicester introduced to relieve Thameslink services. North of Leicester, services function as local stoppers.
	2tph MM London to Derby: more stops south of Leicester introduced to relieve Thameslink services. North of Leicester, services function as local stoppers.
	2tph XC South Coast/South West – Birmingham – Newcastle/Edinburgh: replaced by service running on HS Sheffield- Newcastle
	New services using released capacity:

	2tph new Sheffield – Leeds – York – North East skip stop
6	As Scenario 5, plus HS services north of Newcastle move from ECML to HS-NE *New services using released capacity:* 1tph Newcastle – Edinburgh stopping service 1tph Newcastle – Blythe
7	As Scenario 6, but without the incremental changes listed under Scenario 2.
A	As Scenario 6, plus: 1tph EC London – Doncaster –York – Newcastle replaced by HS service running on classic north of Peterborough 2tph GN London – Cambridge – King's Lynn. Some additional stops introduced due to crowding relief provided by HS services 4tph GA London – Stansted Airport. Some additional stops introduced due to crowding relief provided by HS services 2tph GA London – Norwich. Some additional stops introduced due to crowding relief provided by HS services *New services using released capacity:* 1tph new London – Peterborough commuter services. Note: as HS service to East Midlands in this scenario is less comprehensive than in Scenario 6, the benefit attributed is smaller.
8	As Scenario A, plus 1tph Norwich – Liverpool replaced by HS/Transpennine services *New services using released capacity:* 1tph Peterborough – Nottingham –Sheffield local service 1tph Liverpool – Manchester local service
9	As scenario 8, plus 2 tph London – Bristol additional stops to serve intermediate flows 2 tph London – Cardiff additional stops to serve intermediate flows

Scenario 10, the final network is a phased development which is described in Chapter 7.

6 Evaluation of Scenarios

6.1 Introduction

As with any project, there are a number of objectives, and different options will be better at addressing different objectives. There is, therefore, not a single measure that can be used to say which option is preferred, rather there is a range of measures, some quantified, some not, which need to be considered when comparing options.

We start this chapter by describing the range of criteria that are used to evaluate each of the scenarios which were described in the previous chapter. We then consider each of the issues detailed in Chapter 4 and use the results of one or more scenarios to describe the performance of different solutions to the issues.

6.2 Evaluation criteria

At a high level, the criteria for evaluation are the guiding principles developed throughout the study (principally in Workstream 2) in consultation with the stakeholders, and the NATA criteria, as used in DaSTS by UK Department for Transport; these are similar to the STAG criteria used by Transport Scotland .

The guiding principles are:

(i) Capacity

HSR routes need to be located such that they provide additional capacity for the national transport system where there is forecast to be unmet demand on the long-distance routes and create high-value capacity relief on the existing rail network.

(ii) Sustainable Economic Competitiveness

HSR needs to serve places which are capable of stimulating economies to achieve growth, regeneration and wider productivity benefits and to stimulate and support a sustainable pattern of development.

(iii) The Whole Journey

HSR has to be planned to address the whole journey, as identified in TaSTS/DaSTS, to make it an attractive, lower carbon, alternative to car use.

(iv) Modal Switch from Aviation

HSR needs to be able to attract travellers away from short-haul aviation to/from major international hub airports in order:

- to free-up runway capacity for more valuable longer-distance services, and/or

- to reduce carbon emissions, and/or

- to provide a suitable HSR service in cases where it has been found necessary to withdraw air services that have a significant effect on business travel and the economy.

(v) An Integrated Phased Network for All

HSR needs to be planned as a system, developed in a staged programme, properly integrated with other transport facilities to maximise its value, with complementary measures identified as necessary, to ensure a comprehensive (nationwide) spread of benefits that has relevance and appeal across all social groups and types of traveller.

DaSTS gives the following objectives for the transport system:

- To **support** national **economic** competitiveness and **growth**, by delivering reliable and efficient transport networks
- To reduce transport's emissions of carbon dioxide and other greenhouse gases, with the desired outcome of **tackling climate change**
- To **contribute to better safety security and health** and longer life-expectancy by reducing the risk of death, injury or illness arising from transport and by promoting travel modes that are beneficial to health
- To **promote** greater **equality of opportunity** for all citizens, with the desired outcome of achieving a fairer society;
- To **improve quality of life** for transport users and non-transport users, and to promote a **healthy natural environment**

These are similar to those in the DfT's WebTAG guidance which are:

- environmental impact
- safety
- economy
- accessibility
- integration.

It can be seen that these are essentially covered by the Guiding principles.

We have considered each scenario, and in particular the incremental benefits of moving from one to an enhanced scenario, under the above headings, and provide a description of how they meet these criteria. In addition, we provide the following quantified analysis:

- demand (by abstraction from modes, generated)
- revenue
- user benefits
- non-user benefits
- costs (capital, operating) (Appendix H gives details of Infrastructure costs)
- benefits from rail crowding reduction
- other benefits from new classic services
- benefits from new rail freight services (Appendix J gives details)
- benefit: cost ratio (BCR) taking account of above elements (note in keeping with normal DfT practice the BCRs exclude the Wider Regional Economic Benefits)
- car kilometres removed
- air passenger kilometres removed
- CO_2 reduction
- wider regional economic impacts (at this stage they have been calculated without taking account of the employment changes – the impact of these will be provided separately); they are also only calculated precisely according to DfT guidelines (2008 WebTAG version) for Scenarios 1 and 9 with other scenarios estimated by interpolation

The following sections consider each of the issues discussed in Chapter 4 by comparing the scenarios as described in Chapter 5.

6.3 High Speed line from London/Heathrow/HS-CT to Birmingham and Manchester

The following table summarises the performance of this scenario.

Table 6.1 Summary of London/Heathrow/HS-CT to Birmingham/Manchester

Measurement against guiding principles	
GP1 - Capacity	Significant capacity release on southern WCML, releasing paths for improved passenger and freight services
GP2 – Economy	Mainly improves level of service for already dominant connections to London, but does little to improve frequencies or journey times between non-London city pairs. Heathrow link improves competitiveness to the Midlands, the north east and north west. HS-CT link improves connections from regions to the near continent.
GP3 – Whole journey: car	Manchester International Station opens up new car-based catchment to inter-city rail network, while Birmingham International HS Station expands the existing car-based catchment in this area.
GP4 – Aviation	Heathrow connection allows LHR – Manchester services, abstracting some demand from this market. (This is illustrated in more detail in Section 6.6). Journey time improvement from London/LHR to Scotland will attract some demand from air, but not fulfil full potential.
GP5 – Network for all	Benefits concentrated heavily on London – Birmingham – Manchester corridor, including benefits of classic capacity release to South Midlands. Also benefits Derby, Sheffield and North Wales by through running on to classic network.
Demand Analysis	
Total HS demand (million) (2055)	72.0
Abstracted from classic rail (million) (2055)	48.0
Abstracted from air (million) (2055)	8.2
Abstracted from car (million) (2055)	3.9
Generated HS users (million) (2055)	11.8
Revenue Analysis	
HS Revenue £m (2055)	£4,028
Net Rail Revenue £m (2055)	£1,497
Infrastructure and Operating Costs	
Infrastructure Capital costs £m (2008 prices)	£19,245
HS operating costs £m (2008 prices) in 2055	£1,514
Reduction in classic operating cost £m (2008 prices) in 2055	£519
Number of 200m Rolling Stock units (required in 2055)	133
Other Impacts	
Car kms removed (millions) (2055)	881.0
Air passenger kms removed (millions) (2055)	4,634.0

CO_2 reduction (million tonnes) (2055)	0.273
User and Non-User Benefits	
NPV User benefits £m (2002 prices)	£32,852
NPV Non-user benefits £m (2002 prices)	£4,757
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£8,203
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£922
NPV Other benefits of new classic services £m (2002 prices)	£951
NPV Benefits to rail freight £m (2002 prices)	£1,602
NPV Wider regional economic benefits (£m 2002 prices)	£5,252
Financial Performance	
NPV Net Revenue (£m 2002 prices)	£9,517
NPV Costs (£m 2002 prices)	£22,729
NPV Benefits (£m 2002 prices)	£47,126
NPV Operating Surplus (£m 2002 prices)	£13,588
NPV Overall funding deficit (£m 2002 prices)	-£13,212
Total NPV (£m 2002 prices)	£24,397
BCR (excluding Wider Economic Benefits)	2.85

Note: BCR here and elsewhere is calculated (as in DfT guidance) as the ratio:

BCR = (economic benefits excluding revenue)/ (costs minus revenue)

6.4 High Speed line from London/ HS-CT to Sheffield/Leeds (via M11)

The objective of this scenario is to provide an alternative possible first stage of a high speed rail network. The following table summarises the performance of this scenario.

Table 6.2 Summary of London/HS-CT to Sheffield/Leeds (via M11)

Measurement against guiding principles	
GP1 - Capacity	Provides capacity release on Midland Main Line, southern part of ECML and West Anglia Main Line. Benefits most likely to be for passenger services: freight benefits too (but see Appendix J).
GP2 – Economy	Mainly improves level of service for already dominant connections to London, but does little to expand regional connectivity. HS-CT link improves connections from regions to the near continent.
GP3 – Whole journey: car	Parkway type stations in Nottingham and Stansted area would be attractive to car users

GP4 – Aviation	Little abstraction from air as does not reduce journey times in air markets that much and cannot serve Heathrow	
GP5 – Network for all	Benefits concentrated on London – Sheffield/ Leeds corridor, including benefits of classic capacity release on MML, ECML and W Anglia route to Stansted.	
Demand Analysis		
Total HS demand (million) (2055)		51.6
Abstracted from classic rail (million) (2055)		36.5
Abstracted from air (million) (2055)		3.4
Abstracted from car (million) (2055)		2.6
Generated HS users (million) (2055)		9.2
Revenue Analysis		
HS Revenue £m (2055)		£2,310
Net Rail Revenue £m (2055)		£634
Infrastructure and Operating Costs		
Infrastructure Capital costs £m (2008 prices)		£17,578
HS operating costs £m (2008 prices) in 2055		£1,094
Reduction in classic operating cost £m (2008 prices) in 2055		£358
Number of 200m Rolling Stock units (required in 2055)		98
Other Impacts		
Car kms removed (millions) (2055)		578.4
Air passenger kms removed (millions) (2055)		2,034.5
CO_2 reduction (million tonnes) (2055)		0.127
User and Non-User Benefits		
NPV User benefits £m (2002 prices)		£20,967
NPV Non-user benefits £m (2002 prices)		£5,230
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)		£3,471
NPV Benefits from local classic rail crowding reduction £m (2002 prices)		£2,940
NPV Other benefits of new classic services £m (2002 prices)		£1,577
NPV Benefits to rail freight £m (2002 prices)		£0
NPV Wider regional economic benefits (£m 2002 prices)		£3,728

Financial Performance	
NPV Net Revenue (£m 2002 prices)	£3,648
NPV Costs (£m 2002 prices)	£18,537
NPV Benefits (£m 2002 prices)	£29,845
NPV Operating Surplus (£m 2002 prices)	£5,249
NPV Overall funding deficit (£m 2002 prices)	-£14,889
Total NPV (£m 2002 prices)	£11,308
BCR (excluding Wider Economic Benefits)	1.76

It can be seen that across a range of measures, including both the guiding principles and the BCRs, this options performs less well than the London – Birmingham – Manchester option. We therefore conclude that it is better to start with the west coast corridor, and the remaining scenarios build on this base.

6.5 HS-NW extended to Scotland

The incremental benefit of extending Scenario 1 to Scotland is summarised in Table 6.3.

As well as providing benefits that are cross-border in nature, the extension also confers benefits within Scotland by providing a new fast link between Edinburgh and Glasgow city centres.

Edinburgh Airport Parkway also gives access to benefits to some areas beyond the Central Belt, by offering a more direct access route by rail interchange, and also access from the Highway network.

Table 6.3 Summary of Incremental Benefits of Extending HS-NW to Scotland

Measurement against guiding principles	
GP1 - Capacity	Releases additional capacity for regional passenger service and freight on northern WCML. Also replaces Falkirk route as fastest Edinburgh – Glasgow service, releasing capacity on this service for shorter distance traffic.
GP2 – Economy	Improves linkage between Edinburgh and Glasgow, helping them to work as a single economic unit. Improves Anglo-Scottish connectivity.
GP3 – Whole journey: car	Edinburgh Airport Parkway provides an attractive access point by car in Central Belt.
GP4 – Aviation	Substantially improves competitiveness of rail against air in Anglo-Scottish market.
GP5 – Network for all	Increases benefits to Scottish Central Belt: Edinburgh Airport Parkway link helps improve access to benefits beyond the central belt.
Demand Analysis	
Total HS demand (million) (2055)	28.8
Abstracted from classic rail (million) (2055)	9.5
Abstracted from air (million) (2055)	15.6
Abstracted from car (million) (2055)	2.1

Generated HS users (million) (2055)	1.6
Revenue Analysis	
HS Revenue £m (2055)	£1,443
Net Rail Revenue £m (2055)	£1,352
Infrastructure and Operating Costs	
Infrastructure Capital costs £m (2008 prices)	£16,589
HS operating costs £m (2008 prices) in 2055	£396
Reduction in classic operating cost £m (2008 prices) in 2055	£73
Number of 200m Rolling Stock units (required in 2055)	52
Other Impacts	
Car kms removed (millions) (2055)	528.5
Air passenger kms removed (millions) (2055)	10,350.1
CO2 reduction (million tonnes) (2055)	0.539
User and Non-User Benefits	
NPV User benefits £m (2002 prices)	£24,810
NPV Non-user benefits £m (2002 prices)	£1,956
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	-£3,257 *
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£0
NPV Other benefits of new classic services £m (2002 prices)	£0
NPV Benefits to rail freight £m (2002 prices)	£435
NPV Wider regional economic benefits (£m 2002 prices)	£5,453
Financial Performance	
NPV Net Revenue (£m 2002 prices)	£10,007
NPV Costs (£m 2002 prices)	£13,545
NPV Benefits (£m 2002 prices)	£36,774
NPV Operating Surplus (£m 2002 prices)	£6,646
NPV Overall funding deficit (£m 2002 prices)	-£3,538
Total NPV (£m 2002 prices)	£23,229
BCR (excluding Wider Economic Benefits)	7.57

* this scenario gives excessive demand on the high speed network by the end of the appraisal period; as a result there is a negative figure against rail crowding reduction, with crowding on HSR higher than that relieved on the classic network.

Nevertheless, it can be seen that the extension to Scotland has a very good case. A significant proportion of the demand is shown as being abstracted from air. For modelling purposes, we have assumed that air demand over the appraisal period is not capacity constrained and therefore grows substantially. In reality, airport and other capacity constraints are likely to suppress much of this demand, so the effect of HS will actually be more about releasing this otherwise suppressed demand rather than capturing existing airline demand.

6.6 Scenario 4: Incremental benefit of Heathrow link

Comparing Scenario 4 with Scenario 3 demonstrates the relatively high level of benefits compared to cost that the link to Heathrow, including its connection to the Great Western South Western Main Line provides.

As well as facilitating abstraction from air, it achieve significant abstraction from car and classic rail, as well as generating new trips by opening up new direct rail journey opportunities through enabling the operation of through services. The provision of services to Heathrow will also reduce the demand into central London and some of the pressure on the central London transport network.

Table 6.4 Value of Heathrow link

Measurement against guiding principles	
GP1 - Capacity	Heathrow provides an alternative to central London as an access point to the HS network for parts of the South East. Without Heathrow, more services will need to terminate in London if all available HS line capacity is to be used, increase capacity pressure at this location.
GP2 – Economy	Helps improve the competitiveness of Heathrow as a global hub airport by increasing its catchment area, and freeing runway capacity for growth.
GP3 – Whole journey: car	Helps to reduce economic remoteness of locations on the GWML by providing through links via Heathrow hub to other parts of the country. Improved link to south of Heathrow from SWML and west from GWML will complement already strong existing and planned links (Crossrail and Airtrack) to this hub.
GP4 – Aviation	Provides an alternative to Central London as a location for accessing the HS rail network for parts of the South East.
GP5 – Network for all	Air abstraction achieved by providing a substitute for air service (while city centre services can compete effectively against point to point air, only direct rail services to Heathrow can compete for the air interlining market)
Demand Analysis	
Total HS demand (million) (2055)	10.1
Abstracted from classic rail (million) (2055)	1.8
Abstracted from air (million) (2055)	4.9
Abstracted from car (million) (2055)	0.8
Generated HS users (million) (2055)	2.7
Revenue Analysis	
HS Revenue £m (2055)	£542

Net Rail Revenue £m (2055)	£373
Infrastructure and Operating Costs	
Infrastructure Capital costs £m (2008 prices)	£3,159
HS operating costs £m (2008 prices) in 2055	£281
Reduction in classic operating cost £m (2008 prices) in 2055	-£61
Number of 200m Rolling Stock units (required in 2055)	28
Other Impacts	
Car kms removed (millions) (2055)	210.6
Air passenger kms removed (millions) (2055)	3,132.2
CO2 reduction (million tonnes) (2055)	0.164
User and Non-User Benefits	
NPV User benefits £m (2002 prices)	£15,057
NPV Non-user benefits £m (2002 prices)	£543
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£958
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£0
NPV Other benefits of new classic services £m (2002 prices)	£0
NPV Benefits to rail freight £m (2002 prices)	£0
NPV Wider regional economic benefits (£m 2002 prices)	£2,867
Financial Performance	
NPV Net Revenue (£m 2002 prices)	£2,746
NPV Costs (£m 2002 prices)	£5,972
NPV Benefits (£m 2002 prices)	£18,346
NPV Operating Surplus (£m 2002 prices)	£1,437
NPV Overall funding deficit (£m 2002 prices)	-£3,226
Total NPV (£m 2002 prices)	£12,374
BCR (excluding Wider Economic Benefits)	4.84

A comprehensive set of links to Heathrow as tested here gives a very good case. However, if the HSR to the north becomes capacity constrained and Heathrow trains are at the expense of central London services, then the value reduces substantially (not shown in the above table).

The following table demonstrates the impact that HS has on the aviation market with and without the link to Heathrow.

Table 6.5 Aviation Mode Share and UK CO_2 emissions by mode

	Mode Share (2007) Current	Mode Share (2055) Base	With LHR Link (Sc2)	Without LHR link (Sc3)
London - North West (air mode share)	9%	10%	5%	6%
London - Scotland (air mode share)	74%	78%	19%	28%
North West - Europe (air mode share)	90%	90%	65%	89%
Total HS CO_2 emissions ('000 tonnes)	-	-	46.6	38.2
Total Classic Rail CO^2 emissions ('000 tonnes)	1,157	617	587	589
Total domestic and near continent Aviation CO_2 emissions ('000 tonnes)	1,528	1,842	1,002	1,233
Total Car CO_2 emissions ('000 tonnes)	105,687	51,338	51,279	51,289
Net impact on CO_2 emissions ('000 tonnes)			-881	-647

The table demonstrates the substantial mode shift that HS can potentially induce in these markets, reducing aviation emissions from the markets shown by 46% if the Heathrow link is included, but only 33% if it is not.

6.7 Value of HS-NE to Newcastle (M1 corridor)

The Network Scenarios study indicated the need for a second HS route out of London to prevent overcrowding of HSR services. The HS-NE tested in this scenario is as an increment on a west coast network to Scotland. It provides this additional capacity and widens the benefits of HS rail to the Eastern half of the country.

Table 6.6 Value of HS-NE to Newcastle (M1 corridor)

Measurement against guiding principles	
GP1 - Capacity	Provides capacity release on Midland Main Line and southern part of ECML. Benefits most likely to be for passenger services: little freight benefits (see
GP2 – Economy	Significant economic benefits associated with improved journey times to the East Midlands, Yorkshire and the North East. As well as improving journey times to London from eastern cities, improves linkages from North East, including to Teesside from other northern cities such as Leeds, Sheffield, Manchester and Liverpool via through running on classic north Transpennine.

GP3 – Whole journey: car	Improved linkages between northern cities makes rail more attractive proposition in this market, which is currently car dominated.
GP4 – Aviation	Serving Newcastle enables HS to compete with a further air market.
GP5 – Network for all	Opens up the benefits of HS rail to the eastern side of the country.

Demand Analysis	
Total HS demand (million) (2055)	37.5
Abstracted from classic rail (million) (2055)	24.3
Abstracted from air (million) (2055)	2.4
Abstracted from car (million) (2055)	4.7
Generated HS users (million) (2055)	6.0
Revenue Analysis	
HS Revenue £m (2055)	£2,198
Net Rail Revenue £m (2055)	£801
Infrastructure and Operating Costs	
Infrastructure Capital costs £m (2008 prices)	£26,155
HS operating costs £m (2008 prices) in 2055	£1,059
Reduction in classic operating cost £m (2008 prices) in 2055	£560
Number of 200m Rolling Stock units (required in 2055)	100
Other Impacts	
Car kms removed (millions) (2055)	1,072.7
Air passenger kms removed (millions) (2055)	1,242.6
CO2 reduction (million tonnes) (2055)	0.108
User and Non-User Benefits	
NPV User benefits £m (2002 prices)	£23,979
NPV Non-user benefits £m (2002 prices)	£5,213
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£3,182
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£2,681
NPV Other benefits of new classic services £m (2002 prices)	£1,465
NPV Benefits to rail freight £m (2002 prices)	£0
NPV Wider regional economic benefits (£m 2002 prices)	£4,505

Financial Performance	
NPV Net Revenue (£m 2002 prices)	£5,720
NPV Costs (£m 2002 prices)	£20,190
NPV Benefits (£m 2002 prices)	£34,912
NPV Operating Surplus (£m 2002 prices)	£5,232
NPV Overall funding deficit (£m 2002 prices)	-£14,470
Total NPV (£m 2002 prices)	£14,722
BCR (excluding Wider Economic Benefits)	2.02

This has a good case, but it is not as strong as some of the other schemes; in the scenario tested, the HS line commences initially, while its real value comes later to relieve crowding on HS-NW. It is likely that the BCR of this scheme will improve in later years.

6.8 How should Scotland be served?

The previous analysis (section 6.7) showed there was an excellent business case for extending the HS network to Scotland. In this section we seek to identify which is the best route to select. There are three options:

- To extend the West Coast route
- To extend the East Coast route
- To construct both routes

We have undertaken several appraisals to demonstrate the values of these alternatives. We first compare the costs and benefits of the West Coast and the East Coast route (in both cases starting from London) – this is shown in Table 6.7. We then assess the incremental benefit of adding the West Coast route to a supposedly existing East Coast route with that of adding the East Coast route to a supposing existing West Coast route – this is shown in Table 6.8.

Table 6.7 Choice of routes to Scotland

Measure	Assessment of benefit of providing West Coast rather than East Coast	Assessment of benefit of providing East Coast rather than West Coast
Measurement against guiding principles		
GP1 - Capacity	The West Coast route is more effective in releasing capacity for freight	
GP2 – Economy	The West Coast route is better than East Coast in terms of economic impacts, whether journey time or Wider benefits	
GP3 – Whole journey: car	There is little to choose between the two routes in terms of abstraction from car	
GP4 – Aviation	The WC route abstracts more air demand because journey times to Edinburgh and Glasgow are both ~2.5hours. With EC route, Glasgow JT is nearer 3hrs.	
GP5 – Network for all	There is little to choose between the two routes	

Measure	Assessment of benefit of providing West Coast rather than East Coast	Assessment of benefit of providing East Coast rather than West Coast
Demand Analysis		
Total HS demand (million) (2055)	138.2	141.5
Abstracted from classic rail (million) (2055)	81.9	82.9
Abstracted from air (million) (2055)	26.2	25.1
Abstracted from car (million) (2055)	10.7	10.9
Generated HS users (million) (2055)	19.4	22.7
Revenue Analysis		
HS Revenue £m (2055)	£7,669	£7,703
Net Rail Revenue £m (2055)	£3,650	£3,600
Infrastructure and Operating Costs		
Infrastructure Capital costs £m (2008 prices)	£61,990	£53,977
HS operating costs £m (2008 prices) in 2055	£2,969	£2,719
Reduction in classic operating cost £m (2008 prices) in 2055	£1,151	£1,151
Number of 200m Rolling Stock units (required in 2055)	285	264
Other Impacts		
Car kms removed (millions) (2055)	2,482.1	2,483.0
Air passenger kms removed (millions) (2055)	16,226.7	15,451.3
CO2 reduction (million tonnes) (2055)	0.920	0.879
User and Non-User Benefits		
NPV User benefits £m (2002 prices)	£81,642	£74,550
NPV Non-user benefits £m (2002 prices)	£11,926	£11,825
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£8,128	£6,999
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£3,603	£3,603
NPV Other benefits of new classic services £m (2002	£2,416	£2,416

Measure	Assessment of benefit of providing West Coast rather than East Coast	Assessment of benefit of providing East Coast rather than West Coast
prices)		
NPV Benefits to rail freight £m (2002 prices)	£2,037	£2,037
NPV Wider regional economic benefits (£m 2002 prices)	£15,387	£14,135
Financial Performance		
NPV Net Revenue (£m 2002 prices)	£25,244	£24,271
NPV Costs (£m 2002 prices)	£56,464	£49,208
NPV Benefits (£m 2002 prices)	£118,812	£110,646
NPV Operating Surplus (£m 2002 prices)	£25,466	£27,554
NPV Overall funding deficit (£m 2002 prices)	-£31,220	-£24,937
Total NPV (£m 2002 prices)	£62,347	£61,438
BCR (excluding Wider Economic Benefits)	3.00	3.46

The difference in the appraisal results between the two alternatives is relatively small. The West Coast route has both higher benefits and costs, but the overall BCR is better for the East Coast route. However, the NPV of the West Coast route is still better indicating that there is a case for spending the additional money on the West Coast route.

The above comparison does not take into account the position that the first section of HSR constructed is likely to be the West Coast route to Manchester. In this case, there is an excellent case for the extension to Scotland that could only at this stage be on the West Coast (see Table 6.3).

Table 6.8 Routes to Scotland appraised as increment on other route

Measure	Assessment of incremental benefit of serving West Coast as addition to East Coast	Assessment of incremental benefit of serving East Coast as addition to West Coast
Measurement against guiding principles		
GP1 - Capacity	The West Coast route is more effective in releasing capacity for freight	Adding the East Coast route does not add capacity for freight in useful places
GP2 – Economy	Having both routes ensures all the key linkages are in place between Scotland and the NW and NE of England	Having both routes ensures all the key linkages are in place between Scotland and the NW and NE of England

Measure	Assessment of incremental benefit of serving West Coast as addition to East Coast	Assessment of incremental benefit of serving East Coast as addition to West Coast
GP3 – Whole journey: car	Having both routes ensures all the key linkages are in place between Scotland and the NW and NE of England, hence maximising car abstraction	Having both routes ensures all the key linkages are in place between Scotland and the NW and NE of England, hence maximising car abstraction
GP4 – Aviation	Having WC as well as EC offers best journey times to both cities, increasing level of abstraction compared to EC route alone	Having EC as well as WC offers best journey times to both cities, marginally increasing level of abstraction compared to WC route alone
GP5 – Network for all	The second route provides some additional linkages, but the list of stations on the network is not increased	The second route provides some additional linkages, but the list of stations on the network is not increased
Demand Analysis		
Total HS demand (million) (2055)	10.1	13.4
Abstracted from classic rail (million) (2055)	1.5	2.5
Abstracted from air (million) (2055)	2.0	0.8
Abstracted from car (million) (2055)	0.7	0.9
Generated HS users (million) (2055)	6.0	9.2
Revenue Analysis		
HS Revenue £m (2055)	£467	£500
Net Rail Revenue £m (2055)	£430	£380
Infrastructure and Operating Costs		
Infrastructure Capital costs £m (2008 prices)	£14,122	£6,110
HS operating costs £m (2008 prices) in 2055	£627	£377
Reduction in classic operating cost £m (2008 prices) in 2055	£0	£0
Number of 200m Rolling Stock units (required in 2055)	63	42
Other Impacts		
Car kms removed (millions) (2055)	208.5	209.4
Air passenger kms removed (millions) (2055)	1,218.5	443.1
CO2 reduction (million tonnes) (2055)	0.066	0.025

Measure	Assessment of incremental benefit of serving West Coast as addition to East Coast	Assessment of incremental benefit of serving East Coast as addition to West Coast
User and Non-User Benefits		
NPV User benefits £m (2002 prices)	£12,869	£5,778
NPV Non-user benefits £m (2002 prices)	£323	£223
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£2,428	£1,300
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£0	£0
NPV Other benefits of new classic services £m (2002 prices)	£0	£0
NPV Benefits to rail freight £m (2002 prices)	£0	£0
NPV Wider regional economic benefits (£m 2002 prices)	£1,682	£430
Financial Performance		
NPV Net Revenue (£m 2002 prices)	£2,758	£1,785
NPV Costs (£m 2002 prices)	£15,383	£8,126
NPV Benefits (£m 2002 prices)	£15,951	£7,785
NPV Operating Surplus (£m 2002 prices)	-£3,000	-£912
NPV Overall funding deficit (£m 2002 prices)	-£12,624	-£6,341
Total NPV (£m 2002 prices)	£568	-£341
BCR (excluding Wider Economic Benefits)	1.05	0.95

Building both routes is marginally better value for money than building just the East Coast route (BCR 1.05), and marginally worse value for money than building just the West Coast route (BCR 0.95).

However, we see that no clear conclusion can be drawn from the BCRs, as all are close to 1. Nor are the guiding principles conclusive. The recommendation we make on serving Scotland is therefore based on how phasing might work. In this case, as we have identified the West Coast to Manchester as the best performing corridor northwards from London, and given there are strong benefits in extending HSR to Scotland, we recommend the west coast route as the best first option.

There is then a case that might be made for doing the East Coast as an addition, although options for upgrading should also be considered.

6.9 Scenarios A: HS-NE M11 corridor vs M1 corridor

Overall, the M1 corridor performs marginally better than the M11 in a straight value-for-money comparison.

However, the M11 corridor tends to perform better against the guiding principles by offering benefits over a wider area including parts of East Anglia and the South East.

On this basis, the M11 corridor is selected in preference to the M1 corridor as the route to take forward for development in subsequent scenarios, although no firm recommendation is made and further work is needed to determine the better option.

Table 6.9 HS-NE M1 compared to M11 (figures are incremental costs and benefits of M1 compared to M11)

Measurement against guiding principles	
GP1 - Capacity	The M11 corridor provides wider capacity benefits than the M1, by providing (limited) relief to the West Anglia and Great Eastern Main Lines.
GP2 – Economy	The M11 corridor route creates a number of important linkages that are not provided by the M1, including rail connectivity to growth areas in the Cambridge area from the north to a much greater extent than is provided today.
GP3 – Whole journey: car	The M1 corridor route achieves a marginally higher level of car abstraction compared to the M11 corridor.
GP4 – Aviation	As a whole journey experience, terminating at Stratford rather than Central London means that the M11 corridor offers less attractive connections within London overall, but does offer attractive connections to Docklands, the Thames Gateway, and international services.
GP5 – Network for all	The M1 corridor route achieves a marginally higher level of air abstraction compared to the M11 corridor, due slightly faster journey times between cities with air flows. Serving Stansted does not capture a significant amount of air demand, as this airport caters to a limited domestic market.

Demand Analysis	
Total HS demand (million) (2055)	-8.8
Abstracted from classic rail (million) (2055)	-9.4
Abstracted from air (million) (2055)	0.1
Abstracted from car (million) (2055)	0.7
Generated HS users (million) (2055)	-0.2
Revenue Analysis	
HS Revenue £m (2055)	£189
Net Rail Revenue £m (2055)	£391
Infrastructure and Operating Costs	
Infrastructure Capital costs £m (2008 prices)	£3,681
HS operating costs £m (2008 prices) in 2055	-£114
Reduction in classic operating cost £m (2008 prices) in 2055	£0

Number of 200m Rolling Stock units (required in 2055)	-7
Other Impacts	
Car kms removed (millions) (2055)	214.0
Air passenger kms removed (millions) (2055)	10.2
CO2 reduction (million tonnes) (2055)	0.008
User and Non-User Benefits	
NPV User benefits £m (2002 prices)	£485
NPV Non-user benefits £m (2002 prices)	-£171
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	-£63
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	-£255
NPV Other benefits of new classic services £m (2002 prices)	-£108
NPV Benefits to rail freight £m (2002 prices)	£0
NPV Wider regional economic benefits (£m 2002 prices)	£106
Financial Performance	
NPV Net Revenue (£m 2002 prices)	£2,703
NPV Costs (£m 2002 prices)	£598
NPV Benefits (£m 2002 prices)	£3,018
NPV Operating Surplus (£m 2002 prices)	£2,391
NPV Overall funding deficit (£m 2002 prices)	£2,105
Total NPV (£m 2002 prices)	£2,420
BCR (excluding Wider Economic Benefits)	N/A

6.10 Scenario 8: Transpennine Corridor

Though the value for money performance of this section of infrastructure is not especially strong it does help the overall HS network better fulfil a number of the aims of the guiding principles. In particular, it opens up a wealth of new connections both within the north of England, and across longer distance such as East Anglia to the North West.

Given the strategic importance of this link, it has been included in the overall network proposal. The business case for it can be enhanced if a wider role than the HS and longer distance regional links that we have evaluated can be identified. This could include freight benefits, or more local services.

Table 6.10 Value of Transpennine

Measurement against guiding principles	
GP1 - Capacity	Selective infrastructure upgrades allow the overall capacity of the South Transpennine route to be improved and wider range of services offered. Also reduces pressure on Manchester city centre infrastructure by allowing cross-Manchester Transpennine movements to be routed away from the city centre.
GP2 – Economy	The additional infrastructure enables some significant improvements to be made in the links from Liverpool and Manchester Airport to Sheffield, Leeds and the North East, which today are compromised by having to be made cross-Manchester.
GP3 – Whole journey: car	Further widens the range of east-west linkages from places such as East Anglia and the East Midlands to the North West.
GP4 – Aviation	Significantly improves rail's competitive position on the Manchester – Sheffield corridor, where existing road link is poor.
GP5 – Network for all	Manchester Airport – Edinburgh/Glasgow linkages helps to capture further HS share of this market.
Demand Analysis	
Total HS demand (million) (2055)	8.1
Abstracted from classic rail (million) (2055)	3.8
Abstracted from air (million) (2055)	0.7
Abstracted from car (million) (2055)	1.3
Generated HS users (million) (2055)	2.3
Revenue Analysis	
HS Revenue £m (2055)	£172
Net Rail Revenue £m (2055)	£95
Infrastructure and Operating Costs	
Infrastructure Capital costs £m (2008 prices)	£3,194
HS operating costs £m (2008 prices) in 2055	£139
Reduction in classic operating cost £m (2008 prices) in 2055	£0
Number of 200m Rolling Stock units (required in 2055)	14
Other Impacts	
Car kms removed (millions) (2055)	141.1
Air passenger kms removed (millions) (2055)	390.0
CO2 reduction (million tonnes) (2055)	0.025

User and Non-User Benefits	
NPV User benefits £m (2002 prices)	£3,530
NPV Non-user benefits £m (2002 prices)	£168
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£131
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£4
NPV Other benefits of new classic services £m (2002 prices)	£0
NPV Benefits to rail freight £m (2002 prices)	£0
NPV Wider regional economic benefits (£m 2002 prices)	£1,047
Financial Performance	
NPV Net Revenue (£m 2002 prices)	£682
NPV Costs (£m 2002 prices)	£3,468
NPV Benefits (£m 2002 prices)	£4,380
NPV Operating Surplus (£m 2002 prices)	-£114
NPV Overall funding deficit (£m 2002 prices)	-£2,786
Total NPV (£m 2002 prices)	£912
BCR (excluding Wider Economic Benefits)	1.33

6.11 Value of HS route to South Wales and South West

Comparing Scenario 9 to Scenario 8 demonstrates that the business case for the route to South Wales and the South West is not as strong as some of the others. This is because the journey time savings are not as great and there is no existing air market to capture.

Nevertheless, there are significant capacity benefits, and the HS option needs to be compared against alternative ways of increasing capacity.

Table 6.11 Value of Line to South Wales and South West

Measurement against guiding principles	
GP1 - Capacity	The classic GW route is forecast to have continued growth, and the HS route significantly improves this, building on the planned electrification of the route. It also gives the ability to run additional freight, although the need for this is critically dependent on whether Avonmouth Port expands.
GP2 – Economy	The economic benefit of the link is related to the crowding relief it provides, which may well be underestimated by traditional models, particularly bearing in mind the significant crowding on the alternative highway links, especially the M4
GP3 – Whole journey: car	The forecast abstraction from car is not high, but this is due to the demand crowded off rail in the base case not being properly reallocated to car in our

	model
GP4 – Aviation	There is no significant effect on air demand
GP5 – Network for all	This route provides a critical linkage to Bristol and Cardiff plus other areas in south Wales and the South West, thus expanding the HS network to have a coverage of all principal cities in Great Britain

Demand Analysis	
Total HS demand (million) (2055)	6.5
Abstracted from classic rail (million) (2055)	3.3
Abstracted from air (million) (2055)	0.1
Abstracted from car (million) (2055)	0.3
Generated HS users (million) (2055)	2.9
Revenue Analysis	
HS Revenue £m (2055)	£365
Net Rail Revenue £m (2055)	£181
Infrastructure and Operating Costs	
Infrastructure Capital costs £m (2008 prices)	£1,861
HS operating costs £m (2008 prices) in 2055	£139
Reduction in classic operating cost £m (2008 prices) in 2055	£0
Number of 200m Rolling Stock units (required in 2055)	9
Other Impacts	
Car kms removed (millions) (2055)	61.1
Air passenger kms removed (millions) (2055)	71.4
CO2 reduction (million tonnes) (2055)	0.006
User and Non-User Benefits	
NPV User benefits £m (2002 prices)	£4,654
NPV Non-user benefits £m (2002 prices)	£60
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£2,496
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£0
NPV Other benefits of new classic services £m (2002 prices)	£0
NPV Benefits to rail freight £m (2002 prices)	£0
NPV Wider regional economic benefits (£m 2002 prices)	£255

Financial Performance	
NPV Net Revenue (£m 2002 prices)	£1,017
NPV Costs (£m 2002 prices)	£2,708
NPV Benefits (£m 2002 prices)	£5,731
NPV Operating Surplus (£m 2002 prices)	£1,098
NPV Overall funding deficit (£m 2002 prices)	-£1,691
Total NPV (£m 2002 prices)	£3,023
BCR (excluding Wider Economic Benefits)	2.79

6.12 Incremental benefit of link to HS-CT

The incremental value of the link from HS-NW to HS-CT is summarised in Table 6.12. In this test, we have compared Scenario 9 with a scenario in which services running through on to HS-CT are removed. Specifically, these comprise:

- complete removal of through services on HS-NW from Birmingham and Manchester to Paris and Brussels, calling at Stratford
- removal of extensions of selected services on HS-NE from Central Scotland, Newcastle, Leeds, Sheffield and the East Midlands to Paris and Brussels calling at Stratford and stations in Kent.
- services from Cardiff/Bristol and the Thames Valley via Heathrow to Stratford, Ashford and with occasional extensions to Paris/Brussels are curtailed at Heathrow.

Table 6.12 Value of HS-CT link

Measurement against guiding principles	
GP1 - Capacity	Provides capacity for through services between regions and continent.
GP2 – Economy	Benefits for English regions from direct rail linkages to mainland Europe that are both faster than today and avoid the need to change trains in London.
GP3 – Whole journey: car	No abstraction from car
GP4 – Aviation	Demand abstracted from air demand on English regions and Heathrow to Paris/Brussels flows
GP5 – Network for all	HS service from English regions to European Mainland likely to cater mainly for a leisure market.
Demand Analysis	
Total HS demand (million) (2055)	5.4
Abstracted from classic rail (million) (2055)	1.2
Abstracted from air (million) (2055)	3.8
Abstracted from car (million) (2055)	0.0

Generated HS users (million) (2055)	0.4
Revenue Analysis	
HS Revenue £m (2055)	£288
Net Rail Revenue £m (2055)	£91
Infrastructure and Operating Costs	
Infrastructure Capital costs £m (2008 prices)	£558
HS operating costs £m (2008 prices) in 2055	£109
Reduction in classic operating cost £m (2008 prices) in 2055	£0
Number of 200m Rolling Stock units (required in 2055)	6
Other Impacts	
Car kms removed (millions) (2055)	0.0
Air passenger kms removed (millions) (2055)	2,717.6
CO2 reduction (million tonnes) (2055)	0.136
User and Non-User Benefits	
NPV User benefits £m (2002 prices)	£5,881
NPV Non-user benefits £m (2002 prices)	£263
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£147
NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£0
NPV Other benefits of new classic services £m (2002 prices)	£0
NPV Benefits to rail freight £m (2002 prices)	£0
NPV Wider regional economic benefits (£m 2002 prices)	Not calculated
Financial Performance	
NPV Net Revenue (£m 2002 prices)	£519
NPV Costs (£m 2002 prices)	£1,850
NPV Benefits (£m 2002 prices)	£6,663
NPV Operating Surplus (£m 2002 prices)	£699
NPV Overall funding deficit (£m 2002 prices)	-£1,331
Total NPV (£m 2002 prices)	£4,813
BCR (excluding Wider Economic Benefits)	4.62

The analysis shows that the incremental value for money of building a links from HS-NW and HS-NE to HS-CT and running through services to Kent and Europe is extremely good, reflecting the relatively small additional infrastructure cost and significant level of benefit involved.

Demand Summary of each network component

Table 6.13 compares the demand of the different components of HS usage. Of course longer term projections out to 2055 cannot be certain. Our assessments use the best projections available, taking account of differing projections of growth across the various transport modes.

Table 6.13 Summary of HS demand in 2055 (million passengers per annum)

	Total HS Demand	Abstracted from classic	Abstracted from air	Abstracted from car	Generated HS Users
London/Heathrow/HS-CT to Birmingham/Manchester	72.0	48.0	8.2	3.9	11.8
London/HS-CT to Sheffield/Leeds (via M11)	51.6	36.5	3.4	2.6	9.2
Extending HS-NW to Scotland	28.8	9.5	15.6	2.1	1.6
Heathrow Link	10.1	1.8	4.9	0.8	2.7
HS-NE to Newcastle (via M1)	37.5	24.3	2.4	4.7	6.0
Extending HS-NE to Scotland if HS-NW already to Scotland	13.4	2.5	0.8	0.9	9.2
Extending HS-NW to Scotland if HS-NE already to Scotland	10.1	1.5	2.0	0.7	6.0
Transpennine link	8.1	3.8	0.7	1.3	2.3
Great Western link	6.5	3.3	0.1	0.3	2.9
HS-CT link	5.4	1.2	3.8	0.0	0.4

Over a period of 40-50 years, this leads to some very substantial increases in demand. But then longer distance travel in Britain has been growing strongly; rail demand, for instance, has increased up by over 40% in the last ten years. And the evidence from those countries where HSR has been adopted is that demand continues to grow year-on-year as its relative advantage over other travel modes increases.

For air travel, we assumed that underlying demand growth would continue, at 2.3% per annum, and this leads to a near-trebling of air demand over the period in question. In practice, of course, such growth is dependent not only on the expansion of air services but also of the availability of runway capacity to handle them. This may well be unlikely in practice, and in which case the projected diversion from air needs to be recognised as being a forecast of the level of potential air demand that would switch to HSR; a significant part of this demand may not have been accommodated by the aviation sector over the years to 2055, but if so, the benefit of being able to accommodate it on HSR is just as valuable.

The scale of projected diversion from private car is modest and reflects the demand model structure in which it is assumed that travellers make a choice between using car or public transport, and that HSR is treated as just another (but rather better) component of the public transport offer. This is an intentionally cautious assumption.

It might be felt that the final category of HSR travel – generated or induced demand – is undesirable, because it implies people making journeys that they didn't need to make. In practice, a great deal of induced demand is likely to be in response to attractive advanced purchase fares offers. These provide a means to sell seats on scheduled services that would otherwise go unfilled. This type of travel therefore has little impact on carbon emissions, - as the HSR service was going to run anyway – but it does help to defray the costs of operation.

An important aspect of HSR that makes it a substantial improvement is the difference in reliability over the existing classic network afforded by having a largely segregated network, precisely controlled by state-of-the-art signalling equipment. On the Spanish High Speed system, for example, a reliability level of 98.5% of trains on time is achieved: with less stringent criteria, the best UK intercity operators are currently achieving scores around 90%. Furthermore, new dedicated infrastructure can be designed so as to require significantly less disruptive weekend maintenance work to be undertaken on it, making it much more of '7-day railway'. This is particularly relevant where HS rail is providing access to airports for interlining, as weekends and Sunday in particular are times of peak demand for air travel.

Our demand modelling incorporates an adjustment to the generalised cost of travel to represent both the improved reliability and less disrupted operation of the High Speed network compared to Classic services. Where HS services run through onto the classic network, this adjustment is reduced to represent the increased performance risk on this section of the route.

7 Conclusions: recommended network

7.1 Overview

The analysis described in the previous chapter confirms that Scenario 9 forms an appropriate basis for a high speed rail network strategy. However, it clearly will not be deliverable as a single scheme, and there will be a phased development. This is described in section 7.2.

The phased strategy enables both early benefits and the ability to monitor the results of the first phase to improve the plans for subsequent phases. The later phases can also take advantage of any technical improvements that might emerge over time. In developing our phasing strategy, we have assessed that a rate of construction of about 60km per year is feasible; that is slightly higher than the 50km achieved in France over recent years, but below that achieved in other countries such as Spain. Our assumed construction start date is 2015.

We have also undertaken a number of sensitivity tests to establish the robustness of the proposals. These are described in section 7.3.

7.2 Phasing

The phasing strategy adopted will have implications for the development of regional economies and needs to be considered carefully as a policy decision. For the purposes of this report we present an example phasing strategy that is based on the value for money evidence from the business case work alone, with priorities based on a logical sequence in which the highest-performing sections are built first. In practice, there will be other factors to consider, and each of the sections of route described below is capable of sub-division, so the phasing is likely to be adapted to suit. In particular, our analysis of Wider Impacts has shown that there can be disadvantages to regions not served: therefore securing an earlier spread of benefits is an particularly important consideration alongside pure value for money.

Phase 1

Based on our assumed start dates for construction, and a rate of construction of 60km per year, our modelling assumption is that the first phase of the network would be delivered by 2021, including links to Heathrow and Europe.

The scenario tests demonstrated that the initial case for a HS route in the north west corridor is stronger than for one in the north east corridor. We therefore recommend that the first phase consists of London to Birmingham and Manchester; it might be possible to realise this phase in two parts delivering early benefits for Birmingham.

Once the route to Manchester is available services to Edinburgh and Glasgow on the west coast would immediately be diverted to the high speed route between London and the north west, thus saving valuable time.

There could also be services to the East Midlands and South Yorkshire via Birmingham International which will be faster than current MML services.

The Heathrow and HS-CT links should be built as part of this first phase, in part to deliver immediate benefits, with services both to north east and north east England, but also to avoid the disruption of subsequent engineering work when links were made from HS-NW to these routes. The actual timing of the Heathrow Station construction may be affected by decisions on a third runway and sixth terminal; if this goes ahead as planned, then it would be sensible that construction of the station and the terminal is coordinated.

The initial build of rolling stock will need to include both UIC gauge double deck trains to operate between London and Birmingham/Manchester, and British (W6A) gauge trains to operate on other routes.

This phase delivers a substantial portion of the freight benefits through releasing capacity on the critical west coast main line. It also allows for an increase in commuting services to the rapidly growing Milton Keynes/ Northampton area.

Phase 2

The largest gains are made when the HS network links London to Edinburgh and Scotland. The potential for extensive switching from air and hence reduction in CO_2 emissions is greatest here, as is the increase in rail trips. We have therefore modelled extending the line from the north west to Scotland as the next priority, reaching this point by 2027.

This will result in a HS line throughout to Edinburgh and Glasgow. UIC gauge trains could then operate on these lines giving substantially increased capacity, although our forecasts indicate that some increase in service frequency will also be required to carry the demand. The released British gauge trains can then be cascaded to some of the cross-country services that operate from the south and south west to Edinburgh and Glasgow via the high speed line.

The extension to Scotland delivers further freight benefits.

Provided the network strategy is delivered broadly to the proposed timescales, there should be adequate capacity to operate all services on the HS-NW route, but this will become increasingly full prior to the completion of the next phase.

Phase 3

To deliver increased capacity north from London a route on the east coast to the East Midlands, Yorkshire and Newcastle is the next priority. This is also required as the ECML will be heavily overloaded, even with the transfer of London – Edinburgh traffic to the west coast HS route. This means that it may be appropriate to prioritise this investment earlier, possibly ahead of the full route to Scotland via the West Coast. We have modelled delivery of this incremental addition to the network as being achieved by 2035, but it is technically possible for this to be delivered much earlier as there is no direct dependency on Phases 1 or 2. Indeed, it is entirely feasible for this phase to be taken forward ahead of Phase 2 and even as a first phase; this might be desirable to avoid economic activity being sucked from the Eastern corridor to the north west by the presence of high speed links to London in that corridor.

This scenario essentially provides additional HS services to Sheffield, Leeds and Newcastle, and also services to East Anglia (Stansted, Cambridge Norwich). There is no transfer from the West Coast assumed at this stage.

There is likely to be a need for additional UIC gauge and British gauge trains at this stage; it may be that the shorter distance trains to East Anglia are formed of rather different rolling stock.

Phase 4

In our network strategy, we have included within this phase three elements: the extension via the east coast route to Edinburgh, the Transpennine route, and the western route to Bristol and Cardiff. For modelling purposes, we have assumed these are delivered by 2041, but, again, many of these elements can be delivered earlier.

In reality the western route is self standing (once the Heathrow station and links are constructed), and as we consider it to be a partial high speed route, it might be constructed at whatever time appears necessary to meet the capacity needs of the route.

The Transpennine route is as much for local and regional role, and again the timescales are flexible depending on these other needs.

The completion of an East Coast route to Scotland allows for the transfer of Edinburgh services from the West Coast to the East Coast which is less crowded; some European services also go via Stratford and the East Coast.

The rolling stock required for this final phase is likely to be UIC gauge to operate to Edinburgh, plus British gauge to operate to Bristol and Cardiff. At some point new trains will be required to replace the first generation high speed trains – rolling stock is generally considered to have a lifespan of about 30 years.

7.3 Appraisal of overall network

Table 7.1 summarises the overall network strategy in the same form as the other scenarios, except that the assessment of Guiding Principles is described at greater length in the subsequent text. The methodology for appraising the strategy is the same as that for the individual scenarios with the addition that as some of the infrastructure is not delivered until 2014, it is appropriate to include a residual value. This has been calculated assuming a 60 year life for infrastructure, and assuming straight line depreciation. For rolling stock a 30 year life has been assumed.

Table 7.1 Assessment of Network Scenario

Demand Analysis	
Total HS demand (million) (2055)	178.0
Abstracted from classic rail (million) (2055)	101.5
Abstracted from air (million) (2055)	29.7
Abstracted from car (million) (2055)	12.6
Generated HS users (million) (2055)	34.2
HS Revenue £m (2055)	£8,694
Net Rail Revenue £m (2055)	£4,063
Infrastructure Capital costs £m (2008 prices)	£69,473
HS operating costs £m (2008 prices) in 2055	£3,739
Reduction in classic operating cost £m (2008 prices) in 2055	£1,151
Number of 200m Rolling Stock units (required in 2055)	357
Car kms removed (millions) (2055)	2,661.1
Air passenger kms removed (millions) (2055)	18,028.8
CO_2 reduction (million tonnes) (2055)	1.013
NPV User benefits £m (2002 prices)	£78,482
NPV Non-user benefits £m (2002 prices)	£10,404
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£9,942

NPV Benefits from local classic rail crowding reduction £m (2002 prices)	£3,192
NPV Other benefits of new classic services £m (2002 prices)	£1,871
NPV Benefits to rail freight £m (2002 prices)	£1,850
NPV Wider regional economic benefits (£m 2002 prices)	£11,231
NPV (£m 2002 prices)	£63,337
BCR	3.48

It can be seen that the total infrastructure capital costs including land acquisition, project management, optimism bias, etc is estimated as £51bn. However, the BCR is 3.48 (excluding the Wider Economic Benefits), making this an excellent overall scheme.

The potential to deliver large regional economic benefits increase its value.

The appraisal values are inevitably less than those of the full Scenario with all services (if it could hypothetically be implemented in a single phase) due to the phased introduction of services. In this network scenario, we have included residual values for the infrastructure and rolling stock construction including major renewals/ refurbishment.

7.4 Sensitivity Tests

When investing in a substantial enhancement to Britain's infrastructure for the long term it is inevitable that benefits occur in the long term; indeed, we are estimating that the first phase will not be constructed until 2021 – 12 years from now and 14 from our base demand data. The future is uncertain and we have therefore undertaken a range of sensitivity tests.

The objectives of these tests are to:

- Gain an understanding of risk associated with modelling errors
- Understand the impact of higher HSR fares
- Assess the uncertainty surrounding economic growth
- Assess the impact of the introduction of a national road user charging scheme.

For the sake of simplicity, all these tests were undertaken on a final version of Scenario 9, but without any phasing.

For the first of the tests, it can be noted that in the forecasting work, no assumption was taken on an inherent preference for HSR over classic rail; this is clearly a conservative assumption, and other studies have included such a preference. If one assumes that HSR has an inherent improvement in quality equivalent to 10 minutes of journey time, then the resulting increase in demand for HSR is 8% (revenue increases by 7%). The impact on net rail revenue is higher at 12%, as a lower proportion of the additional demand is abstracted from classic rail. It results in 24% more abstraction from car. The impact on user (and hence total) benefits is large, with the BCR increasing from 2.59 to 3.23.

Applying a premium to HSR fares clearly reduces HSR demand and improves net rail revenue. Its impact on HSR revenue is marginal, with a 10% fares premium over classic fares producing a slight increase, but 20% a slight decrease. A 10% fares premium reduces HSR demand (journeys) by 7%, while a 20% premium reduces it by 15%. The higher fares result in a significant reduction in the BCR from 2.59 to 2.47 (10% increase) or 2.30 (20% increase),.

The impact of economic growth on HSR is marked. We tested increasing or decreasing GDP per capita by half a percentage point per annum. The impacts on HSR demand are + 24% and - 22%. Most of the benefits change in a broadly similar way to these numbers, except for crowding which is particularly sensitive to growth. The lower GDP growth results in only a third the level of crowding benefits, whereas the higher economic growth doubles these benefits. The overall BCRs are also very sensitive, as crowding is an important element of these. The lower economic growth reduces the BCR from 2.59 to 1.82; the higher economic growth increases it to 4.01.

The case for HSR is not very sensitive to the implementation of road user charging; certainly based on the assumption we made which was of a 50% increase in the marginal cost of driving. This resulted in 4% increase in HSR demand, and the BCR increasing to 2.98. Tables 7.2 and 7.3 summarise the results of the sensitivity tests.

Table 7.2 Summary of sensitivity tests to HSR mode constant and fare

Sensitivity Test	Base	HSR mode preference 10 mins	HSR fares +10%	HSR fares +20%
Demand Analysis				
Total HS demand (million) (2055)	178.0	192.4	165.9	151.5
Abstracted from classic rail (million) (2055)	101.5	104.5	97.7	91.4
Abstracted from air (million) (2055)	29.7	31.0	27.0	23.6
Abstracted from car (million) (2055)	12.6	15.6	11.1	9.8
Generated HS users (million) (2055)	34.2	41.3	30.1	26.8
Revenue Analysis				
HS Revenue £m (2055)	£8,694	£9,282	£8,829	£8,672
Net Rail Revenue £m (2055)	£4,063	£4,545	£4,372	£4,548
Other Impacts				
Car kms removed (millions) (2055)	2,748	3,282	2,359	2,010
Air passenger kms removed (millions) (2055)	18,708	19,474	17,139	15,152
CO_2 reduction (million tonnes) (2055)	1.1	1.1	1.0	0.8
User and Non-User Benefits				
NPV User benefits £m (2002 prices)	£99,086	£115,078	£90,950	£83,352
NPV Non-user benefits £m (2002 prices)	£12,763	£13,308	£12,149	£11,540
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£12,002	£11,181	£12,050	£11,835
NPV Wider regional economic benefits (£m 2002 prices)	£15,584	£19,843	£13,620	£11,909
Benefit Cost Ratios (exclude Wider Economic Benefits)				
BCR	2.59	3.23	2.47	2.30

Table 7.3 Summary of sensitivity tests to economic growth and road user charging

Sensitivity Test	Base	GDP – 0.5% pa	GDP + 0.5% pa	Road user charging
Demand Analysis				
Total HS demand (million) (2055)	178.0	139.4	220.3	184.9
Abstracted from classic rail (million) (2055)	101.5	82.6	121.1	106.1
Abstracted from air (million) (2055)	29.7	23.4	38.0	31.1
Abstracted from car (million) (2055)	12.6	11.1	14.1	11.9
Generated HS users (million) (2055)	34.2	22.4	47.1	35.7
Revenue Analysis				
HS Revenue £m (2055)	£8,694	£6,779	£10,993	£9,046
Net Rail Revenue £m (2055)	£4,063	£2,909	£5,703	£4,251
Other Impacts				
Car kms removed (millions) (2055)	2,748	2,479	3,020	2,431
Air passenger kms removed (millions) (2055)	18,708	14,719	23,929	19,416
CO2 reduction (million tonnes) (2055)	1.1	0.8	1.3	1.1
User and Non-User Benefits				
NPV User benefits £m (2002 prices)	£99,086	£76,252	£129,043	£103,074
NPV Non-user benefits £m (2002 prices)	£12,763	£12,261	£13,348	£12,603
NPV Benefits from HS and Intercity rail crowding reduction £m (2002 prices)	£12,002	£3,875	£24,855	£14,184
NPV Wider regional economic benefits (£m 2002 prices)	£15,584	£12,086	£19,938	£16,039
Benefit Cost Ratios (exclude Wider Economic Benefits)				
BCR	2.59	1.82	4.01	2.98

7.5 How does the preferred network meet the guiding principles

This section details how the recommended network strategy fulfils the aims stated under the guiding principles set out in Chapter 1.

Capacity

HSR networks need to be planned so that they create additional commuting capacity where there is forecast to be a capacity short-fall on current plans.

Freight network capacity released on the main lines needs to be matched by suitable availability of paths to reach terminals, ports and to cross London.

The HS networks will provide relief from capacity problems on most of the main rail routes in the UK:

- West Coast Main Line: Most of the current Intercity traffic, served predominantly by Virgin West Coast, will transfer to the HS-NW route. A residual Intercity service on the route will still be needed to serve the needs of smaller centres such as Coventry, Stoke and Wigan, but significant capacity will be released for regional, commuting and freight services; this route is overwhelmingly the most important for freight.
- East Coast Main Line: Again, much of the current Intercity traffic, will transfer to HS, this time HS-NE. A residual Intercity service will be required, probably operating more as 'skip-stop' pattern to serve smaller centres and provide links over shorter distances than can efficiently served by HS. Some capacity is also expected to be released to enable additional commuting services. Some freight capacity might be released, although our analysis showed that the increase in demand was expected to be lower on the ECML than on the WCML (see Appendix J).
- Midland Main Line: Intercity traffic to Derby, Nottingham and Sheffield will largely transfer to HS services, initially to a limited extent via HS-NW and then more fully via HS-NE. The residual Intercity service will need to focus on Leicester, while additional commuting services between the East Midlands cities and on the route into London will also be released.
- Great Western Main Line: There are already a number of schemes committed or expected that will address many of the capacity issues on the Great Western Main Line over the next decade: Reading Station remodelling, Electrification, Super Express Train, and Crossrail. Thus our preferred network strategy takes an incremental approach that seeks to address the most significant capacity constraint that will exist after these schemes have been implemented: the two track section between Didcot and Wootton Bassett junction. Providing extra HS capacity on this section will enable greater segregation of longer distance markets such as Bristol and Cardiff to London onto the new HS services, releasing capacity for growth on existing services, and potential inter-modal freight services to Avonmouth Port.
- Edinburgh – Glasgow routes: most journeys between these two centres will switch to the services via the upgraded Carstairs Bypass route, releasing capacity for shorter-distance journeys on the route via Falkirk between these two cities.
- Across all these routes, we forecast that by 2055 around 22.4m additional passenger journeys will be carried using the capacity released on the classic network, as well as up to 33 additional freight trains per day on the WCML.

HSR routes need to provide additional capacity into the centre of the major cities they serve, particularly where the inter-urban rail network is operating at, or close to, capacity.

The preferred scheme includes proposals to expand stations and their approaches, or provide new stations and their approaches in many major urban centres that are currently operating at close to maximum capacity.; This would release platform and passenger capacity at the existing stations. Ultimately, however, these proposals will need to be considered in the context of the wider proposals to address general rail capacity problems as these develop.

Sustainable Economic Competitiveness

HSR needs to access city centres and to have high-quality stations where large-scale regeneration and high development densities are considered desirable, or where existing demand is intense.

Cities so served need to have complementary city-region and regional development plans across the relevant sectors so that HSR has a material economic impact.

The preferred network primarily serves City Centre locations, and as discussed under the Capacity heading, includes provision for substantially improved station facilities in many key centres. The recent experience at St. Pancras International demonstrates how such investment can be a catalyst for further investment and development.

We have also proposed a limited number of non-city centre stations where opportunities present themselves. It will be important to ensure that these stations fit with local and regional development plans.

The effect of HSR needs to be such that the locational disadvantages of northern and western cities are reduced and unwanted long-term development pressure in the southeast relieved.

Attractive centre to centre journey times between cities are vital in reducing locational disadvantage. The preferred network seeks to create as many efficient centre to centre linkages as possible, not just from major cities to London. Our analysis of Wider Impacts has shown that there is a significant quantifiable benefit of £14bn to be drawn from such a network by allowing groups of cities, such as the northern cities, Edinburgh/Glasgow and Bristol/Cardiff to function more efficiently as single economic entities. The reduction barriers between these cities that HS rail can achieve will help to re-draw the economic geography of Britain.

The overall HSR service offer needs to be perceived to offer a step-change in quality, with faster journeys offering an advance in accessibility and a level of reliability that fosters investor confidence.

Based on the experience of other countries, we have been able to include the potential impact of the enhanced reliability on the level of demand that HS rail in the UK is likely to attract through our modelling work.

Whole Journey

To create a connected rail-based alternative across a wide set of destinations, there is a need to have HSR stations serve as hubs, connected conveniently into feeder rail and other public transport services.

A further reason for primarily serving city centre locations that by doing so, High Speed rail is best placed to tap into existing public transport, including local rail services, to act as feeder services, providing a sustainable means of access to HS services.

We have identified a number of non-City Centre locations where there are opportunities to take advantage of existing or planned high quality public transport links as well as road connections:

- Heathrow Airport: with Crossrail and Airtrack now progressing, we propose to locate a High Speed hub at this location. Indeed, further links from this hub to the Great Western and South Western main lines will further help to improve connectivity from the wider South East and South West of England to the site, providing an attractive alternative to Central London as the point for accessing the HS network from these areas. Thus serving Heathrow is important not just for mode shift from aviation, but also from other modes, notably car. In total, we forecast that around 14m trips per annum will use the station by 2055.
- Stratford International: with good quality links from the International and new HS Stations to Stratford Regional, the location offers excellent connectivity to significant parts of Central London, Docklands, the Thames Gateway development area, and wider South East, as well as connections to Europe.
- Edinburgh, Stansted, Birmingham, Manchester, and East Midlands Airports: the primary function in serving these locations is to take advantage of their existing transport connections, by both Highway and PT modes, rather than abstracting air traffic.
- Washington Parkway, Tees Valley Parkway: though car is likely to be the dominant mode of access at these stations, there are proposals for an extension to the Tyne and Wear Metro and a new Tees Valley Rapid Transit scheme that respectively would provide high-quality links from these locations to nearby urban areas.

There will have to be substantial provision for road-based access modes, including cycle and private car, at HSR stations, planned from the outset to minimise overall carbon emissions.

Parkway stations will only be considered if they do not detract from the ability to achieve the objectives set in relation (a) to city centres and (b) to achieving an overall reduction in carbon.

The significant shift of mode from car to HS rail of 12.6m trips per annum by 2055 we have forecast will only be achievable if the whole journey experience offered by HS rail is more attractive. For many users, the car will represent the most attractive means of accessing HS rail.

The non-city centre locations that we propose to serve are located at strategic points on the highway network, so that car access times from a wide catchment area can be achieved.

Mode Switch – Aviation

To be an acceptable substitute for international inter-lining traffic, access from HSR to air terminals has to be as attractive and convenient, including security and ticketing issues, as from another flight.

The largest inter-lining market in the UK is based on Heathrow Airport, and as such, the preferred network incorporates a rail hub at this location to facilitate the creation of substitute services for most of the main domestic air routes serving the interlining market.

Our proposal is that this hub should be located within the Heathrow complex, and ideally be integrated into one of the terminals to offer as seamless a journey experience as possible.

As tested, we have assumed that domestic air services continue as a competing mode with HS rail in these markets, albeit at a lower level of service in response to loss of demand to rail, resulting in 29.7m journeys per annum in 2055 classified as abstracted from air, though strictly speaking, many of these journeys will be demand that will be suppressed by air capacity constraints rather than diverted air journeys. The business case for HS rail could be further enhanced if agreement for complete substitution of selected air services could be achieved.

HSR has to be able to offer journey times that will compete effectively with air and win significant route market share.

The HS network is designed to ensure that journey times in the relevant markets are competitive with air. This is especially pertinent to the Anglo-Scottish market, the UK's largest domestic air market. The proposed network provides journey times from both Edinburgh and Glasgow to Central London and Heathrow that are around 2.5 hours. This is achieved through direct routings, and keeping intermediate stops to a minimum.

HSR has to be able to match effective airline frequency. The capacity of an HSR train is much higher than a typical domestic aircraft; this means either the air passenger flows are large or the HSR service not only serves the airport market but also other destinations, and/or a series of cities that can be attractively served by a single airport service.

The service frequency to/from London from regional cities is anticipated to be at least hourly in most cases, more frequent in many. Much of the current air market will be diverted to these services. The trains to Heathrow will take those passengers for whom this is a better destination (going to west London or Surrey/ Berkshire, for example), and also those interlining at Heathrow.

Nevertheless, capturing these markets alone will not be sufficient to support the levels of service we are proposing. Therefore, the services have been designed to capture two further sources of demand. First, as already noted under whole journey, the Heathrow hub will also be an attractive option for passengers in the South East whose choice otherwise would be to interchange in central London or drive. Second, by developing a series of cross-Heathrow routes, demand for a new series of cross-country links will also be carried.

To address the near-continent short-haul market, HSR services will need to be capable of direct operation over the HS-CT route and onwards over the expanding European high-speed rail network.

A link to HS-CT is included in the proposed network, allowing through services from a number of cities other than London to be made for the first time. Furthermore, by providing a station on the HS network at Stratford International, interchanges from domestic HS service to service the continent should be relatively simple.

Integrated, phased development to deliver comprehensive benefits.

There will have to be a long-term national strategy with a phased flexible implementation approach.

The approach we have proposed in the previous section shows how a comprehensive national HS network can be implemented over a period of a few decades as a series of incremental schemes. Each phase is likely to authorised and funded separately; without the vision of what the ultimate HS network will look like, there is a risk that earlier schemes are progressed in a manner that does not easily facilitate further development of the network.

To ensure the long term benefits of HSR are secured for the cities, regions and devolved nations, the delivery of HSR should be supported by complementary planning and economic development measures

The business case for our proposed network is set against the planning and economic background as it stands today: the case will be made stronger, and the benefits delivered will be greater if complementary measures are in place. These measures include both transport schemes to facilitate access to the HS stations and planning of regeneration schemes to ensure the potential economic benefits are fully realised.

The benefits of freeing capacity on existing main lines and local networks need to be demonstrated for communities that may not be directly served by HSR.

Table 7.1 below summarises how a number of communities that are not directly served by HS services could be affected by HS rail.

Table 7.1 Proposed changes in rail service for communities not served directly by HS

Location	Impacts
Milton Keynes and Northampton	Improved service frequency provided by new semi-fast services using released WCML capacity. These will also provide new or improved linkages to locations in the West Midlands and Manchester area.
Coventry	Current 3tph service to London reduced to 2tph, with additional stops at Milton Keynes/Northampton. While service to London will be reduced, links will be improved to South Midlands growth area. Also improved local service using capacity freed by reduction in Intercity service.
Wolverhampton	Current 1tph link maintained, with additional stop in Milton Keynes, providing new linkage to this area.
Nuneaton, Tamworth, Lichfield	Additional 1 tph Trent Valley service implemented using released capacity. Also opportunity to create new link to Manchester.
Stoke on Trent	Current 2tph maintained, but with additional stops in Trent Valley and/or South Midlands, creating new linkages.
Warrington, Wigan,	Services to London improved by through running onto HSL.

Preston, Lancaster, Lake District	Additional semi-fast service also provided on WCML.
Leicester	2tph fast service to London maintained, with additional stops. 2tph semi-fast service also with additional stops added.
Stevenage, Huntingdon	2tph additional stops from semi-fast ECML services. Also new or improved linkages to Leeds, Doncaster, Newcastle
Grantham, Doncaster, York	1tph HS through running service ECML service maintained, but with more stops
Didcot, Swindon	Level of service broadly maintained, but may be more stops. Crowding relief through transfer of longer distance GWML passengers to HS.

7.6 Conclusion

Overall there is a good case for a high speed rail network, delivering both transport and economic benefits.

- It will markedly improve rail journey times between many cities – for example London to Glasgow journey times will decrease from 4hr 10min best time today to 2hr 30min.
- It will provide a substantial increase in rail capacity to meet growing demand in a way that provides additional benefits to travellers worth over NPV £15bn over a sixty-year appraisal period
- It will result in substantial transfer of demand from air and also car – 29.7m air journeys and 12.6m car journeys per annum will be removed from the UK by 2055
- It will reduce CO_2 emissions – just over 1million tonnes less of CO_2 will be produced
- It will facilitate transfer of freight from road to rail – worth NPV of just under £2bn over a sixty-year appraisal period
- It will enable rail to cater for growth in local demand around some of our busiest cities – enabling up 21m additional journeys p.a. to be carried
- It will also facilitate increased inter-regional services on the existing network –enabling a further 1.5m additional journey p.a. to be carried
- If accompanied by appropriate planning measures, it will enable a reshaping of the economic geography of Britain

Appendices

A Corridor Status Reports

B Technical Constraints

C Costs of 4-Track Alignments

D Tunnelling Costs

E Anglo-Scottish Alignment Options

F M1 vs M11 corridor comparisons

G Scenario Infrastructure Assumptions and Costs

H Scenario Service Patterns

I Freight Benefits

J Regional benefits