APPENDIX 3

High Speed Rail
London to the West Midlands and Beyond

A Report to Government
by High Speed Two Limited

PART 11 of 11

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ICE 3 high speed train on the Frankfurt-Cologne high-speed rail line, Sebastian Terfloth;
Eurostar, Dave Bushell www.canbush.com/ppbfrontpage.htm;
Gümmenen viaduct over the river Sarine with TGV 9288, Berne, Switzerland, Chriusha;
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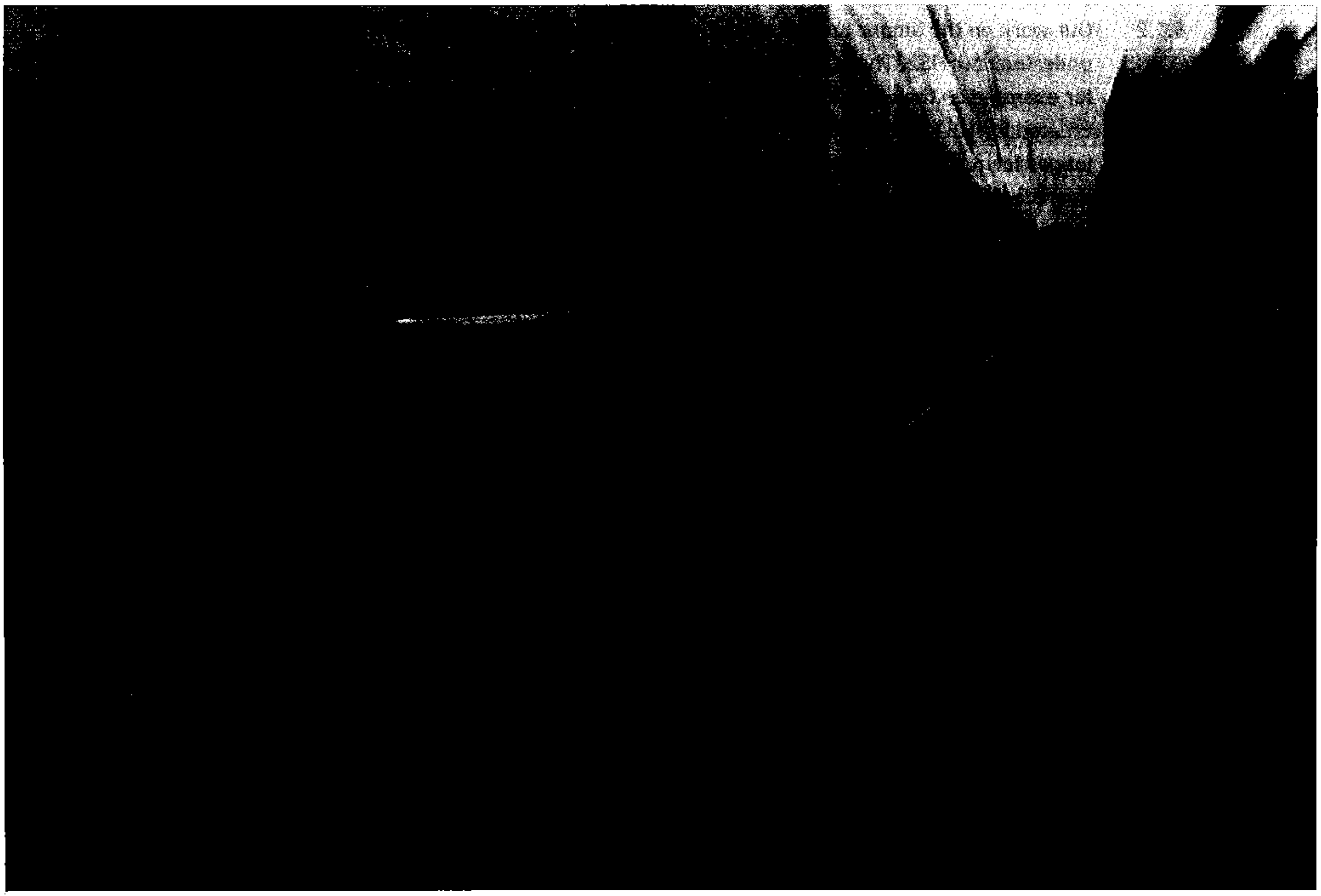
Chapter 6 – Developing a Longer Term Strategy



6.1 Approach and findings

Introduction

6.1.1 This chapter sets out our thinking on a potential longer term strategy for high speed rail, following Government's request for 'advice on the potential development of a high speed line beyond the West Midlands, at the level of broad corridors'.[10] Beginning with the interpretation of our remit and key findings, the chapter goes on to describe the work we have completed, and concludes with a summary of the potential next actions.

6.1.2 Our work on the longer term strategy is strategic rather than the much more detailed work we undertook for HS2. The latter has substantially informed our thinking on the longer term strategy, for example on the estimated unit rates for construction, and we have also used the demand model created for HS2 to test longer term networks. Nevertheless, the analysis we have undertaken on the longer term strategy is not intended to be fully comprehensive in scope and depth, and it has not been designed as a basis on which to make planning decisions of the same nature as those which Government will take on HS2. Further work would be needed to develop longer term proposals in more detail.

Scope and extent

6.1.3 That the basic alignment of a second high speed line in the UK should be from London towards the West Midlands is a widely held view. Some have argued that any new line should go further in the first instance, but the basic orientation is reasonably clear, given the obvious centres of population which lie in this direction and the associated need to relieve pressure on the WCML.

6.1.4 Beyond this, there is less certainty about whether and where further high speed lines may be justified in the future. We were asked specifically to look at the potential for high speed rail to serve three of the largest English conurbations – Greater Manchester, West Yorkshire, and the North East – and Scotland. To these we also added the East Midlands and South Yorkshire, both of which potentially lie on an easterly line of route towards Yorkshire. They are major centres of population, exhibiting significant passenger

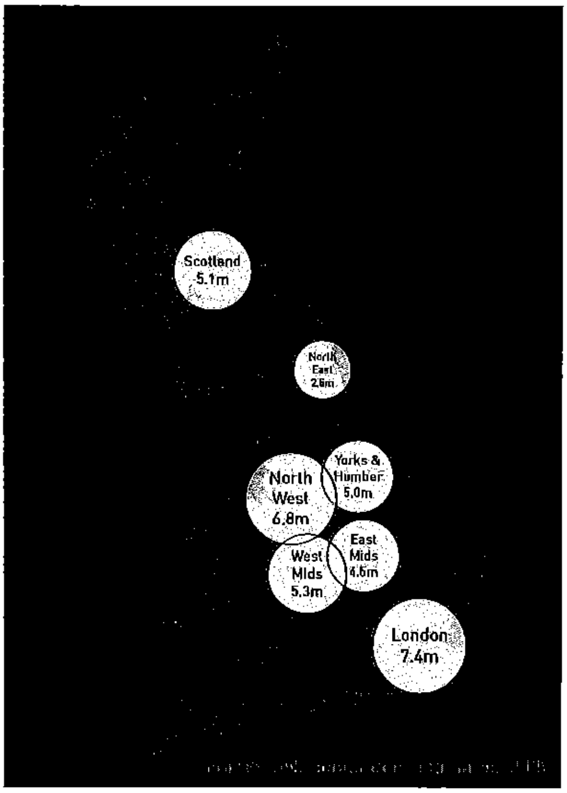


Figure 6.1a Population of applicable English regions and Scotland
(Source: ONS population estimates, 2005)

10 Remit letter from Lord Adonis to Sir David Rowlands, www.hs2.org.uk

flows to and from London on today's conventional rail network. Together, the regions which support these conurbations account for over 60% of the total English population, with Scotland adding a further substantial market.

6.1.5 The remit focused on the potential extension of the core HS2 route to form a wider network, and as such did not include links to other conurbations – in the South, South West and East of England or South Wales – which would not form natural extensions of HS2 but rather require wholly separate high speed lines out of London. So while these lay outside our scope this year, this is not to say that they would not be justified.

6.1.6 In looking at these areas, our work on the longer term strategy has been motivated by three factors:

- **The need to 'future proof' HS2.** The design of HS2, even at this early stage, has the potential to close off viable options for the future. This can only be avoided by establishing an idea of the shape a future network might take and the capacity it might require.
- **The need to identify where Government's focus and resources might best be targeted next.** If Government wishes ultimately to construct an extended high speed line, or network of lines, it will be prudent to do so incrementally. Our work on a longer term strategy aims to indicate the next priorities for further work.
- **The need to set HS2 in an overall context and vision of the future.** We have aimed to set out a possible vision for the future of high speed which will stimulate further debate, and around which further consensus might be built.

6.1.7 Our conclusions on the longer term network add to the growing evidence base on the widespread implementation of high speed rail, which during 2009 has already been bolstered by contributions from Greengauge 21 and Network Rail in particular.

Objectives for a longer term strategy

6.1.8 As we set out in Chapter 1, there is a range of objectives for high speed rail, although the emphasis on certain objectives could shift for a wider network of lines running over longer distances. Whereas providing additional capacity between London and the West Midlands is an important objective for HS2, this may be less relevant in other areas of the country, where line capacity may not be so constrained, or where other infrastructure projects are under way to relieve constraints. Conversely, over longer distances the scale and impact of high speed rail's journey time savings and associated improvements in connectivity become more pronounced, thus creating the potential to stimulate economies and facilitate a shift in travel from air to rail. Fundamentally however, we have assumed the same objectives over the longer term as for HS2.

Basic approach

6.1.9 Figure 6.1b describes the approach we adopted in order to examine the potential development of lines beyond the West Midlands, reflecting both the short time available for modelling and the strategic level at which we have addressed the issues.

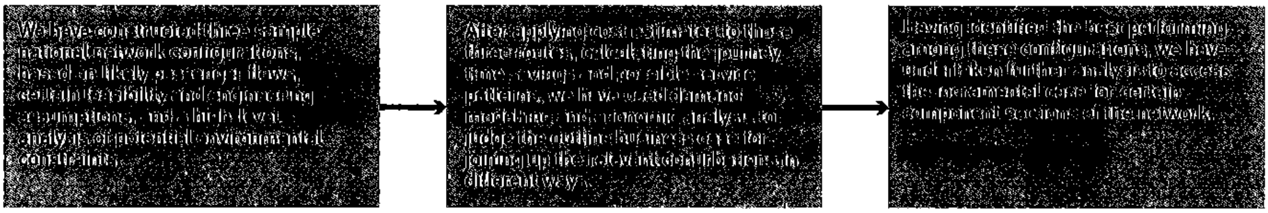


Figure 6.1b Longer term strategy process

Options considered

6.1.10 Our assessment of the potential case for a widespread network of high speed lines has been based on three possible national network configurations, which are outlined below. All three build on the preferred scheme for HS2 between London and the West Midlands. None has been fully optimised: rather they have been developed instead to provide an understanding of the relative merits of different basic approaches. On the strength of those tests we have also been able to conduct some analysis of the incremental case of the likely next steps.

An 'Inverse A' Configuration

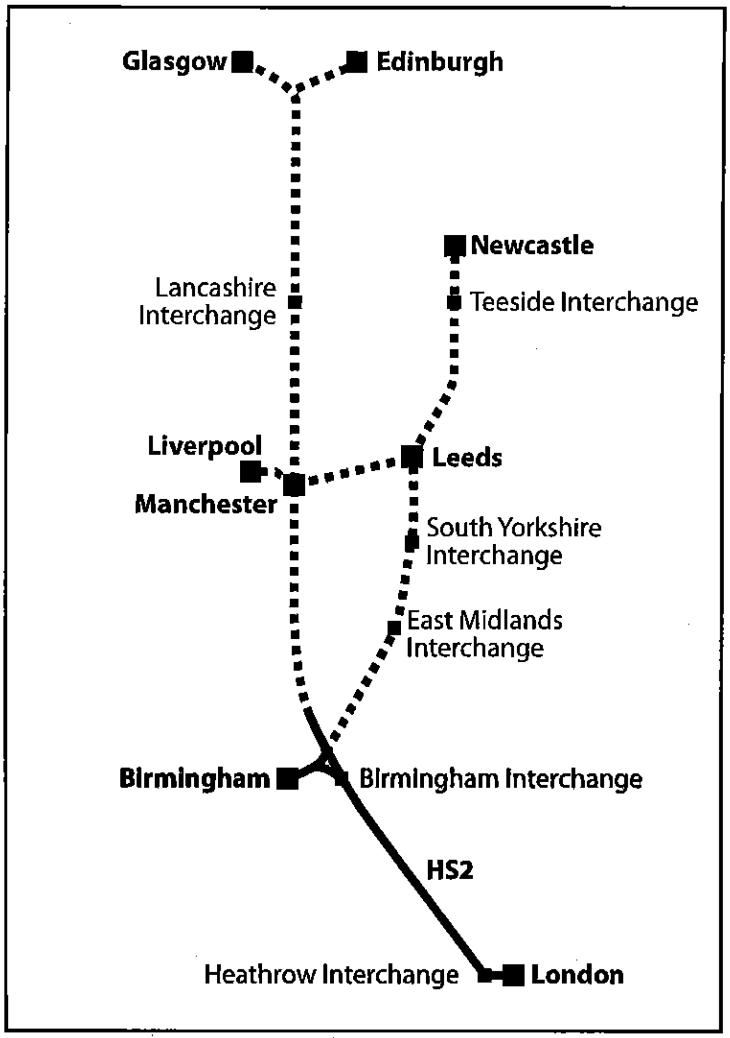


Figure 6.1c Possible configuration – Inverse A

6.1.11 The Inverse A configuration is an adaptation of networks which have been examined in other past studies. It is the most comprehensive network able to be supported by the capacity of HS2, relying as it does on one route north from London. We report on the possible need for a second line from London later in this chapter.

6.1.12 The Inverse A aims to maximise benefits to the widest number of people by offering direct London access to each of the conurbations in our remit, as well as Merseyside (via the existing classic line), East Midlands and South Yorkshire. The transpennine link between Manchester and Leeds would carry only east-west flows, with services to and from London travelling either side of the Pennines. This configuration would also unlock potential for a network of high speed inter-regional services.

A 'Reverse S' Configuration

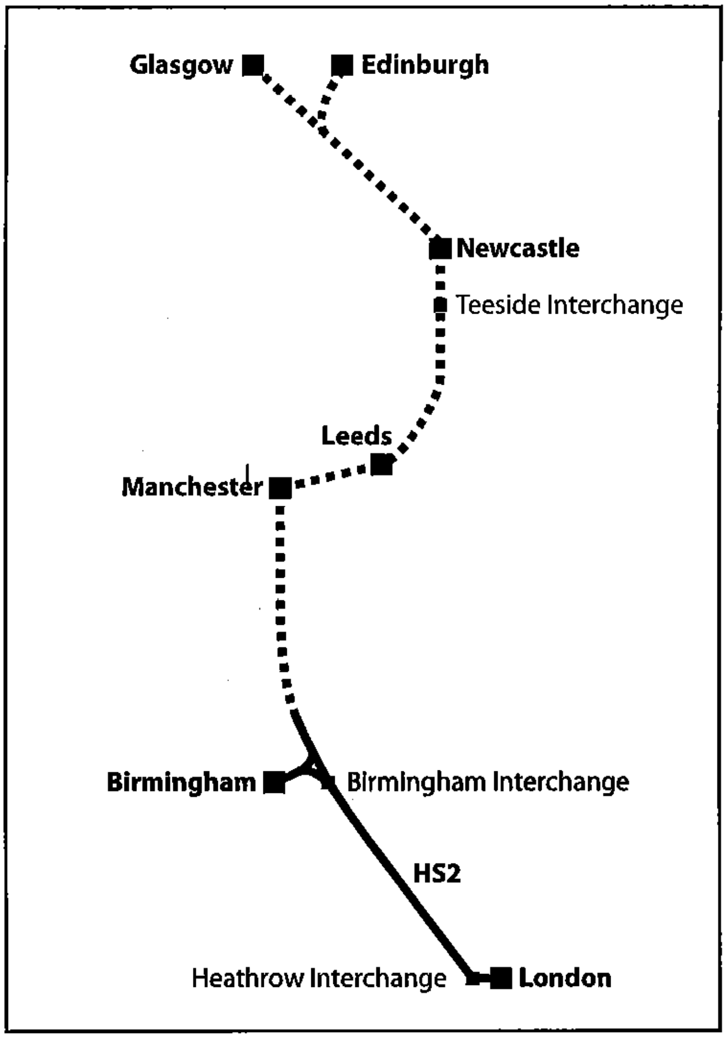


Figure 6.1d Possible configuration – Reverse S

6.1.13 Similar network configurations have also formed the subject of investigation in the past. The network provides connections to all the major conurbations detailed in the remit, using a linear route which would minimise the total amount of construction. Under this scenario, all trains north of Manchester would need to cross the Pennines. This would increase journey times between London and Leeds, Newcastle and Scotland, compared to the alternative configurations.

6.1.14 In Scotland a number different permutations exist for serving Edinburgh and/or Glasgow. In each of the configurations, we assume separate legs serving Edinburgh and Glasgow and have not modelled the benefits of a link between the cities.

A 'Reverse E' Configuration

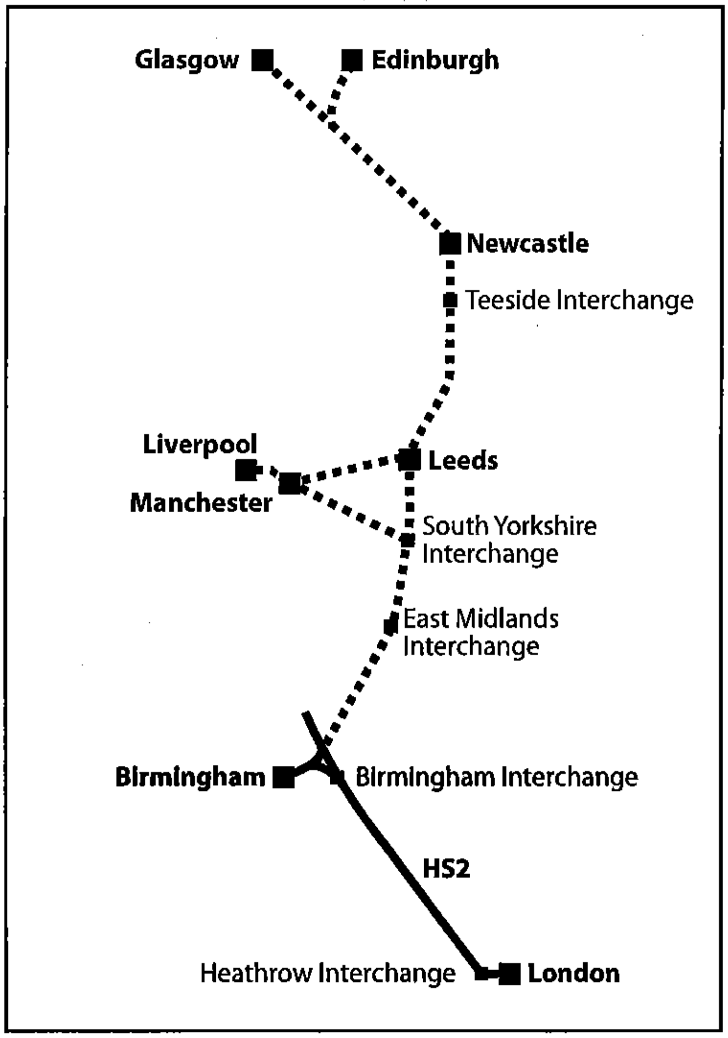


Figure 6.1e Possible configuration – Reverse E

6.1.15 The Reverse E configuration builds upon HS2 to the east of the Pennines. Unlike the Inverse A and Reverse S configurations, this network does not extend from the northern limit of HS2, which would remain connected to the WCML.

6.1.16 Because HS2 extends beyond Birmingham, the best journey times to Manchester and Liverpool under this scenario could remain those achieved with classic-compatible HS2 trains, running on the WCML. The purpose of the high speed connections to Manchester and Liverpool in that instance could be to enhance regional links across the Pennines, but we have not modelled this. Such a line could also be used to achieve better high speed journey times to the North West but only with a more central alignment of HS2 (towards Leicester rather than Birmingham). However, this would rule out a Heathrow connection, entail longer journey times to Birmingham, and compare poorly with journey times to the North West in the Inverse A. With a more central alignment of HS2, the 'Reverse E' would become more akin to the proposal put forward by the 2M group of London Councils (known as 'High Speed North'). As our remit was to consider the development of HS2 beyond the West Midlands, we have not investigated the 2M proposals in detail.

6.1.17 The following sections of this chapter describe our approach to modelling the different network configurations, assumptions on service patterns and journey times, costs, environmental approach, appraisal of demand and the strategic business case. The key conclusions that emerge are:

- There is a good case for going on to develop high speed lines beyond the West Midlands.
- The Inverse A network performs best; it provides the highest levels of demand and benefits, because of its wide coverage, and the fact that it delivers better journey times.
- The Reverse E does not serve the North West well, delivering journey times no better than those which would be delivered by HS2.
- Journey times north beyond Manchester with the Reverse S are significantly slower than with the Inverse A or Reverse E.
- We therefore recommend that the longer term network has branches from the West Midlands to both sides of the Pennines.
- In the first case these branches should be developed from the HS2 trunk. This would not preclude provision of a second leg into London at a later date if further demand justifies what would be a substantial additional cost.
- We have been able to design HS2 in such a way that options for the future remain open. However, the choices made in the next stage will be more dependent on the Government's long term network aspirations.

Scheme modelling

Definition of networks

6.1.18 Sitting beneath the schematic diagrams above is a series of routes sketched within broad corridors. We believe these are credible routes, but they have not been engineered, nor have they yet been through any substantial process of optioneering. In order to avoid the risk of blighting wide areas with what remain unrefined options, we have not included the mapped routes within the report.

6.1.19 Following the approach taken in the West Midlands with HS2, we have generally assumed spur access into major city centres (for example at Manchester and Leeds), with junctions on the principal route permitting connections both north and south. Importantly this would allow high speed benefits to be shared by those making journeys between major cities outside London. The alternative would be either to run through (or most likely under) city centres – a policy likely to encounter the same difficulties as we identified in Birmingham – or to build city centre spurs which provide only southbound access to the principal route for London trains, which would create a London-centric network. Subsequent phases of planning and investigation would offer the opportunity to fully assess the merits of these options at particular locations, and this should rightly be done on a case-by-case basis.

6.1.20 Our work to develop proposals for HS2 has pointed to a strong case for an additional West Midlands station to the south east of Birmingham. We believe that similar stations are likely to be worth investigating on the outskirts of several of the major cities included in the networks above. Such stations can broaden the overall market for high speed rail, reduce city centre congestion and provide connectivity with services which would otherwise bypass the city en route to a different principal destination. For example, an interchange station south of Manchester could connect with the airport and motorway network and provide a Manchester connection for Scotland-bound services. We have not typically incorporated these stations in our demand modelling, to avoid prejudging their existence and locations – which, as with the Birmingham Interchange, would need to be subject to more specific analysis, as a part of the route optioneering process. The exception is in West Yorkshire, where we modelled an interchange station to the east of Leeds in the Inverse A and Reverse E, and to the west of Leeds in the Reverse S configurations.

6.1.21 We have also assumed a number of interchange 'through' stations in locations where a number of towns and cities fall within a potential catchment area (for example in the East Midlands, South Yorkshire, West Yorkshire, Teesside), and where there may not be scope for a city centre spur. The demand modelling uses existing station proxies for these to reflect an assumption that any such stations would be built with good connections to the surrounding transport infrastructure.

6.1.22 All three of the networks are based primarily on the construction of entirely new high speed lines (although we have modelled Liverpool as a classic line connection to the North West high speed line). In Chapter 2 we explained that the basic model for high speed rail should generally strive for totally segregated new lines. This allows the highest service frequency of up to 400m long 'captive' high speed trains to operate at the highest speed, thereby unlocking the full capacity potential of the new line. It would also allow the full reliability benefits of segregation to be realised.

6.1.23 However, we do not entirely rule out that in certain locations, even in the very long term, there may be a case for running into urban centres on the classic line using classic-compatible high speed trains, or indeed for running such trains on the classic line for longer sections of route. Certainly, this would bring cost savings and might reduce the environmental impact of any new line. Alternatively, some sections of the existing network could be rebuilt to full GC gauge and to a higher line speed, connecting with the new high speed lines (following the German model of "Neubaustrecke" and "Ausbaustrecke" – newly built lines and rebuilt lines).

6.1.24 Initially we have only tested networks with one trunk into London (i.e. HS2). Work on HS2 has demonstrated the difficulty and expense of constructing a terminal in London. We believe we may have found the only plausible station site in central London without very large-scale demolition and potentially prohibitive cost. Therefore we have decided to model solely one-trunk networks at this stage. If and when experience of actual demand growth suggests that capacity on HS2 could become significantly overcrowded, further investigation of a second trunk would be needed.

Specification

6.1.25 We anticipated that the technical specification of further lines beyond the West Midlands would follow that developed for HS2, which are discussed in Chapter 2 and described in more detail in the HS2 Technical Appendix. Some of these bear particular relevance and are worth restating here:

- **Capacity.** As the single trunk over which all London trains would run, the capacity of HS2 determines the capacity of the network. Over the longer term, we assumed an hourly line capacity of 18 train paths. This relies on the realisation of certain anticipated improvements in train control and braking systems, to allow shorter headways. This is in contrast to the Day One operation of HS2, which would be limited in capacity to 14 paths per hour in peak periods only, with up to 10 paths in use at other times.
- **Line speed.** We assumed future lines, as with HS2, would be built to a maximum line speed of 400kph, so as to be able to exploit further expected advances in train technology. However, we have adopted the same assumed operational line speeds as HS2 for the purposes of journey time calculations – i.e. a timetabled maximum speed of 330kph.
- **Interoperability.** We assumed full compliance with the EU's Technical Specifications for Interoperability, including such specific parameters as full GC Gauge throughout the network, 400m platforms at all stations and minimum track curvature.
- **Rolling stock.** Under conditions of a fully segregated longer term network all trains could, ultimately, be off-the-shelf 'captive' high speed trains – of the type we envisage running between London and Birmingham on Day One. These could run in either 200m or 400m formation, according to demand. In practice, if a national network were built incrementally, there would continue to be a 'hybrid' role for the classic-compatible fleet (which, if purchased for use on a Day One HS2 lines, would continue to be operational long into the future).

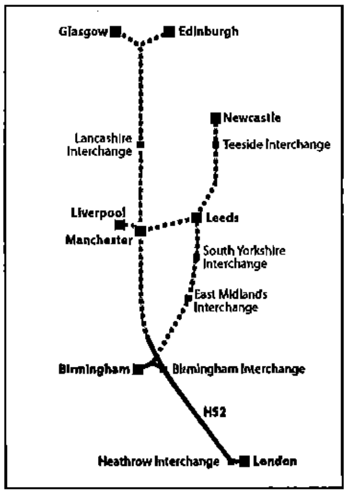
Journey time and service pattern assumptions

6.1.26 We calculated journey times for routes on the three networks for modelling purposes, and based these on assumed speed profiles and route distances. These are generally conservative estimates. The benefits from journey time savings can be very substantial but we have avoided the temptation to 'assume the best'. In reality, initial optimum journey times will typically be restricted by a number of factors, such as tunnelling prompted by specific environmental mitigation, line speed restrictions to reduce noise impacts on the local population and by constrained speeds on urban route sections.

6.1.27 Certain headline journey times are indicated below for each of the networks. In order to model the three networks we have also devised a notional service pattern for each. These are not optimised but rather reflect an indicative service within the overall capacity of the line. They have not been subjected to the same level of scrutiny as those developed for HS2.

6.1.28 The journey times given below are for the single fastest modelled journey time between two destinations. In some cases these include intermediate stops, and as a result do not necessarily represent the fastest possible journey time that could be achieved. In designing service patterns there will always be a delicate balance to be struck between on the one hand stopping trains to widen accessibilty and improve connections, and on the other reducing the number of stops to achieve better journey times. We do not purport to have found the optimal balance in this exercise. The notional service patterns also assume that, of the services to any destination in any given hour, not all would achieve these fastest times. For instance, every one in three trains may also stop en route at an interchange station, lengthening the journey time to a degree.

Inverse A



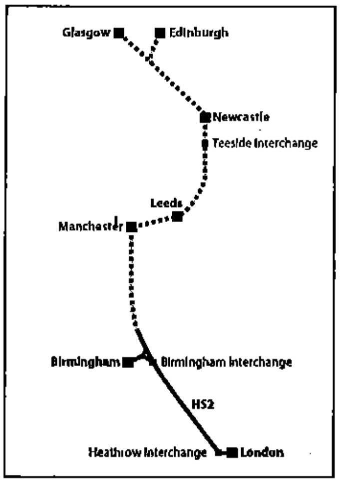
London to:	
Birmingham	0:49
Manchester	1:20
Liverpool	1:36
Glasgow	2:40
Edinburgh	2:40
Newcastle	2:00
Teesside	1:40
Leeds	1:20
South Yorkshire	1:13
East Midlands	0:53

Key Cross Country services:	
Birmingham to Manchester	0:40
Birmingham to Leeds	1:05
Birmingham to Newcastle	1:50
Manchester to Glasgow/Edin	1:45
Manchester to Leeds	0:23
Liverpool to Manchester	0:25

Modelled service pattern:

Modelled service patterns are based on 3 trains per hour (tph) between London and Birmingham, Leeds Manchester and Newcastle, with other destinations mostly receiving a 2tph service.

Reverse S



London to:

Birmingham	0:49
Manchester	1:20
Liverpool	1:50*
Glasgow	3:17
Edinburgh	3:17
Newcastle**	2:07
Teesside	1:54
Leeds	1:35

*Liverpool would continue to receive the Day One HS2 service.

**Journey times to destinations north of Leeds cannot be easily compared with those in the Inverse A due to stopping pattern differences.

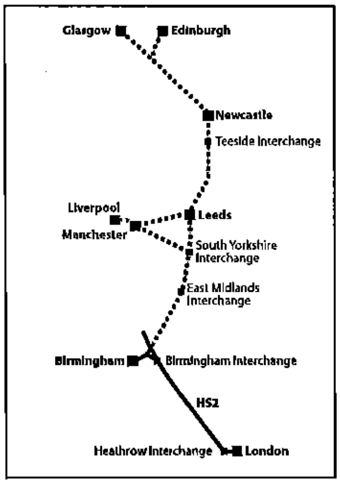
Key Cross Country services:

Birmingham to Manchester	0:40
Birmingham to Leeds	1:07
Birmingham to Newcastle	1:50
Manchester to Edinburgh	2:48
Manchester to Leeds	0:23

Modelled service pattern:

Modelled service patterns are based on 3 trains per hour (tph) between London and Birmingham, Leeds with other destinations mostly receiving a 2tph service.

Reverse E



London to:

Birmingham	0:49
Manchester	1:40*
Liverpool	1:50*
Glasgow	3:10
Edinburgh	3:10
Newcastle	2:00
Teesside	1:40
Leeds	1:20
South Yorkshire	1:13
East Midlands	0:53

*Under this scenario, the Day One journey times to Manchester and Liverpool would not be bettered by running via the East Midlands, and so we have assumed the Day One service via HS2 and WCML would continue

Key Cross Country services:

Birmingham to Leeds	1:05
Birmingham to Newcastle	1:35
South Yorkshire to Leeds	0:20
Manchester to Leeds	0:23
Liverpool to Manchester	0:25

Modelled service pattern:

Modelled service patterns are based on 3 trains per hour (tph) between London and Birmingham, Leeds and Manchester, with other destinations mostly receiving a 2tph service.

Costs

6.1.29 In order to be able to assess the relative business case for the three networks and for a longer term network as a whole we have developed some broad infrastructure cost assumptions for the various components of the network configurations. These are based on basic unit rates derived from our work on HS2, and calculated using assumptions about the composition of certain route sections. To assemble these costs we have used the following per-kilometre and station unit construction rates (expressed here without any optimism bias):

- **Flat terrain.** We have assumed a unit rate per kilometre of approximately £11m over sections of route which, at the level at we have studied them, appear to present relatively straightforward engineering challenges. As with all the unit rates, this is derived from similar sections of route on HS2, and therefore includes an allowance for road crossings etc, insofar as these feature in the sampled HS2 sections.
- **Undulating terrain.** For more difficult sections of route, where the terrain is more difficult to cross and would typically require the construction of additional structures (such as viaducts) and earthworks we have assumed a unit rate of approximately £17.5m per route kilometre.
- **Urban routes.** For urban sections of route we have adopted a unit rate of approximately £23m per route kilometre. This reflects the additional expense of laying high speed infrastructure through urban areas, where typically there are more structures crossing the route, and limited space.
- **Tunnels.** Tunnelled route sections are ascribed a unit rate of approximately £80m per route kilometre. This is based on a single bore, twin track tunnel designed for speeds of up to 320kph. Such tunnels are employed on various sections of HS2's route.
- **Stations.** We have assumed a range of rates per station, rising from £150m for a two platform station on the main line of route, to £240m for a four platform terminal station.

6.1.30 To all infrastructure capital expenditure we have added an uplift of 66% to reflect optimism bias, in line with Treasury Green Book guidance, which reflects the very early development stage of this analysis.

6.1.31 For rolling stock capital expenditure, and the unit rates for operations and maintenance we have adopted the same cost assumptions as for HS2 (which are detailed in Chapter 4), and based our calculations on the service patterns modelled.

6.1.32 The indicative costs for the components of the three configurations are illustrated in Figure 6.1f, expressed here in 2009 prices with the 66% optimism bias included. These are intended to give a broad indication of the cost magnitude and are not intended as cost forecasts of engineered routes. Two points are worth noting in particular:

- The most direct route between the North East and Scotland has been assumed with a dividing point in Lanarkshire. This has been assumed in order to provide an equal service in terms of journey times to Glasgow and Edinburgh. An alternative less direct route (avoiding more difficult terrain) may result in longer journey times but lower costs.
- The costs for the components to both Manchester and Leeds include taking the line back to the WCML and ECML respectively, so that classic-compatible services could continue to serve other destinations, such as Liverpool, Glasgow and Newcastle in the interim (as under the HS2 Day One scenario).

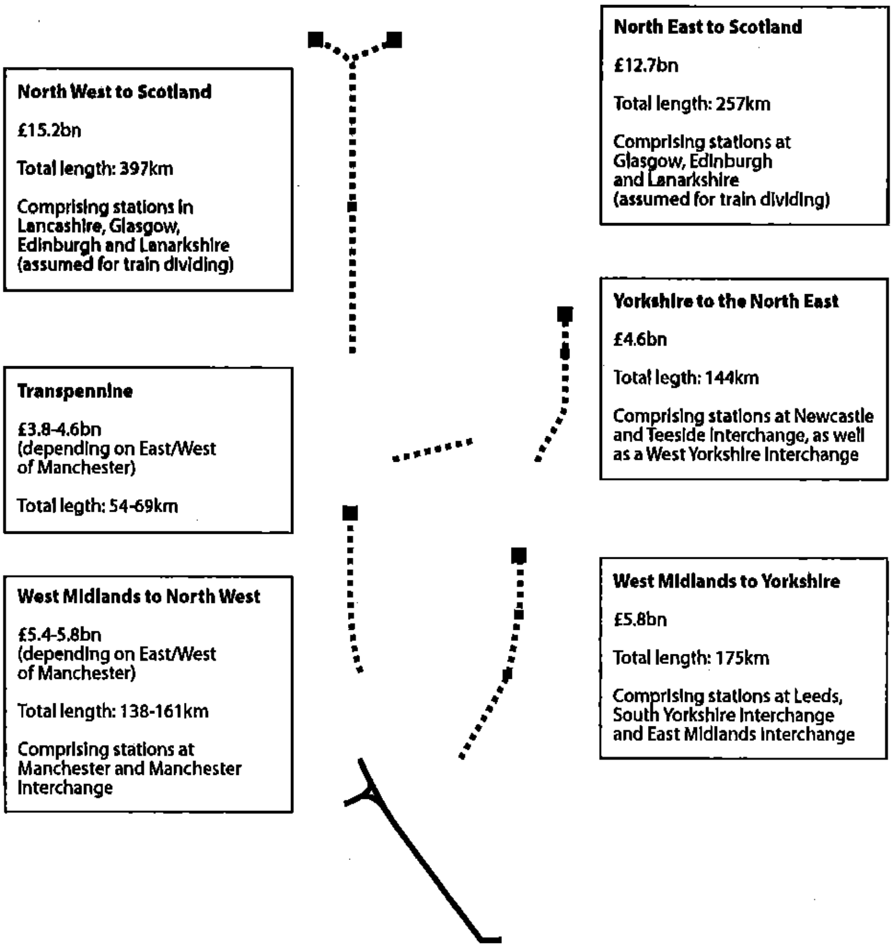


Figure 6.1f Indicative costs for component route sections (2009 prices)

6.1.33 These indicative costs have allowed us to determine overall capital cost assumptions for the three configurations that we have modelled, and these are described below, together with the operational costs. These costs include HS2. This is because the configurations have been modelled as a single entity, and so in the indicative BCR analysis which follows their total benefits must be weighed against total costs. We have not included land or project costs at this stage.

Notional costs for the three networks, including HS2 (in 2009 prices)	Inverse A	Reverse S	Reverse E
Infrastructure capital costs	£52.2bn	£44.3bn	£49bn
Rolling Stock capital costs	£9.7bn	£8.6bn	£10.3bn
Operations and Maintenance	£2bn p.a.	£1.7bn p.a.	£1.9bn p.a.

Figure 6.1g Indicative costs for the three configurations (2009 prices)

Environmental approach

6.1.34 While options remain as broad concepts, rather than specific route options, it is not possible to carry out the equivalent environmental appraisal that we have undertaken for HS2. At this stage, we have limited our investigation to potential impacts on nationally designated sites. The following points are worth particular mention here:

- We have made a number of assumptions to include tunnelled route sections in places where either urban or environmentally sensitive areas would be likely to preclude a surface alignment. Clearly these assumptions would need to be challenged as more detailed route development work progressed. The extent of tunnelling is liable to vary considerably from the estimates we have included here.
- Many more nationally designated sites affect potential routes beyond Birmingham than has been the case between London and the West Midlands. These include the National Parks of the Yorkshire Dales, Peak District, Lake District and Northumberland, and the World Heritage Site at Hadrian's Wall. The need to avoid significant impacts to such sites creates significant uncertainty. Such constraints may rule out whole corridors for high speed rail development or, perhaps more likely, force changes to the scheme which inhibit its objectives or increase its cost.

Longer term demand

6.1.35 Forecasting the future of demand for transport is a difficult task and becomes harder the further out to the horizon one projects. In the case of HS1 and the Channel Tunnel, expected patronage in the first ten years of operation was overestimated by a factor of around three. With a possible opening date for HS2 in 2025, the potential subsequent construction of a wider network of high speed lines stretches far out into the future.

6.1.36 We have modelled the three wider network options with the same cap in demand growth in 2033 as assumed for our modelling of HS2. The modelling has been carried out at a strategic level which precludes estimating detailed local effects, such as the accessibility of a new high speed station. Existing city centre stations are therefore used as proxies. We have taken a relatively conservative approach since:

- We assume no benefits from released capacity. This would require a level of detail in both train planning and modelling that is not possible in the time available. Therefore we have assumed classic rail services are unchanged.
- We have assumed 400m trains to all destinations on the network. In practice demand does not warrant this level of capacity on some routes and an optimised service pattern may be able to reduce costs without loss of benefits
- We do not include the benefits of reliability gains that we expect a dedicated high speed network might deliver.
- We have included the benefits of HS2 in all of the networks. This means that the analysis is not incremental to the HS2 business case, nor can it be compared to the HS2 business case (due to differences in assumptions). We have undertaken some limited incremental analysis for Leeds and Manchester in subsequent sections.

6.1.37 The forecast demand on all three network designs shows a considerable increase in demand for rail trips. In particular trips to and from London from all of the regions would increase substantially, reflecting the fact that regardless of the network configuration, there would be significant improvements in journey times. The exception is the East Midlands which would not be served at all by the Reverse S.

6.1.38 The most significant increase in demand is from Scotland reflecting greater scope for mode shift from air. This represents almost half of the increase in rail demand as journey times on high speed rail become competitive with the air market.

6.1.39 Unsurprisingly the inverse A provides the highest total demand, reflecting the wider coverage and faster journey times (particularly to London). The forecast increase in demand with the Inverse A is around 35% greater than the increase on the Reverse S. The Reverse E delivers the next biggest increase, since journey times to key markets around the East Midlands and Leeds are the same on both networks.

6.1.40 However it is worth noting that this network does not deliver any more benefits or demand for trips between the North West and London above those of HS2. In this case trains using the Reverse E network to access the North West would be no faster than classic-compatible trains using HS2 and the WCML.

6.1.41 The pattern of demand flows is reflected in the overall benefits accumulated by each network. Again the Inverse A provides the greatest benefits. This is both in terms of time savings (reflecting the wider accessibility to the network), as set out in Figure 6.1h, and in terms of the revenues that are generated from the large number of passengers forecast.

	Inverse A	Reverse S	Reverse E
Total Benefits £m, NPV, 2009 prices	£103bn	£73.9bn	£87.3bn

Figure 6.1h Forecast total benefits for the three configurations

6.1.42 The Reverse E also delivers strong benefits, providing comparable journey times to the East Midlands, Yorkshire and the North West. Where it differs from the Inverse A is in providing slower journey times to Scotland, and to the North West (which could continue to be served by classic-compatible trains via the WCML). This reduces the benefits by over 15% compared to the Inverse A.

6.1.43 The Reverse S delivers the lowest benefits, with slower journey times to London for all locations north of Manchester, and no direct service to the East Midlands.

Strategic Business Case

6.1.44 The pattern of journey time savings is also reflected in the economic appraisal for the three schemes. Given the caveats that follow, the indicative BCRs for the three configurations, given in Figure 6.1i should be treated primarily as relative assessments rather than absolute figures – given that with further optimisation and design optioneering, together with development of capital cost estimates, the absolute values are subject to change. The calculations which underpin these results are provided in the HS2 Demand and Appraisal Report.

	Inverse A	Reverse S	Reverse E
Indicative BCR	2.3	1.8	1.9

Figure 6.1i Indicative BCR for the three configurations

6.1.45 We have not been able in the time available to do a full incremental analysis of the various elements of a wider network, however of the three networks we have tested, the Inverse A performs the best in the indicative BCR terms, which is largely a reflection of the fact that it offers more considerable journey time savings to a larger overall market. Although both the Reverse E and Reverse S would represent a lower cost, this cost saving is less than the loss of benefits due to slower journey times.

6.1.46 The results also allow us to draw some particular conclusions:

- The strongest case is for fast, frequent journeys between the places with the greatest demand. In particular fast and direct services to London are important.
- As a consequence there appears to be a case for considering routes both to the east and west of the Pennines. In particular Leeds and Yorkshire gain significantly from direct links to London.
- The extremities of the network will require more complex analysis of the options available. It is clear that a high speed network brings significant regional benefits. However a business case for a new line is only likely to exist where the capacity is effectively utilised. This means there will be a need for more intelligent use of infrastructure, potentially including classic-compatible trains and upgraded classic lines.

6.1.47 There are a number of reasons why we would expect the absolute values to change upon the completion of further more detailed work. For example, there is likely to be some substantial variation in the costs (in either direction), once specific routes have been designed and assessed, further environmental mitigation explored and land and project costs valued and incorporated. However, we believe the indicative results given above should give confidence that there is a good case for a wider network beyond HS2. It is reasonable to expect that the business case for the networks could be substantially improved following a more detailed consideration of:

- **The effects of optimising service patterns.** The analysis above is based on sample service patterns rather than an optimised specification. Stopping patterns and frequency can have a significant effect on the business case. For example reducing the number of stops on a service increases the journey time benefits to the ultimate destination but reduces frequencies at stations en route. A similar trade-off applies in the decision of which destinations to serve at higher frequencies. In modelling terms this optimisation involves an iterative process of adapting supply to demand, in effect generating a greater ratio of benefits for every pound of operating expenditure.
- **The potential impacts of recasting the classic network.** As with HS2 in London and Birmingham, further high speed lines offer the potential to release capacity on the existing network. This is particularly the case with the Inverse A, which would release capacity on the WCML, MML and the East Coast Main Line (ECML). By removing a number of long distance services, capacity can be used to improve commuter access, which in many cities is under increasing strain, and which would be likely to offer significant benefits. These benefits are not reflected in the analysis above, which assumes the existing classic services continue to run in addition to high speed services. As well as being able to tailor the provision of services to more effectively meet commuter demand, some operational cost savings could be expected. This would provide a further enhancement to the business case.
- **Reliability impacts.** In addition to faster journeys and higher capacity, higher speed networks also offer benefits from improved reliability. The benefits estimated for a wider network above do not include this aspect. As outlined in Chapter 4, reliability accounts for about 5-10% of the total benefits generated by HS2. For a wider network, the changes to reliability could be expected to exceed this.

Incremental network components

6.1.48 Having concluded that a network configuration with branches to the east and west of the Pennines performs best, we have looked at the strategic case for incremental components of this configuration, focusing primarily at this stage on the likely next steps building on the base that HS2 provides.

6.1.49 These were analysed in a slightly different way from the three networks considered previously. Specifically they were considered as increments on the HS2 service as specified in Chapter 3. This means there were several differences, including:

- The frequencies reflected those set out in the HS2 service specification
- Reliability benefits were modelled and included in the assessment of benefits
- There was some re-use of released capacity on the WCML (although any additional benefits of released capacity over and above those delivered by HS2 were not considered)

6.1.50 This means the data presented below is not directly comparable with the three networks outlined above. However they are comparable to the results set out in Chapter 4.

HS2 to Manchester

6.1.51 In some ways the logical next step from HS2, which ends near Lichfield, would be to extend the line to the North West and Manchester, increasing journey time benefits and releasing further capacity on the WCML north of Birmingham – a valuable freight artery. An extension to Manchester could bring further journey time savings of around 20 minutes over and above the savings delivered by HS2. Classic-compatible trains rejoining the WCML in the North West could deliver additional savings of just under 15 minutes to Liverpool, Preston and Glasgow. The extension would deliver significant additional benefits at relatively low cost since HS2 would have already borne the cost of accessing London and the additional operating costs would be limited given HS2 would already be serving Manchester using classic-compatible trains.

6.1.52 Our high level assessment suggests that an extension to Manchester could deliver net benefits worth around £8.1bn on top of those delivered by HS2. The substantial majority of these are due to time savings to Manchester and Scotland. However there are also benefits from reduced crowding since higher capacity 400m-long trains could now run as far as Manchester according to demand. The longer high speed route would also provide additional reliability benefits to Manchester and beyond. This could deliver a BCR of the order of 2.2 for extending HS2 to the North West.

6.1.53 Our analysis of this incremental leg has pointed out the presence of difficult route choices in and around Manchester however, which would need to be made in light of Government's long term aspiration. For example, easier access to the city centre may be achieved from the east. This would also allow faster journey times between Manchester and Leeds across the Pennines, if the line was extended in such a way. Such a route would however close off opportunities to other parts of Lancashire and Merseyside, and from the east of Manchester a west coast line north towards Scotland may be more difficult to achieve. In order to determine the best solution a similar process to that which we have undertaken for London to the West Midlands would need to be carried out. Such an exercise would need to be informed by the eventual aspirations for a network.

Summary of formal evidence and views from stakeholders from the North West

During the course of the year we held talks with a number of stakeholders from the North West – including through the more formal Northern Stakeholders group – briefing them on our approach to the work in hand and hearing their views.

In particular we received evidence from the Greater Manchester Passenger Transport Executive (GMPTE) and Manchester Airport Group (MAG), who commissioned work during the year on the strategic economic arguments for HSR to the North West.

The GMPTE/MAG study sought to analyse the potential Wider Economic Impacts that would be generated by a high speed line to the North West, identifying benefits beyond those reflected in the standard transport project appraisal, including the positive impacts on productivity of redistributing employment and influencing its sectoral mix, and also of expanding regional employment. The study suggested that high speed rail to the North West could generate Gross Value Added (GVA) benefits in the order of £970m per annum. The study also concluded that Manchester, with the highest proportion of firms in the financial and business services sector among the major northern cities (46%), *'provides the critical economic mass that makes it the best chance for accelerated growth outside London'*. The study also noted the potential for the Manchester Hub proposals to further increase the value of a high speed connection, and the opportunity to support Manchester Airport as the UK's major international airport outside the South East including acceleration of Manchester's 'Airport City' proposals.

HS2 to Leeds via the East Midlands and South Yorkshire

6.1.54 We have also considered an extension to Leeds as an increment on the HS2 scheme design, including a connection to the East Coast Main Line. The capital costs are relatively low, despite the increased costs of stations, due to the likely easier topography along the line. This increment adds new services in addition to those specified for HS2 – and therefore imposes significant additional operational costs. Overall the present value costs of the Leeds extension are around 95% higher than the Manchester extension.

6.1.55 However, the extension to Leeds opens entirely new markets to HS2 and would offer a step change in journey times between London and cities such as Nottingham, Sheffield and Leeds. The line would also link three of the largest flows of long distance trips outside of London – linking Yorkshire and Humberside, East Midlands and West Midlands. The step change in journey times would result in a significant increase in demand, driving very significant benefits – totalling as much as £30bn in present value terms. This extension provides time savings comparable to those offered by HS2 to Birmingham, Manchester and Liverpool. The large demand response would also generate substantial revenues. This suggests a strong strategic business case, where the net additional revenues from the extension come close to covering both construction and operating costs.

Summary of formal evidence and views from Leeds and Sheffield City Regions

In September 2009 the City Regions of Leeds and Sheffield jointly published a summary analysis of the case for high speed rail to serve Yorkshire. This was based on more detailed reports commissioned by South Yorkshire PTE and Metro (the West Yorkshire PTE) after the creation of HS2L. These reports were submitted to HS2, and have been provided to Government alongside our own report.

Overall, the studies concluded that high speed rail to Yorkshire could access a population of around 4.4million and an economy with around 2 million jobs across the Leeds and Sheffield city regions. The studies estimated that, in addition to the standard transport user benefits of around £29bn (based on an updated figures from the 2003 SRA study), further productivity benefits of a link to Yorkshire would be worth between £1.3bn and £3.1bn to the Leeds and Sheffield city regions and London (in NPV over the 60 year appraisal period, calculated using the then guidance on Wider Economics Benefits).

The report also noted the potential for a high speed rail network connecting Yorkshire, North West , the North East, and East Midlands to create a stronger economic zone outside London, and recommended that the creation of a more diverse and balanced UK economy should be an objective for any new line. A central recommendation from the work was that HS2 should be designed in such a way as to permit its extension to Yorkshire to the east of the Pennines. A further recommendation was that a more easterly leg, via Cambridge or Peterborough should also be assessed as an alternative.

Summary of evidence and views from the East Midlands Development Agency

In early December 2009, the East Midlands Development Agency provided HS2 Ltd with their report *'The Case for High Speed Rail to the Three Cities'* which considered the inclusion of Derby, Leicester and Nottingham as part of a UK high speed rail network.

This report, commissioned from Arup, encourages the Government to consider high speed rail as part of a coherent development strategy of the wider rail network over the next 20-30 years. It advocates that high speed rail is a project to deliver national economic transformation, helping improve the connectivity of the main urban centres in Britain with the key economic zone of London, as well as strengthening links between city regions to create a stronger non-London economic zone. This enables the development of a more diverse and better distributed UK economy.

The wider rail strategy includes – in the short to medium term – further upgrades to the existing Midland Main line, to enable journey times between the Three Cities and London to be more comparable to equivalent distance rail trips on the East Coast Main Line, with a high speed rail route being implemented in the longer term.

The journey time and wider economic impacts of both of these changes have been estimated using current DfT transport appraisal guidance. The report suggests enhancements to the Midland Main Line could deliver productivity benefits in the range of £0.5 – £0.7bn, of which half of this value would be to the Three Cities area. Arup have also considered the range of route scenarios developed by Greengauge 21 for their high speed route to the North East from London. The estimated wider economic impacts of a station in the Three Cities area are forecast to be in the range of £0.8 - 1.04bn depending upon the location of the station and the connectivity between the Three Cities.

Transpennine link between Manchester and Leeds

6.1.56 The demand between Manchester and Leeds is likely to be one of the highest non-London flows. A high speed rail link could deliver significant time savings. However, the costs would be high, and if a high speed branch had been built directly from the West Midlands to Leeds via the East Midlands, the number of high speed trains using a transpennine link would be limited. Our analysis suggests that the business case for a full high speed line between Manchester and Leeds is much less strong, on an incremental basis, than the case for the branches from the West Midlands to Manchester and Leeds. However the business case could be improved in a number of ways and we recommend further work to investigate these, including the potential for:

- Mixed high speed and classic running – On the assumption that the capacity of the line would be underused, it may be possible to divert other trains (e.g. cross-country trains) via this short section of high speed line – providing benefits to a wider populations without affecting the reliability of the core network.

- Upgraded classic line – Given the environmental and financial costs likely to be imposed by an entirely new line between Leeds and Manchester and the fact that the line is used by a lot of people making shorter point-to-point journeys, there may be a case for increasing the speed and capacity of the existing line, as the Northern Way has suggested.

Summary of evidence and views from the Northern Way

The Northern Way – the partnership led by the three northern Regional Development Agencies – published a document called *'Transforming Our Economy and Our Connectivity: High Speed Rail for the North'*. The document draws together and builds upon evidence produced by a range of organisations, including Network Rail and Greengauge 21, and other analysis prepared on Northern Way's behalf.

The Northern Way produced 14 substantial conclusions about the need for high speed rail to the North and the shape of the network, which are summarised below:

- High speed rail should be developed as a network, built on two north-south routes, connected across the Pennines. The greatest economic benefit would be generated by bringing northern cities closer together as part of a network, with regional connectivity as well as London links.
- In order to derive the maximum economic benefit the network should access city centres.
- Links across the Pennines would drive economic growth, and may be best achieved with a mixed traffic line operating at speeds significantly higher than the existing trans-Pennine routes.
- Evidence suggests that a route to Manchester should be the first stage of a national high speed rail network.
- To prevent distorting business investment decisions, a route to the North's cities to the east of the Pennines should be developed in parallel with a route to Manchester.
- Investment strategies on the existing East Coast and Midland Main Lines, and trans-Pennine routes are required in the interim as part of an overall national rail investment strategy.

In supporting a mixed use line across the Pennines, the report drew particular attention to the importance of trans-Pennine connections in providing opportunities for businesses east of the Pennines to access Manchester Airport for extending the increasingly overlapping labour markets in the North, and also for the two-way flow of intermodal freight traffic from the North's ports to markets. The report acknowledges that this is likely to mean creating a route with operational speeds lower than the North-South high-speed lines.

Serving the North East and Scotland

6.1.57 Under the conditions modelled with the Inverse A, we see strong benefits from Scotland suggesting that high speed rail does change the nature of the market substantially. Our modelling suggests that domestic air trips between Scotland and London would fall by more than 60%. Relative flows on the model suggest that serving Scotland via the West Coast is preferable in terms of benefits due to the further reduction in journey times by 30 minutes. For Newcastle, a similar story emerges – with substantially greater benefits yielded by more direct access to London.

Summary of evidence and views from Transport Scotland

Transport Scotland, the national transport agency of the Scottish Government also published in October 2009 a strategic business case study which explored the case for the investment in a high speed line to Scotland.

Acknowledging that Edinburgh and Glasgow city centres contribute up to 30% of Scottish output and their city regions make up more than 70% of Scotland's economy, the report explains that supporting the development of these two cities is a key part of the Scottish Government's Economic Strategy. In particular the Scottish Government highlights the importance of linkages to London and the south, as '*they facilitate commerce and industry, and in particular the export of financial and business services, which together make up more than 25% of Scotland's exports to the rest of the UK*'. The report notes further that good rail links are twice as important to these industries as to other sectors in the Scottish economy.

The study reviewed the potential welfare benefits of a high speed link and noted that '*failure to bring the high speed line to Scotland will disadvantage the Scottish economy, particularly the tourist industry. A limited development of high speed lines in England will mean that cities in England unfairly benefit compared to those in Scotland, as they attract more visitors, and make Scotland appear the poor relation in the UK*'.

It concluded that only by extending the high speed line to Scotland could a step change in journey times to under 3 hours be achieved, thereby unlocking the full economic and modal shift benefits. The study includes analysis of potential welfare benefits accruing to Scotland from reduced journey times to London, estimating that a 2hr reduction in journey times would generate over £1bn in benefits. These calculations were based on existing demand between only Glasgow, Edinburgh and London, and so are likely to be underestimated, as they do not include background growth in demand or generated trips. The report also concludes that a high speed line would boost Scotland's tourist market and has the potential to reduce the number of domestic flights between Scotland and London. Using a strategic analytical framework Transport Scotland estimated that approximately 156,000 tonnes of carbon could be saved each year (leaving aside embedded carbon from construction) if high speed rail achieved a 91% modal share between London and Scotland.

Transport Scotland considered certain possible broad route alignments. The report acknowledged a preference for a line serving Glasgow and Edinburgh independently using a line which splits north of the border to provide direct access to both cities. The alternative, serving Glasgow via Edinburgh would limit the overall benefits to Scotland. Transport Scotland also stated an initial preference for a network configuration that served Scotland via the west coast, which it concluded would '*[provide] the best opportunity to realise economic welfare and environmental benefits while limiting cost*'.

The full Strategic Business Case prepared by Transport Scotland can be found within the stakeholder submissions which are published alongside this report.

6.1.58 At the extremities of the network there will inevitably be a far lower requirement for train paths, such that capacity would be substantially underused by high speed trains alone. Over such stretches of route there would be scope for maximising the line's 'yield' by interspersing non-stop high-speed services with additional slower passenger or freight services. Alternatively, it would be possible to determine a desired journey time to Edinburgh, Glasgow or Newcastle and then analyse the most cost effective physical solution. This would potentially lead to an approach which has a mix of new route sections and upgraded gauge-cleared sections, as happens in Germany and Switzerland. We have not done material work on these approaches but recommend they are considered further in due course.

Summary of evidence and views from North East stakeholders

The Association of North East Councils (ANEC) has been a strong advocate for high speed rail to the North East and submitted a paper on the potential benefits, on behalf of all the region's local authorities, which was endorsed by the North East Chamber of Commerce and the Regional Development Agency, One North East. ANEC state that the case for high speed rail to the North East starts from a fundamental view that *'a network of high speed lines must link all regions and major cities of the country, to enable all regions to realise their full economic development potential and contribute to sustainable future growth for the UK.'*

The submission from ANEC further highlighted that the North East has the fastest growth rates in the UK and states that capacity exists for the region to play a bigger role in UK growth, but efficient transport connections are vital to seize this opportunity.

ANEC suggest that a failure to connect the North East to a high speed network could weaken investment in growth sectors in which it has a competitive advantage, such as low carbon technology, regenerative medicine, design and digital technology. This would undermine the region's aspiration to raise its Gross Value Added (GVA) average to 90% of the national average, from 80% today.

As part of their submission ANEC also commented that a phased approach to the development of a high speed network will 'give an early economic advantage to those areas connected first' and it was 'critical this does not send a signal to investors which will be difficult to turn back from'. Encouraging development along a single corridor would create lop-sided economic growth in the UK.

ANEC point out that the Tyne and Wear and Tees Valley City Regions would add a population of over 2.5 million to the potential catchment area of an east coast high speed line. Together with 4.4 million in the Leeds and Sheffield City Regions, ANEC state there is a strong case for joining up large urban centres of population, and relieving capacity on the existing East Coast Main Line. ANEC conclude, following a 2008 study by Atkins, that a high speed connection to the North East is predicted to create a £3.1 billion productivity boost to the region.

During the year we also met Nexus and the Tyne and Wear Integrated Transport Authority, who also submitted evidence on the case for high speed rail to serve Tyne and Wear. This focused on the importance of end-to-end journey times between the North East and London, and thereby on the need for a network that served the North East directly, rather than with route via the West Midlands and North West. Nexus also noted the potential to enhance intra-regional links with the released capacity.

Implications of the longer term network for HS2

6.1.59 In many respects the West Midlands is the northern limit to which the first stage of a network can be designed whilst still leaving open a range of options for the shape of an eventual network. Developing proposals for access to Manchester or Leeds will inevitably trigger decisions about the long term plans to serve destinations further north. Nevertheless the design of HS2 has the ability to predetermine certain aspects of the eventual network, for example in the size of its stations, or the way in which it serves Heathrow. This section draws together and explains the most significant of these aspects in the HS2 design.

Four-tracking HS2

6.1.60 We have considered the possibility of laying four tracks along the HS2 alignment, thereby increasing its long term capacity, to 30+ train paths per hour in each direction, rather than the maximum of 18 we assume for a two track railway. However, for the following reasons we have not pursued this option:

- The level of demand we have assumed – with growth continuing to 2033 and then levelling off – does not appear to support such a substantial increase in capacity. That is not to say that the demand may not materialise at some point after the next 25-30 years. However it does suggest that HS2 would need initially to bear a substantial degree of additional cost and environmental impact on the basis that the demand may materialise. We do not believe this to be a credible position.
- Were a second trunk into London to be justified, there are compelling reasons to believe that its optimal alignment would not follow the same as that of HS2. Firstly, a more easterly leg would enable high speed rail to address a broader market, and bring with it the possibility of further improved journey times to destinations east of the Pennines. Secondly, we believe there is no plausible site for the approximately 20-platform station that would be required to serve a four track high speed railway operating at full capacity, and nor is there a surface alignment into London that could support a four-track HS2. Were HS2 to be four-tracked to a point somewhere outside London, the second pair of tracks would need to enter London entirely in tunnel and terminate at a different station (although it is worth restating here that our analysis of the possible sites in central London suggests there is no obvious location for a second high speed terminal). A further reason for preferring a second route alignment is the added resilience it would give to a national network.

6.1.61 In short, a decision to four-track HS2 would need to be made against the backdrop of considerable uncertainty about future demand, and when other potentially superior options exist should the demand materialise. For these reasons we have recommended as part of our proposals for HS2 that it remain only a two-track railway. If demand materialises, a second leg could be built from the East Midlands to London.

Other implications

6.1.62 As we have explained in section 3.6, in Birmingham we have assumed a six platform station at Fazeley Street to allow for the growth of cross country services in anticipation of a future network. In the event that Government wished not to pursue options for a longer term network this design would need to be reviewed. In London we believe that a ten platform station would be required from Day One in order to provide operational resilience. The delta junction outside Birmingham on HS2 has also been designed specifically to permit trains to leave HS2 and head east, and for cross country high speed trains to head east from Birmingham without rejoining HS2. Its design could be simplified in the event that Government chose not to pursue an eastern leg.

Summary and key recommendations

6.1.63 Given that our analysis of longer term options has been at a strategic level, we do not seek to present here definitive conclusions on the precise configuration of a wider network of high speed lines, nor on the particular ways in which regions should or should not be served. However, our analysis has allowed us to draw a number of conclusions:

- There is a good case for going on to develop high speed lines beyond the West Midlands and, of the networks we have looked at, a network with two branches either side of the Pennines performs best.
- While there appears to be a good case for continuing HS2 on to the North West and Manchester, there looks also to be a particularly strong case for a branch to Yorkshire and Leeds, via the East Midlands. Both appear to be strong candidates for more detailed work as part of the next stage of development.
- Government needs to decide its aspirations for the longer term network before plans for the next stage can be worked up in detail. We have been able to design HS2 in such a way that options for the future remain open, but this will not be the case for route sections beyond Birmingham.
- The longer term network should initially be built out from the HS2 trunk. If there is further demand in the longer term, a second leg could be provided from the East Midlands to London.

6.1.64 Bearing these conclusions in mind, we recommend that:

- Further analytical work should be carried out on the ultimate nature and scope of the network, so that Government can state its aspirations in more detail. As part of this, Government may wish in particular to commission further work to assess the value of classic line upgrades on less-intensely used sections of route.
- This would enable detailed work to be undertaken on the branches from the West Midlands to Manchester and Leeds, which we recommend are the priorities for the next stage of development of a high speed network.

Glossary

AONB	Area of Outstanding Natural Beauty
AoS	Appraisal of Sustainability
AVE	Alta Velocidad Española, the high speed train service in Spain
BAA	BAA Airports Ltd, owners and operators of six UK airports, including London Heathrow
BCR	Benefit Cost Ratio
Captive	'Captive' is used to describe rolling stock which could only be used on HS2 infrastructure (or GC-gauge stretches of the classic network)
Classic rail	The non-high speed railway
Classic-compatible	Rolling stock which can operate on both new high-speed lines and the existing classic network
Day One	A term used to describe the conditions on HS2 on the first day of operation, as distinct from HS2 as part of a wider network
DBFM	Design Build Finance Maintain
DBT	Design Build Transfer
DfT	Department for Transport
ECML	East Coast Main Line
ERTMS	European Rail Traffic Management System
EU	European Union
GC	The standard structural gauge as specified by EU legislation
GDP	Gross Domestic Product
GMPTE	Greater Manchester Passenger Transport Executive
GVA	Gross Value Added
GWML	Great Western Main Line
HS1	High-speed railway line running from London through Kent to the Channel Tunnel (formerly Channel Tunnel Rail Link (CTRL))
HS2	Proposed high speed railway line between London and the West Midlands
HS2 Ltd	High Speed Two (HS2) Limited
HSL-Z	Dutch Hogesnelheidslijn
HSR	High Speed Rail

ICC	International Convention Centre, Birmingham
ICE	Intercity-Express, a Siemens high speed train used in Germany and elsewhere
IPC	Infrastructure Planning Commission
kph	Kilometres per hour
LUL	London Underground Ltd
MML	Midland Main Line
mph	Miles per hour
MtCO2	Million tonnes of Carbon Dioxide
NEC	National Exhibition Centre, Birmingham
NLL	North London Line
NPS	National Policy Statement (introduced as part of the 2008 reform of the planning system)
NPV	Net Present Value
ORR	Office of Rail Regulation
PDFH	Passenger Demand Forecasting Handbook
Pendolino	A tilting train manufactured by Alstom, currently operating on the West Coast Main Line
PPP	Public Private Partnership
PV	Present Value
PVB	Present Value of Benefits
PVC	Present Value of Costs
QRA	Quantified Risk Analysis
RAB	Regulatory Asset Base
Reference Case	A set of assumptions about the future, against which the impact of our proposals has been compared
Reference Train	A train, the performance characteristics of which been used to model the HS2 service.
SAC	Special Area of Conservation
SBRs	Supplementary Business Rates
Structure gauge	The minimum height and width requirements along a route
SSSI	Site of Special Scientific Interest

T5	Terminal 5 of Heathrow Airport
T6	Potential Terminal 6 of Heathrow Airport
TEN-T	Trans-European Transport Network
TfL	Transport for London
TGV	High speed trains in operation in France
TOC	Train Operating Company
tph	Trains per hour
TSIs	Technical Specifications for Interoperability
VfM	Value for Money
WCML	West Coast Main Line
Webtag	Web-based Transport Appraisal Guidance, as issued by DfT

List of Supporting Documents

1. **HS2 Record of Stakeholder Engagement**
   This document outlines HS2's approach to engaging with key stakeholders throughout 2009.

2. **HS2 Technical Appendix**
   This suite of documents contains the overarching HS2 technical specification, supported by a number of other documents which provide additional detail on particular topic areas.
   - Project Specification
   - Day One Train Service Assumptions for Demand Modelling
   - International Requirements
   - Rolling Stock Strategy
   - Rolling Stock Maintenance Strategy
   - Infrastructure Maintenance Strategy

3. **Appraisal of Sustainability Report**
   This report for HS2 by Booz-Temple describes how the proposals for HS2 support objectives for sustainable development. It contains the findings of an appraisal of sustainability (AoS) that has helped to define the preferred scheme and its various options.

4. **Appraisal of Sustainability: Non Technical Summary**
   A summary of the HS2 Appraisal of Sustainability Report, prepared for HS2 by Booz-Temple.

5. **HS2 Demand and Appraisal Report**
   A report by HS2 setting out the results of analysis from the demand and forecasting model and the economic appraisal.

6. **Route Engineering Study Final Report**
   This report for HS2 by Arup presents the findings of a route engineering and alignment study for a potential new high-speed rail line from London to the West Midlands.

7. **HS2 Cost and Risk Model**
   This document describes the costs of the HS2 project, the work carried out in reaching our cost conclusions, and the approach to risk in the cost model.

8. **International case studies on delivery and financing**
   A report for HS2 by Ernst and Young on the experience of delivery and financing of international high speed rail projects.

9. **Delivery Considerations**
   A report for HS2 by Ernst and Young on the delivery considerations for HS2.

10. **Financial Considerations**
    A report for HS2 by Ernst and Young on the financial considerations for HS2, including the results of the financial modelling.

11. **HS2 Consultation Strategy**
    This document prepared by HS2 provides advice to Government on a proposed consultation strategy.

12. **Stakeholder Submissions**
    A record of the submissions provided to HS2 by stakeholders during 2009.

13. **List of Reference Documents**

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