HEATHROW

AND

HIGH SPEED RAIL

The Transportation Case
Against Airport Expansion

A study by

Colin Elliff BSc CEng MICE

Author’s Foreword

The impact of transport on the environment is huge. Aside from more local issues of noise and pollution, it is one of the principal contributors to global warming. Transport is responsible for over 25% of world CO_2 production, whether emitted from jet engine flume, from vehicle exhaust pipe, or from power station chimney (in the case of electrified railways). Further emissions come from the kilns and furnaces that create the cement and steel necessary to build the infrastructure on which the planes, lorries, cars and trains will move.

The link between global warming and the rising levels of atmospheric CO_2 is now commonly accepted. Indeed, the catastrophic consequences of global warming are taken so seriously that Government has committed to an 80% cut in emissions by 2050, in the recent Climate Change Act. What is less well understood is the equally direct historic link between CO_2 emissions, energy use and economic prosperity.

The challenge of maintaining the standards of living that we all enjoy, whilst achieving the necessary reductions in CO_2 emissions, is extreme and unprecedented. It will only be met through a radical re-examination of all aspects of the way in which we live, work – and travel.

Yet the argument for the proposed third runway and sixth terminal at Heathrow Airport is principally economic, paying little attention to environmental issues. It is based on the perceived threat posed to national prosperity by the severe congestion on the existing two runways; and expansion has been advanced as the only viable solution.

But while there is no doubt that Heathrow’s congested runways constitute a very serious aviation problem, it does not necessarily dictate the aviation solution of another runway. The smarter approach is to examine whether Heathrow’s many short-haul flights – to which the congestion can reasonably be attributed – could instead be diverted to other modes. And with around one quarter of Heathrow’s flights to destinations potentially within 4 hours of London by high speed rail, it is clear that rail could provide a viable alternative to expansion, and at a fraction of the environmental cost and energy use.

So, in the modern carbon-critical world, there seems to be no justification to fly these short-haul routes, and hence none to expand Heathrow – but an imperative instead to develop an alternative rail-based solution, with the high speed necessary to deliver equivalent journey times.

There is nothing particularly new or radical in the high speed rail solution. It’s commonly acknowledged as the best option in transport to achieve mode shift and reduce CO_2 emissions, both through superseding short-haul aviation, and through creating the extra capacity on the existing network for more local journeys and freight transport. With 15 years of successful operation, the Eurostar service from St Pancras now dominates the cross-channel travel market to Paris and Brussels. There is an even longer history of high speed operation within many western European countries, and a sophisticated cross-border network is now developing.

Almost alone among its principal European neighbours, the UK has remained aloof from the high speed revolution. The benefits are self-evident, in both reduced journey times and in capacity relief to existing congested networks; yet the line has been peddled, that British geography and demography are different, in some mysterious way unsuited to high speed rail.

There is no denying that the UK is different from say France and Spain on one hand, or Belgium and Holland on the other. But the commonalities are far greater than the differences. A high speed corridor linking London with Edinburgh and Glasgow – along which over 5% of Heathrow's flights currently operate – is of a similar length to the successful TGV route between Paris and Marseille, linking similar populations. The population densities in the Low Countries, and the resultant congestion on the rail networks, are similar to what prevails in many parts of the English rail network.

So there seems no reason why the benefits of high speed rail cannot be realised in the UK; and at last the political consensus is growing to make high speed rail happen. Many proposals have already been advanced for the development of high speed rail in the UK, by Greengauge21, Arups, and now the Government's HS2 Company.

But while these proposals are to be welcomed, they do not appear to comprise the rounded, inclusive and environmentally-friendly transport solution that the UK so urgently requires. All appear to focus on Heathrow before continuing through the Chilterns towards Birmingham and Manchester along the North-West Corridor, with little or no attention to other areas of the UK.

And with the continuing threat of expansion at Heathrow, compounded by the growing issue of climate change, the importance could not be greater, of getting the UK high speed rail solution right. My belief, based on nearly 30 years' experience in railway civil engineering and a lifelong interest in railways, is that the current thrust of high speed rail development is misdirected, offering neither viable alternatives to short-haul nor an effective, optimised intercity railway – which, after all, is the true purpose of high speed rail.

The aim of this study is to advance the alternative vision of an inter-regional intercity high speed network that can benefit all parts of the UK, and at the same time draw Heathrow into the wider solution. It builds on the excellent analysis work already undertaken by the transport planners at Greengauge21 and at Atkins, that has established the fundamental economic case for high speed rail. But in addition it seeks to impose the discipline of railway engineering, to develop an enhanced UK rail network that addresses contemporary, rather than 19th century needs – and one capable of achieving sufficient mode shift from higher-emitting aviation and road transport to produce an overall *decrease* in transport emissions.

This study documents as never before the wide range of benefits that a properly-oriented high speed network could bring to UK transport. This is not to say that the High Speed North scheme and associated Heathrow Compass Point network proposed herein comprise the perfect, fully-finished transportation solution. The same applies to this study; all should be considered 'works in progress', requiring further input to fully develop the solution for UK strategic surface transport, integrated with international connections. But I believe that collectively they raise the bar, setting new standards for what can be achieved with sensible, joined-up transport proposals.

By laying bare the detailed thinking behind these proposals I am opening them up to scrutiny and challenge – as integrated solutions addressing transport, environmental and economic needs. This is the same rigorous examination that should be applied to all the competing solutions, both for high speed rail and for airport expansion.

It is vital, both for the future of UK transport and of the wider environment, that we find the right solution.

Colin Elliff BSc CEng MICE

Acknowledgements

I would like to acknowledge the valuable assistance of my father George Elliff MSc CEng MICE MCILT, in the compilation and editing and of this document. Heathrow and high speed rail both comprise vast topics, and it was essential to keep me to the factual and the relevant!! The best efforts of all contributors have been devoted to eliminating all errors and typos; but the responsibility for any errors that remain is mine.

I would like to express my gratitude to various members of staff and councillors of the 2M Group (of London & SE councils opposed to Heathrow expansion) who have offered immense encouragement and assistance in the development and documentation of a transport scheme of national significance, that of necessity goes far beyond the immediate local concerns surrounding Heathrow.

The 2M Group has consistently supported the principle of high speed rail as an alternative to expansion of aviation, at Heathrow and elsewhere. However, owing to the local sensitivities that will inevitably emerge along the potential route of a new railway nearly 1000km long, it is important to emphasise that the detailed proposals documented in Sections 7 and 9 of this study are mine; they should not in any way be construed as policy of the 2M Group of councils.

My thanks go also to my wife and children for their continuing support and patience during the many evenings that I have spent, huddled over my laptop. They hope, as I do, that the results will be worthwhile.

Colin Elliff

This document should be considered as a ‘work in progress’, requiring further development in many aspects. To this end, comments and potential contributions are welcome. These may be incorporated in further editions after discussion between the authors; appropriate acknowledgement will of course be given.

Please send any comments to colin.elliff@tiscali.co.uk.

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Glossary of Terms

2M Group	Grouping of London & SE councils opposed to Heathrow expansion.
BAA	British Airports Authority, operator of Heathrow, Gatwick, Aberdeen, Edinburgh and Glasgow airports (*inter alia*) – now operating as BAA Airports Ltd.
BCR	Benefit-to-cost ratio
DfT	Department for Transport (HM Government)
ECML	East Coast Main Line
ETS	Emissions Trading System
Eurogauge	Term to describe wider and taller carriages and wagons permitted to run on European network, but not in UK. Also referred to as Bern Gauge.
Greengauge21	Pressure group dedicated to establishment of high speed rail in the UK.
GWML	Great Western Main Line
HS1	High Speed 1 : High speed line from St Pancras International to Channel Tunnel, previously known as Channel Tunnel Rail Link.
HS2	High Speed 2 : Proposition by Greengauge21 for north-west aligned high speed line from London to Birmingham and WCML.
HS2 Company	Organisation established by DfT to investigate and report upon options for high speed line development in the UK. ***Not to be confused with Greengauge21's HS2 Proposition.***
HS3	High Speed 3 : Proposal by Greengauge21 for high speed line/corridor aligned to east side of Pennines
HSL	High speed line (generic term)
HSN	High Speed North
LHR	London Heathrow Airport
LUL	London Underground Ltd
MML	Midland Main Line
OOC	Old Oak Common
Paris CDG	Paris Charles de Gaulle airport
SRA	Strategic Rail Authority : now defunct Government Agency (in existence 2001-2006) tasked with strategic development of UK railways.
TP	Transpennine
tph	trains per hour
TSI	Technical Specifications for Interoperability : common railway technical standards applicable across EU.
WCML	West Coast Main Line
W10	Rail vehicle profile defined by standard maritime 9'6" container on standard flatbed container wagon.
XC	CrossCountry
750V DC	Electrification system in use on Network Rail Southern network, with 750 volts direct current delivered to train via track level conductor rail, also referred to as the 'third rail'.
25kV AC	Electrification system in wider use on Network Rail main line network, with 25 kilovolts alternating current delivered to train via overhead wires.

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Executive Summary

Heathrow Airport has long posed a massive challenge for UK transport, economic and environmental policy. It is the UK's premier international gateway, and its continued efficient functioning is vital to the national economy. However, rising passenger volumes in line with increasing globalisation are putting the existing two-runway operation under such strain that expansion, to a third runway and sixth terminal, has now been deemed essential by Government.

Although the massive local environmental impacts have generated intense controversy, relatively little attention has been paid to the associated transport issues. There seems to be an acceptance, in Government and elsewhere, that Heathrow is an aviation problem for which there can only be an aviation solution.

This study is centred upon the core proposition, that the pressure for expansion at Heathrow can be attributed to the congestion caused by short-haul flights. These flights – comprising around 25% of the total number – are to destinations potentially within four hours of London by high speed rail (the commonly accepted criterion for air/rail crossover). Conversion of these flights to rail would relieve the pressure for expansion and reap all the benefits of a cleaner, greener and more sustainable form of transport.

Three major initiatives are required, to realise these gains:

- Development of a UK high speed intercity rail system, to bring the key Scottish destinations of Edinburgh, Glasgow and Aberdeen within the four-hour horizon.
- Efficient links from the UK main line rail network (high speed and conventional) to facilitate rail 'spokes' to the airline hub at Heathrow.
- Ongoing improvements and integration of the European high speed rail system.

The study examines Heathrow's role in the national transport system, and highlights in particular its poor links to the national rail network and its lack of connections by air to most regional centres. This leaves the UK's one hub airport effectively disconnected from most of the regions it purports to serve.

There are already many proposals, to improve rail links to Heathrow and to develop high speed rail northwards from London. The author has also advanced his own proposals, namely 'High Speed North', an optimised UK intercity high speed network connected to an enhanced local 'Compass Point' network centred upon Heathrow. This study closely examines all of these schemes, both for their efficacy as transport proposals, and specifically for their ability to provide a viable alternative to an expanded Heathrow. All proposals are considered against a rigorous specification of transport, environmental and economic requirements, and outline costs and timings are identified.

The general conclusion is that current schemes seem highly disjointed and (in the case of high speed) excessively skewed towards Heathrow. This hugely compromises the ultimate UK high speed solution, offering poor value in both financial and environmental terms. By contrast, the more balanced High Speed North proposal provides a far superior intercity network and a more effective alternative to short haul flights. Equally important, it can be achieved for significantly lower financial and environmental cost.

This study sets out a vision for a better transport future for the UK in which genuine environmental and economic gains can be realised through the holistic integrated planning and implementation of an optimised surface transport system. It requires not one solution, but two – a radical improvement of rail access to Heathrow, linked with (but independent of) development of a comprehensive high speed rail network. These solutions will benefit the entire UK, and make a significant and highly positive contribution to the fight against climate change.

1. Introduction

The recent announcement of Government support for Heathrow expansion might at first sight seem like business as usual in the development of national infrastructure. The need to ensure future UK prosperity, through the expansion (and assumed decongestion) of its principal international gateway, has been balanced against the undisputed environmental impacts and intense local opposition, with the final decision weighted in favour of the perceived economic benefits.

In principle, this is no different from other major decisions, to construct motorways, reservoirs and power stations etc. But in its scale, its impact and its timing, the proposed expansion of Heathrow is different. There is an unprecedented Government commitment to an 80% cut in CO_2 emissions by 2050[1], together with much other posturing on 'green' issues; against this, official determination to press ahead with expansion seems illogical. It is clear that the issue of Heathrow expansion has become a touchstone for the Government's true resolve to tackle critical environmental issues.

This document does not seek to comment extensively on the local environmental or economic issues. Its main focus rests with the transport issues that lie at the heart of the Heathrow debate.

1.1 Basic Assumptions

Three fundamental precepts are assumed:

1. ***Congestion is bad for business***. This was always a self-evident truth, but much weight has been given to this statement by the recent Eddington Transport Study[2].
2. ***Transport is such a major contributor to CO_2 emissions, and therefore to climate change, that national policy must be directed towards satisfying any particular transport need at the lowest environmental cost***. This is the principle of 'environmental best practice' that must govern all future transport developments, whether to tackle congestion or to address any other issue. The aim for any major project should be to achieve net reductions in emissions.
3. ***The basic economic case for high speed rail is already well established***. Reports such as the Strategic Rail Authority's *High Speed Line Study*[3], and subsequent updates by Atkins[4] have demonstrated benefit-to-cost ratios of greater than 2.0 for the development of high speed rail in the UK, and there is no need to revisit this work. This study will therefore concentrate on more practical issues of how Heathrow can be effectively tied into wider UK high speed rail development, and how the high speed rail solution for the UK can be optimised, in accordance with principles of environmental best practice.

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1.2 The High Speed Rail Alternative to Airport Expansion

It can readily be appreciated that there are two ways to address airport congestion. The first, and most obvious, is simply to add terminal and runway capacity, as the proponents of airport expansion would advocate. But greater capacity means more flights, and inevitably more CO_2 emissions and associated pollution; and unless radically improved surface access is put in place, it also leads to more local congestion. These are the unavoidable consequences if the current proposals for Heathrow expansion are ever to go ahead.

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[1] 2008 Climate Change Act : Bibliography Item 16.
[2] Bibliography Item 5.
[3] Bibliography Item 3.
[4] Bibliography Item 13.

But the other approach is to reduce the congestion by eliminating the flights for which a practicable alternative exists, or can feasibly be developed. The fundamental need is for travel and communication, and this can be met in more than one way. While long haul flights offer the only practicable means of communication between continents, short-haul routes of up to 4 hours' journey time (between city centres) by rail can offer an attractive alternative.

This is exemplified by the success of Eurostar services on High Speed One, where over 70% of the London-Paris market has been captured by rail, at a fraction of the emissions of aviation. Similar success has been achieved on the London-Brussels corridor. Rail should equally be able to compete on other corridors eg London-Amsterdam and London-Edinburgh/Glasgow. With high speed rail offering maximum speeds of over 300kph, the 4 hour horizon to which rail can be competitive with aviation extends to around 1000km from London, to beyond Hanover, Frankfurt and Lyon.

On this basis, around 25% of Heathrow's departure list – to mainland UK and to near Europe – is potentially convertible to rail. This potential will be realised with the development of a UK high speed rail network, and with continuing growth and integration of the various European high speed systems.

At first sight, a reduction in flights of around one quarter – simplistically offering almost a 33% potential for expansion back to the current operating levels – would deliver the same capacity increase that Heathrow's third runway might provide. This would seem to avoid any requirement for expansion. But for Heathrow, the further issue of its hub status must also be considered.

1.3 Main Line Rail Access to Heathrow Essential

Heathrow's wide range of long-haul flights to intercontinental destinations draws in significant passenger flows from satellite airports, both in mainland UK and near Europe. High speed rail between city centres cannot accommodate these flows unless the question of airport access is also addressed.

This is a principle commonly accepted by all contemporary high speed rail schemes. But while most schemes are specifically oriented to include Heathrow as an integral part of the routeing of the high speed line, the High Speed North scheme detailed in this study takes a different approach.

Instead of creating a high speed hub at or near Heathrow, the High Speed North scheme seeks to achieve radical improvements in local rail access to the airport. This can be accomplished through development of the existing Heathrow Express system into a 'Compass Point' network. This has the merit of providing comprehensive local links and connections to the main line network at outer-suburban hubs.

With such a network in place, it is no longer necessary to route the high speed line via Heathrow. Instead, it becomes possible to develop High Speed North into the Midlands and North of the UK along the optimum M1 corridor. This offers huge advantages in terms of efficient network development, favourable topography, and minimised controversy through following existing transportation alignments.

The result is by far the most cost-effective and comprehensive railway solution with the greatest environmental gains. This all stems from a basic recognition that development of UK high speed rail and improvements to surface access at Heathrow are separate, albeit linked issues. To fully appreciate this crucial distinction, it is necessary to gain a comprehensive understanding of the transportation issues that surround Heathrow.

2. Heathrow – the Case for Expansion??

Heathrow is the UK's biggest and busiest airport. It is the principal focus for long-haul flights from the UK to intercontinental / non-EU destinations; additionally, it acts as a hub, allowing interchange for passengers on short-haul flights from satellite airports both in the UK and in near Europe. The international communications that Heathrow provides are thus vital not only to the economy of London and the South-East, but also to the entire UK.

As international travel develops in line with continuing globalisation of the world economy, and rising population, there is a constant clamour from airlines for further landing slots; but with Heathrow already operating at its full capacity, there is little flexibility either to accommodate this demand, or to cope with the congestion that accompanies even the slightest disruption.

There is a concern that the continuing suppressed demand and ongoing congestion at the country's principal international gateway is damaging to the national economy. Multinational businesses might opt to relocate elsewhere, and international airlines might choose to locate their hub operations at less congested airports such as Paris Charles de Gaulle or Amsterdam Schiphol, which are already larger than Heathrow's two runways, and have the potential to expand further. These are the issues that have led to the current proposals, to enlarge Heathrow with a third runway and a sixth terminal.

Although the scale of the threat posed to the UK's future prosperity is a matter for debate, there is no doubt that there are serious economic issues at stake, or that there is a major transportation problem which urgently needs to be resolved.

2.1 Current Expansion Plans

The Government's solution to the problem is to increase airport capacity by the construction of a third runway to the north of the current airport site, with associated sixth terminal.

The third runway, and associated terminal facilities, will require the demolition of the entire village of Sipson, and major parts of the adjoining Harmondsworth. In all, around 700 homes will be lost, requiring the forced relocation of over 2000 people. Flightpath disturbance and intrusion, potentially affecting millions of Londoners, will be extended to many areas of the capital previously unaffected by the close overflying of aeroplanes

But before airport expansion goes ahead, it is necessary to rigorously examine whether this will actually be the best means of addressing the problems at Heathrow. The first step in such an examination is to consider the development of Heathrow since its opening in the post-war era, and the 'vital statistics' of current operations.

2.2 Heathrow – a Brief History

Heathrow Airport opened in 1947 as London's (and by default the UK's) principal international airport. It was based around a wartime airfield constructed on a relatively unoccupied area of the historic Hounslow Heath, clear of suburban development and public transport routes. From its inception it has comprised two runways in east-west orientation. Terminals 1, 2 and 3 were progressively developed in a central bloc around the control tower at the centre of the airport, a convenient mode of operation that persisted until the 1980's, when Terminal 4 was opened on the southern perimeter. In 2008, Terminal 5 was added; this is located at the west end of the airport, in a preferable position between the runways.

The extra capacity afforded by the opening of Terminal 5 allows much-needed redevelopment of the central terminal area; Terminals 1, 2 and 3 will be progressively transformed into 'Heathrow East'. However, while terminal capacity has been increased in line with the general expansion of aviation over the past decades, no similar increase in runway capacity has so far been achieved.

This has left Heathrow, with only two runways, as the apparent poor relation of other European international airports such as Paris CDG (4 runways), Amsterdam Schiphol (5) and Frankfurt (3). The essential problem is one of location. Unlike its continental competitors, Heathrow is hemmed in by suburban development, and this has restricted options for development of new runways, and has imposed limitations on operating times (flights are booked to depart from 06h00 to 22h30) and runway operation.

2.3 Surface Access to Heathrow

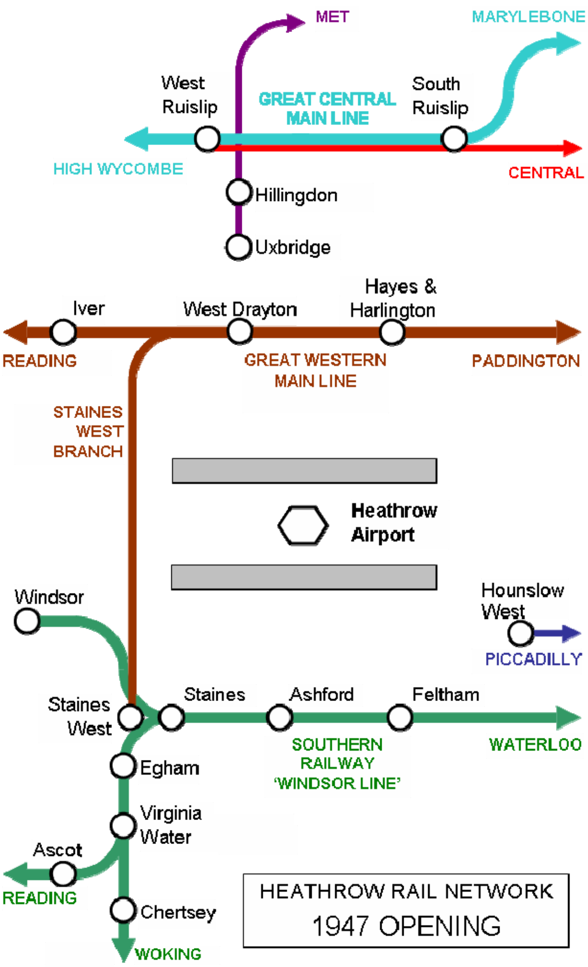

Figure 2.1

The pressures on runway capacity have been long discussed, and are central to current expansion plans. Much less attention has however been paid to deficiencies in surface access, an issue of almost equal importance. Provision of efficient surface access has consistently lagged behind development of the airport.

For its first 30 years of operation, there was only road access to Heathrow. The extension of the Piccadilly Line from Hounslow West in 1977 brought significant improvements, but the airport still lacked meaningful links to the main line rail network.

The opening of Heathrow Express in 1997 did little to improve the situation. The new line, like the Piccadilly, was oriented towards central London; without intermediate stops in west London, it only provided a main line connection at Paddington (the least centrally-located of all London termini).

Limited further improvements have been achieved through the recent introduction of the Heathrow Connect service, stopping at intermediate stations en route to Paddington. An appreciation of Heathrow's current rail connectivity can be gained from Figures 2.2 and 2.3

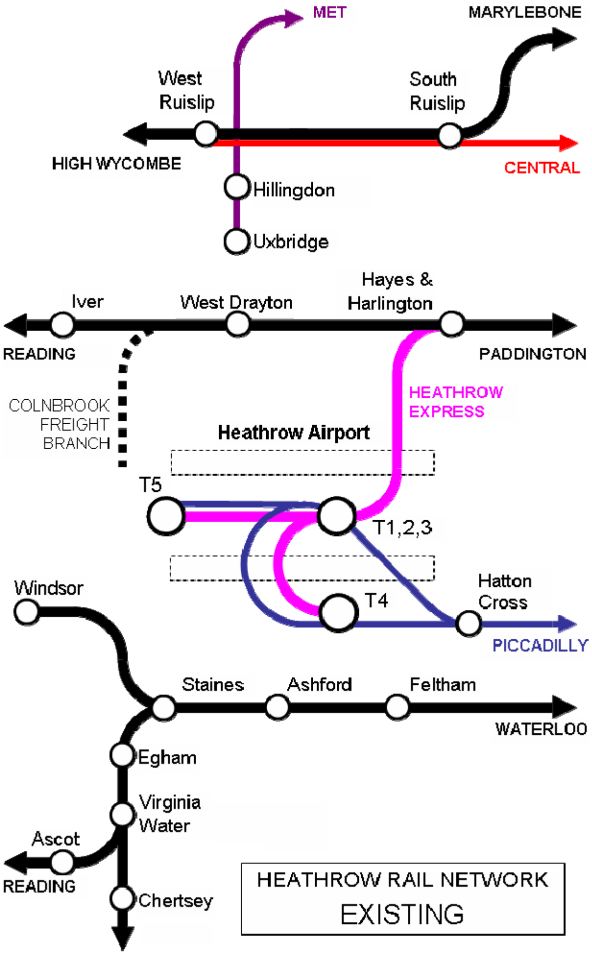

Figure 2.2

Figure 2.2 (to left) illustrates a lack of rail connections either to Feltham and Staines in the south, or to Uxbridge and Ruislip in the north. It is significant to note that the connection to Hayes & Harlington and other Great Western Main Line (GWML) stations has only been very recently introduced through the Heathrow Connect service, a full 10 years after the initial opening of Heathrow Express.

Figure 2.3 (to right) attempts to capture the quality of Heathrow's links to the wider strategic rail network. A minimum hourly main line service with a single change to frequent local trains directly accessing the airport terminals is taken as the quantum of good connectivity. Coloured lines indicate that the Great Western network, as far as Plymouth and Swansea, meets this standard; but this is only achieved through a circuitous connection to Heathrow Express at Paddington. The remainder of the network (indicated in grey) is effectively disconnected.

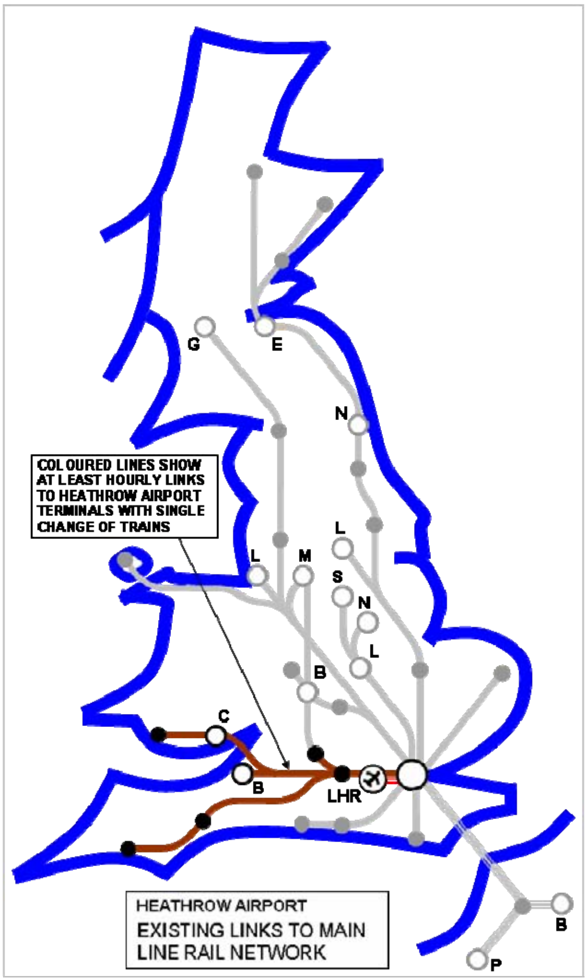

Figure 2.3

2.4 Heathrow – Surface Access Statistics

It is clearly desirable that surface access to the nation's principal international gateway is radically improved, with direct rail links to the adjoining local networks. The potential passenger flows on such new links can be assessed from the following 'vital statistics' pertaining to the current intense operations at Heathrow Airport:

- An aircraft lands at (and takes off from) Heathrow every 90 seconds.
- Over the 16+ hour duration of its daily operation, this amounts to over 650 planes taking off, and over 650 landing.
- Nearly 100,000 people depart or arrive per day (ie a total flow of 200,000).
- Around 30,000 comprise transit passengers, transferring to another flight.
- The balance (ie 70,000) therefore comprises the basic surface access flow.
- These numbers are swelled by families and friends.
- Around 68,000 people work at Heathrow, contributing a daily commuting flow additional to passenger flows.

Collectively, this amounts to a massive surface access issue, with well over 100,000 people arriving and a similar number departing each day. BAA's figures[5] indicate that an annual total of around 15M arriving airport passengers (or around 42,000 per day, 60% of the total) are either bound for central London, or pass through it en route to further-flung destinations. On a simple reading of the statistics, this would leave a daily flow of 28,000 (or 40%) leaving on other axes ie south, west and north.

However, it is reasonable to assume that many of the passengers travelling via central London only do so for want of a more direct alternative; hence the demand for non-London-centric journeys is considerably suppressed. A truer figure may be around 35,000 (or 50%). Some journeys will be made by either local bus or long-distance coach, or by taxi; but currently, the majority of these non-London journeys are made by private car. It is no coincidence that the section of the M25 adjacent to Heathrow is the busiest (~200,000 vehicles per day), and is always the first to require further widening.

The 68,000 airport workers must also be considered. These will tend to generate more localised and symmetrical flows. Up to 50,000 might be headed along south, west and north axes. Allowing for perhaps half of the workforce to be working on a given day, and 60% then to be travelling to/from central airport locations, 15,000 might still be added to the passenger flows. This would give a total of around 50,000 travellers per day leaving Heathrow in directions not served by either Heathrow Express or the Piccadilly Line. Considered over a 16 hour period, this would amount to a passenger flow of around 3000 per hour – or around 1000 per hour to south, west or north. This is easily sufficient to justify the provision of frequent rail services on all these 'Compass Point' axes. The potential for further rail traffic, arising from links along these 'Compass Point' axes between communities to north and south of the airport, should also be considered. This issue is discussed in greater detail in Item 6.5.

The above comprises an extremely simplistic traffic analysis. But the magnitude of potential rail passenger flows from Heathrow can be easily demonstrated by the intense road traffic flows emanating from Heathrow onto the M25 and M4 (with the proposed third runway, vehicle flows are predicted to rise[6] to at least 125,000 and 100,000 per day, respectively). No railway, aligned either to the west along the M4 corridor, or north-south following the M25, exists to capture these flows, an obvious omission in the coverage of the national railway network.

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[5] Bibliography Item 4.
[6] Bibliography Item 10.

3. Heathrow – Proposed Diversion of Short-Haul Fights to Rail

The transportation case against Heathrow expansion is centred upon the notion that the airport can function better, and serve the national economy better, with fewer planes taking off and landing. The principal means by which this improvement can be achieved are through the diversion of short-haul flights to high speed rail, and through the improvement of surface access to the airport. These two aspects comprise the primary focus of this study.

However, since the critical consideration determining runway capacity is the number of flights, rather than the number of passengers, it is also worth examining alternative strategies to achieve more efficient use of limited runway space. A variety of strategies is suggested in Item 3.4, for which further studies should be undertaken.

3.1 4-hour Air-Rail Crossover

The commonly-accepted criterion for determining the convertibility of a short-haul flight is whether the equivalent rail journey between city centre termini can be accomplished within four hours. In approximate terms, the relative journey times break down as follows:

Rail & Air journey times in hours		
Journey element	*Rail*	*Air*
Extra journey time city to airport	–	0.5
Check in, customs & security	0.5	1.0
Journey time (air includes taxiing)	**4.0**	2.0
Baggage reclaim & customs	–	0.5
Extra journey time airport to city	–	0.5
Total	4.5	4.5

Table 3.1 : Air/rail crossover for intercity journeys

It is important to recognise that the four-hour horizon is not a hard and fast line at which there will be a step change between air and rail dominating. Nor does it take account of frequency or journey experience, both normally superior with high speed rail. It is more accurately characterised as a generalised crossover point at which a significantly greater proportion of travellers will choose to travel by rail, rather than to fly.

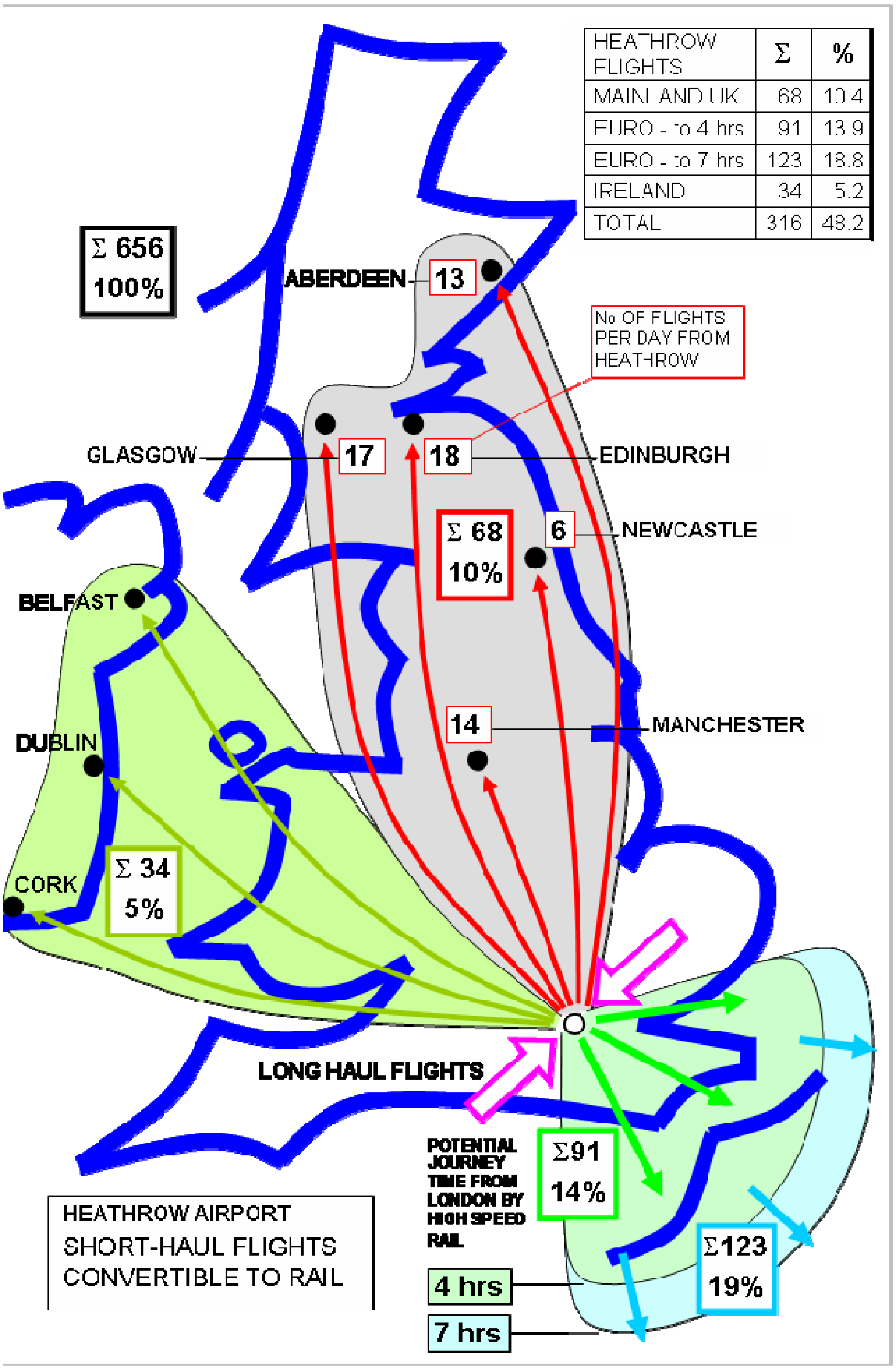
On this 'business as usual' model, airlines will continue flying to prime destinations well within the four-hour time contour eg Manchester and Paris. But in a world increasingly concerned at the environmental impact of flying, four hours could also represent the point at which Government policy begins to strongly favour the more environmentally-friendly rail alternative, albeit with higher speeds to compete with the more damaging aviation alternative. Increasingly however, it will be travellers themselves who make this choice. In such a world, it is possible to imagine rail travel becoming an acceptable and attractive alternative for seven-hour journeys.

It must be stressed that either in Europe or in the UK, high speed rail developments are primarily required to address surface transport issues of congestion, improved connectivity and environmental improvement through mode shift (largely from road transport) onto decongested existing rail networks. They are far more than simple alternatives to aviation, and the benefits that they will bring through conversion of short-haul flights can be considered a desirable bonus.

3.2 Heathrow Departure List Analysis

A full review has been undertaken of Heathrow's departure list, to determine the number of flights potentially convertible to rail. Figures 3.2 & 3.3 indicate Heathrow's local network of short-haul flights by both destination and volume; for purposes of comparison, time contours are added, to show current rail journey times from central London. Heathrow's full departure list is presented in Appendix A.

Within mainland UK, the key destinations with 12 or more daily services (indicative of service gaps generally no greater than two hours) are Manchester (14), Edinburgh (18), Glasgow (17) and Aberdeen (13). In Europe, the key destinations are Paris (18), Brussels (14), Amsterdam (20), Frankfurt (17), Munich (15), Madrid (13) and Milan (19).



HEATHROW FLIGHTS	Σ	%
MAINLAND UK	68	10.4
EURO - to 4 hrs	91	13.9
EURO - to 7 hrs	123	18.8
IRELAND	34	5.2
TOTAL	316	48.2

Figure 3.2

It is readily apparent that the railway network in its present form is not capable of converting sufficient of Heathrow's flights to rail. All the major Scottish destinations (ie Glasgow, Edinburgh and Aberdeen, accounting for 48 daily flights) fall outside the critical four-hour time contour, and in Europe, the effective network does not spread beyond Paris and Brussels. On this basis, only 49 of Heathrow's flights are convertible to rail. This figure represents no more than 7.5% of the total number of flights, and is clearly insufficient to justify the required fundamental change in airport development plans.

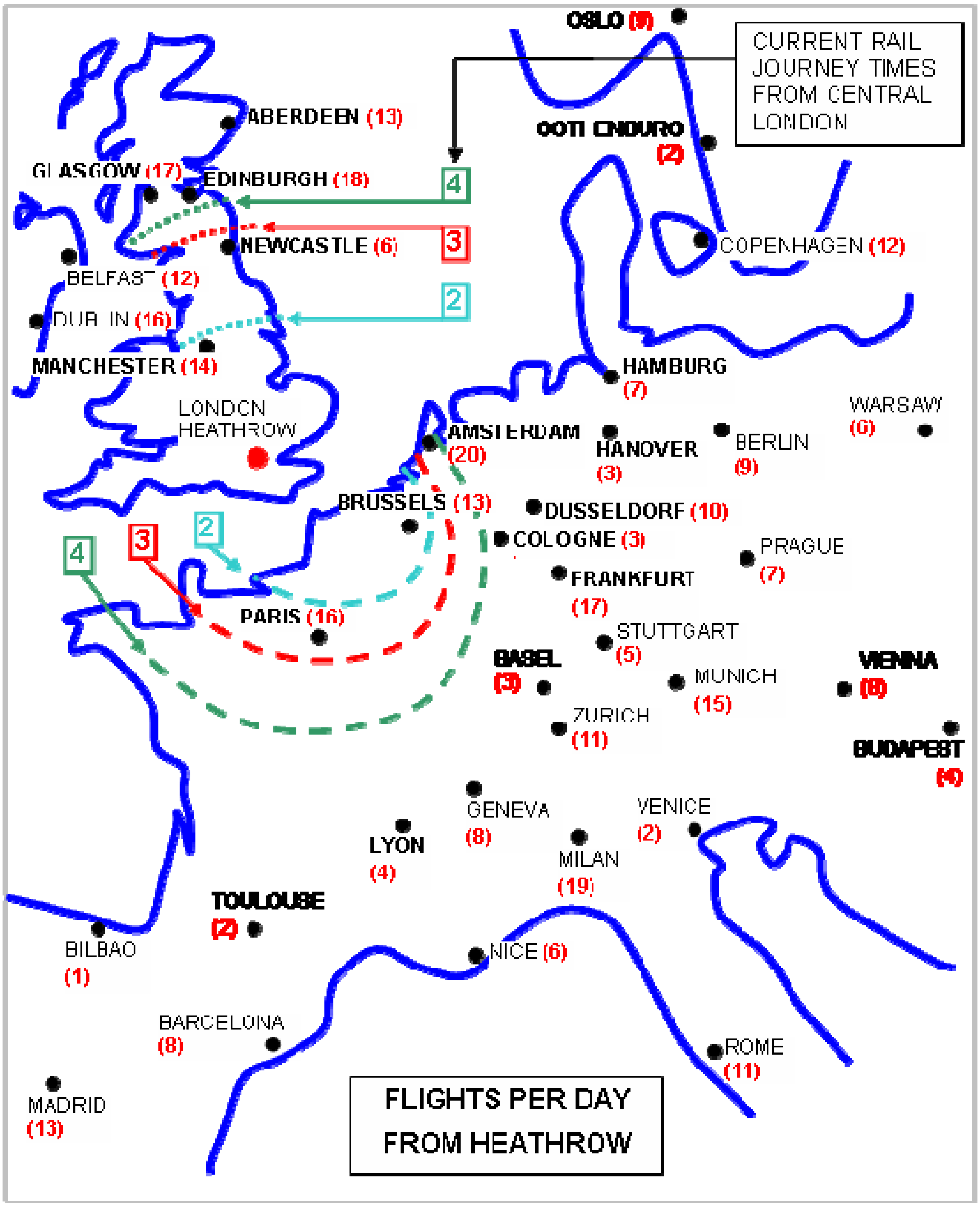


Figure 3.3

3.3 Elimination of Short-Haul Flights through High Speed Rail

But the situation will be transformed with ongoing development and integration of the European high speed networks, and with the projected construction of high speed lines within the UK. The effect of developed high speed rail links on the critical four-hour time contour is illustrated in Figure 3.4, together with a likely configuration of direct hourly (or better) links extending into Europe beyond Paris and Brussels.

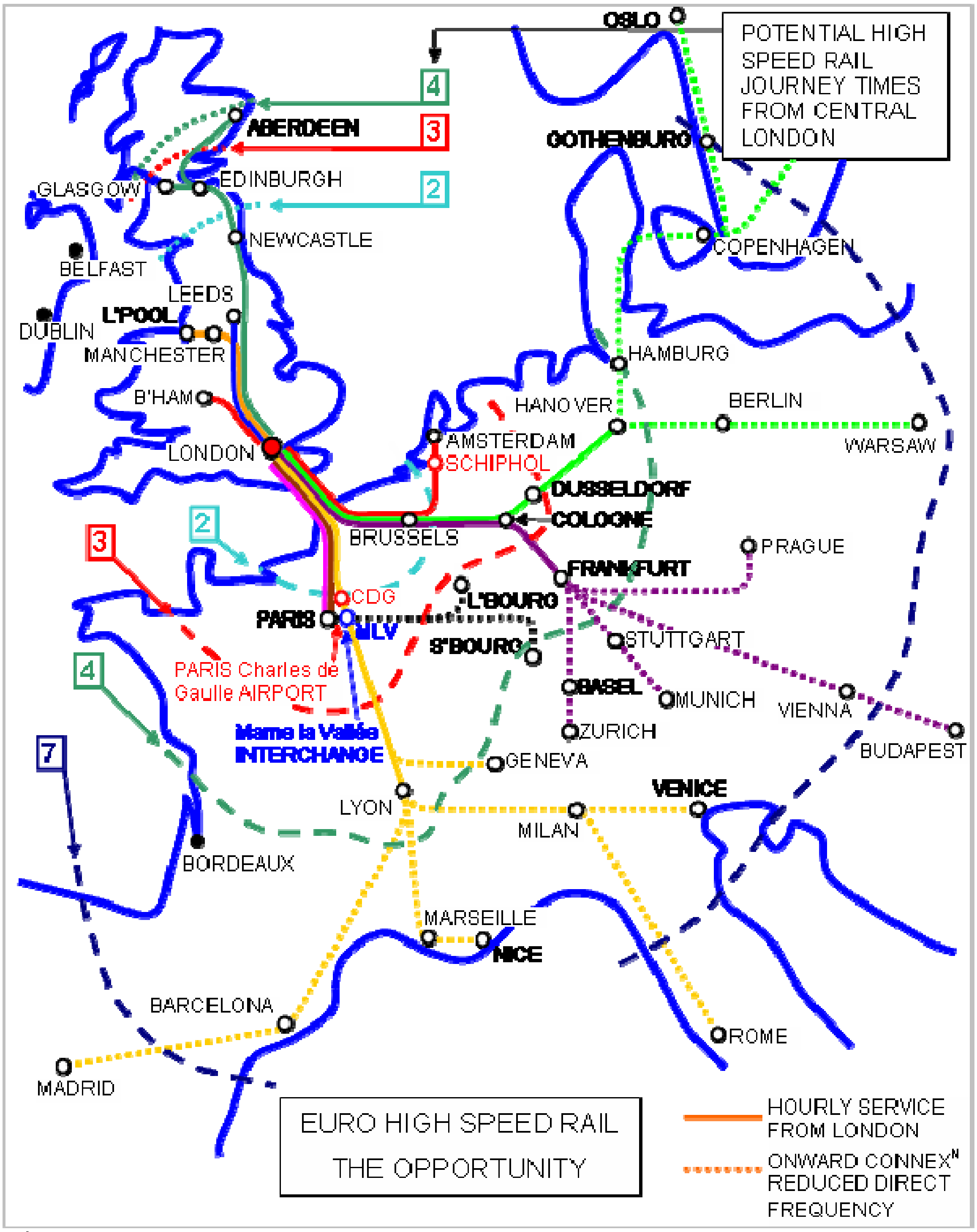


Figure 3.4

All principal cities (and Heathrow destinations) on mainland UK would now be within four hours of central London. In Europe, the four-hour time contour would extend to Hamburg, Frankfurt and Lyon, easily encompassing cities such as Amsterdam, Cologne and Dusseldorf. This now increases the number of potentially convertible flights to 159, representing almost a quarter of Heathrow's total departures.

With these flights eliminated (and equivalent rail connections put in place), Heathrow would be transformed. The two runways, currently operating at 99% capacity, would now be running at around 75%. This would appear to represent a massive gain, immediately addressing current congestion issues, and bring major benefits in increased operational resilience and capacity. These are close to the 'benefits' adduced to the current expansion plans at Heathrow, but achieved at a fraction of the environmental cost.

The question will inevitably arise, of how the increased capacity might be used. There is a clear risk that for every short-haul flight diverted to rail, a new long-haul flight will be allowed to land at Heathrow. If taken to extremes, this would maintain congestion at current levels, and, through larger planes flying longer distances, greatly increase global CO_2 emissions. It would seem preferable that the major part of the capacity gain is used to assure robust and resilient operation at Heathrow, with the ability (currently lacking) to recover from delays. However, it is for BAA and the Government to determine how the extra capacity should be best used, with due regard to efficient operation and to local and global environmental issues.

3.4 Further Rationalisation of Heathrow Operations?

As the debate around issues of airport expansion and rail alternatives progresses, the criticism is certain to arise that a potential 25% reduction in flight numbers, achieved through diversion of short-haul to high speed rail, will not be sufficient – and that the third runway and sixth terminal are still required to meet projected increases in aviation volumes.

Although these projections appear to address neither the CO_2 reduction requirements of the 2008 Climate Change Act nor growing 'Peak Oil' concerns (discussed further in Section 4), it is important still to focus on Heathrow expansion primarily as a transport issue, with the ultimate goal of assuring efficient movement of people at acceptable local environmental impact.

The 25% figure is the proportion of Heathrow's flights which should not need to exist, on account of high speed rail's potential to offer at least an equivalent journey opportunity at lower environmental cost. This is the fundamental rationale of this study – sufficient diversion of short-haul flights to rail to eliminate any requirement to expand. However, a 25% reduction should not be regarded as an end in itself, but as the starting point from which further efficiencies could be gained.

Several salient facts have emerged during the research that has been undertaken in the compilation of this study:

- With approximately 100,000 passengers departing Heathrow each day on 656 flights, passenger numbers average at around 150 per plane.
- This approximates to the capacity of the Boeing 737 or Airbus A320 series, used for short-haul flights; however, Heathrow's longer-haul flights are operated by larger jets, either Boeing 767/777s (circa 300 capacity) or Boeing 747s (circa 450 capacity). This indicates an average seating capacity in the region of 300.

- Study of the Heathrow departure list reveals frequent examples of competing airlines flying to the same destination (or airport 'pairs' such as Newark / New York or Linate / Malpensa airports at Milan) departing within minutes of each other.
- If the Gatwick departure list is considered against that of Heathrow, similar duplication is evident.

There would appear to be considerable opportunity to rationalise Heathrow's flight list, by eliminating wasteful competition, by the use of fewer (but possibly larger) airliners and by integration of Heathrow's operations with other London airports, particularly Gatwick.

In recent years, Government has shied away from imposing such restrictions, preferring instead to allow the mechanisms of free enterprise to regulate the market. But the level of environmental threat posed by airport expansion – either in the forced displacement of local communities or in its profligate contribution to global warming – is such that conventional free market considerations no longer apply. If 'business as usual' travel is to continue, it must be under the strictest conditions of environmental best practice.

3.5 Further Conversion of Flights to 7-hour Time Contour?

Figure 3.4 also illustrates a seven-hour time contour, extending to cities such as Copenhagen, Berlin, Warsaw, Prague, Milan and Barcelona. These journeys would inevitably be slower than the equivalent flight, and conversion could not currently be justified on any business model. However, taking the environmental 'long view' of ever more stringent restrictions on CO_2 emissions and/or increasing oil prices as world reserves are exhausted, it may become necessary for rail to take over these air routes. Before such a radical change takes effect, however, through trains running from the UK to distant European destinations should begin to establish the rail market on these routes for a slower but more pleasant journey experience.

Flights to all destinations within the seven-hour time contour represent 43% of Heathrow's departure list. This figure would rise to 48% if flights to Irish destinations were also considered. But with no credible proposals yet put forward for surface links either over or under the Irish Sea, Heathrow's flights to Belfast, Dublin, Cork and Shannon are not included in any plans to eliminate short-haul aviation.

3.6 Heathrow – Hub and Spoke Operation

Much of the business case for Heathrow, in either its present or projected expanded form, centres around its function as an aviation hub. Around 30% of arriving passengers – around 11.5M annually – are transferring to other flights. The essential rationale for these inevitably time-consuming transfers is a lack of direct airline routes between originating point and destination. This is an increasing phenomenon as airlines tend to favour the 'hub and spoke' model, by which long haul services are concentrated at a single hub, and 'spoke' services are run as feeders from satellite airports.

Within the UK, around 40% of passengers – around 1.5M annually – on domestic flights to Heathrow are changing to longer haul routes. On European short-haul routes, a lesser but still considerable percentage will comprise transfer passengers. It is essential that the needs of these connecting passengers are not ignored when developing alternative railway solutions.

3.6.1 Connection of Hub Airport to High Speed Line

The concept of 'interlining', by which airlines have substituted scheduled short-haul services in favour of high speed rail, is already established, most notably on the Paris-Brussels corridor. The rail alternative will be attractive if it can match the journey time and frequency of aviation. Thus one essential prerequisite, which should be factored into any solution, is that the hub airport must have easy access to the high speed line. It is instructive to re-examine the air versus rail model for surface connections to long-haul flights.

Rail & Air journey times in hours		
Journey element	*Rail*	*Air*
Extra journey time airport to HSL	0.5	–
Check in, customs & security	0.5	1.5*
Journey time (air includes taxiing)	**3.0**	1.5
Baggage reclaim & customs	–	0.5
Extra journey time airport to city	–	0.5
Total	4.0	4.0

Table 3.5 : Air/rail crossover for airline transfers

Now that the journey elements under consideration are starting at the airport, rather than in a city centre, the relative isolation of the airport works against rail. This puts the air to rail crossover point at around three hours' journey time by rail. This still gives rail a clear advantage on key UK connections to Manchester, Edinburgh and Glasgow, and also to Paris, Brussels and Amsterdam. For cities closer to the four-hour time contour, such as Aberdeen and Frankfurt, a small time disadvantage might seem to apply.

3.6.2 Efficient Flight-to-Flight Connections??

Crucial to the comparison is the time that it takes to make the air-to-air transfer (shown asterisked). This is attributable in part to the mechanics of security and baggage transfer, and to a 'safety margin' for late incoming flights (note that with short-haul European flights typically operated by 737-sized jets of around 150 seats working at 80% load factor, there is relatively little spare capacity on subsequent services to accommodate late-running travellers, when compared with a Eurostar train with 750 seats working at 60% load factor).

The other key factor is service frequency. While rail can typically work at hourly or better frequencies, serving several destinations en route eg London-Brussels-Cologne-Frankfurt-Stuttgart-Munich (shown as an hourly service on Figure 3.4, albeit less frequent beyond Frankfurt without a change of trains), short-haul aviation only serves single destinations. Given the limited capacity available at hub airports, this inevitably impacts on service frequency and regularity.

Even on the key Heathrow-Frankfurt route, with 17 flights per day, there are still gaps of up to two hours. This makes the advantages of an aviation connection over rail at best marginal. On all other less frequent routes (eg Heathrow - Cologne with three daily flights, and gaps of over four hours), there is no doubt that an hourly rail-based connection would easily outperform aviation.

3.6.3 Feeder Flows to Neighbouring Hub Airports

A secondary function of short-haul flights from Heathrow must also be considered – that of feeder flows to other hub airports. As evidenced by the departure board of any provincial airport, the prime continental hubs for onward long-haul flights are Paris CDG and Amsterdam Schiphol. Here, the developing European high speed network (as depicted in Figure 3.4) delivers priceless advantages.

Schiphol is located on the new high speed line from Brussels to Rotterdam and Amsterdam, and would be served by direct London-Amsterdam trains, presumed to run at hourly intervals. Paris CDG is located on the high speed *peripherique* around Paris, which is the natural conduit for international services from the UK to southern France and thence to Switzerland, Italy or Spain. So connections to these airports could be integrated without difficulty into the UK's wider high speed network.

3.7 Railway 'Spoke' Connections to UK Hinterland??

With Heathrow acting as the key international gateway to the entire UK, it is vital for future economic prosperity that all areas of the country are efficiently linked to this gateway. This was a major recommendation of the recent Eddington Transport Study[7]. The required connections might be effected by air, but the preference must be surface links, and by public rather than private transport.

As has already been noted, however, Heathrow's surface connectivity is poor, with effective rail links only to central London. On other axes, public transport only comprises low-quality bus and coach routes, and with the motorway network focussed upon Heathrow, the private car has come to dominate instead.

Putting environmental concerns aside for a moment, aviation might provide a solution. However, even the briefest review of Heathrow's domestic network, depicted on Figure 3.6, shows that this is not the case. There are no flights to any airport within 300km, none at all to Wales, and within England only two northern airports (Manchester and Newcastle) are served.

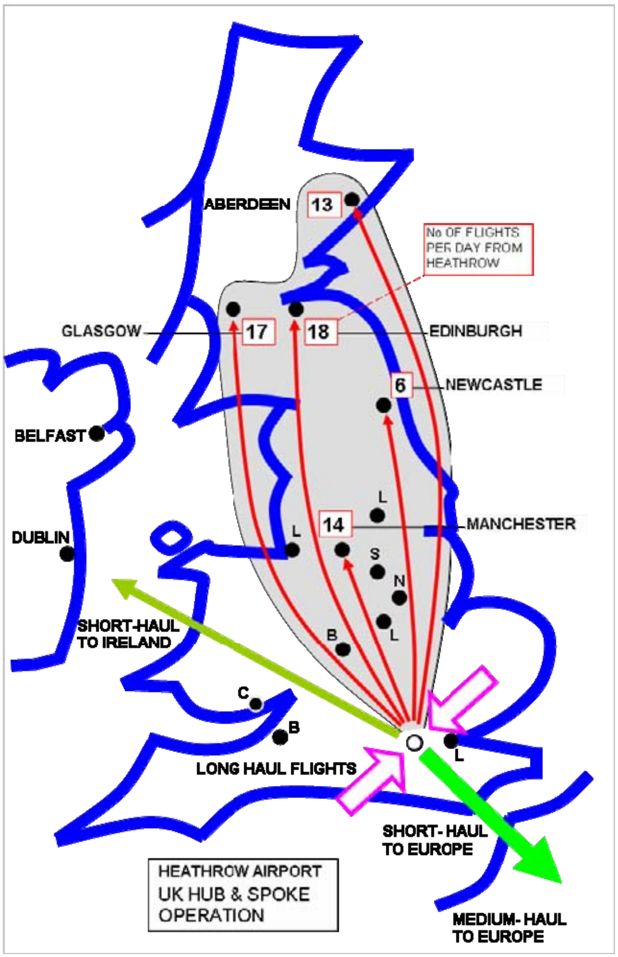


Figure 3.6

[7] Bibliography Item 5.

It should be noted that earlier in 2009, Leeds/Bradford and Durham Tees Valley airports both lost their services to Heathrow. This was due, at least in part, to the infrequent services on offer (five daily to Leeds/Bradford, three daily to Durham Tees Valley) and the consequential long connection times at Heathrow.

A similar problem would seem to exist for Newcastle; even with six daily flights and a greater distance from London (over 400km), there are service gaps of over four hours and hence difficult onward connections.

There is a question of 'critical mass', the frequency that is required to maintain a viable intercity or satellite feeder service, matching the expectations of travellers. Only Manchester and the Scottish airports (particularly Edinburgh and Glasgow, at over 600km from London) have what might in intercity railway terms be described as frequent services; other major UK cities have proved unable to sustain domestic services to Heathrow, and this in the future may also apply to Newcastle.

If Heathrow were to expand in line with current plans (a 26% increase from 48M air movements per annum to 60.5M), a certain proportion of this increased capacity would be devoted to domestic flights. *Economic Impacts of Hub Airports*[8] indicates a figure of 20%, around 34 flights per day. With these extra flights distributed both to existing mainland UK destinations and to new (or restored) destinations – perhaps 10 in total – it is evident that most internal services would still have less than 10 flights per day, with the likelihood of gaps of more than two hours between flights.

Considered as a whole, it is evident that most of the UK regions have extremely poor links by air to Heathrow, and that the problem of Heathrow's isolation from its immediate English and Welsh hinterland seems certain to persist even with the projected expansion. As has already been noted (Item 2.3), Heathrow's surface access alternative is also wholly inadequate, with very poor connections to the national rail network.

This lack of international connections must impact greatly upon the UK's future economic performance in a global economy, and upon the required regional regeneration after a recession. There seems no prospect of an expanded Heathrow delivering the wide-ranging and radical improvements that are (and have always been) necessary. A comprehensive surface access strategy must instead be put in place.

[8] Bibliography Item 21

4. Heathrow Expansion – the Environmental Context[9]

There is a clear tension in Government policy, between support for aviation expansion (of which Heathrow is currently the prime example) and wider aims for reductions in CO_2 emissions. The 2003 Aviation White Paper[10] envisages a near trebling of UK air passenger numbers between 2002 and 2030, and major infrastructure developments to support this rise – including the proposed expansion at Heathrow. The 2008 Climate Change Act[11] sets out a requirement for an 80% cut in CO_2 by 2050, as well as lesser intermediate targets. It is likely that these targets, or similar, will be enshrined in international environmental treaties.

The radical targets for CO_2 reduction stem from the growing realisation that the rise in global temperatures caused by unrestrained consumption of fossil fuels (the principal cause of human-generated CO_2) must be restrained. But it is only this use of fossil fuels that has brought about today's high standards of living, of which aviation is one particularly high-consuming aspect.

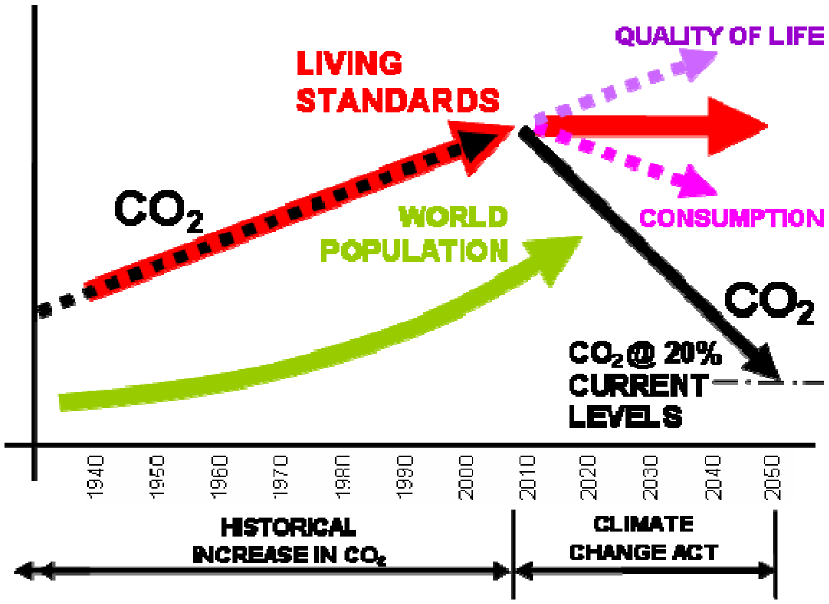


Figure 4.1 : Implications of 2008 Climate Change Act

The difficulty of reducing CO_2 emissions to 20% of their present levels cannot be underestimated. This will go to the heart of all aspects of modern life and threaten contemporary standards of living, which until now have risen hand-in-hand with increasing emissions. Figure 4.1 attempts to give some appreciation of the true scale of the challenge facing modern society[12]. If the fight against climate change is to be 'won', the historic linkage between living standards and CO_2 emissions must be decoupled.

This has never been attempted before; and its achievement would represent an unprecedented success.

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[9] Local environmental issues are not specifically considered, as noted in Section 1.
[10] 2003 Aviation White Paper predicts a rise in UK air passengers from 180million per annum to 475 million per annum. Bibliography Item 2.
[11] Bibliography Item 16.
[12] It should be noted that the CO_2 emissions targets of the 2008 Climate Change Act are baselined on 1990 'Kyoto' figures. But there have been few if any meaningful reductions in the period to 2009 – it can in fact be argued that national emissions have grown owing to increases in the UK share of international aviation, and also to the trend of industrial production transferring to the Far East and other countries outside the EU. Hence the projected decrease in emissions is simplistically illustrated as beginning in 2009.

Given the scale of the threat, it seems illogical to allow any industry's emissions to increase; in the case of the proposed expansion of Heathrow, it is especially illogical when that industry involves the highest emissions of any mode of public transport.

4.1 Typical Transportation Emissions

Statistics for comparative environmental performance of different transport modes are expressed as the quantity of emissions per passenger over a given length to be travelled, and are measured in grams of CO_2 emitted per passenger kilometre. Emissions figures[13] for short-haul aviation relative to other transport modes are given in Table 4.2. The figure for short-haul aviation is factored to take account of the greater damage caused by high level emissions (radiative forcing).

Transport Mode	*g_{CO2}/pass.km*
Short-haul aviation	230
High speed rail (300kph)	95
Conventional rail (200kph diesel)	75
Conventional rail (200kph electrified)	55

Table 4.2 : Comparative operational transport emissions

On these statistics, the superior performance of rail is evident. High speed rail – inevitably involving the highest emissions of any form of rail transport – emits just over 40% of the CO_2 of comparable aviation. But these figures are based on a very onerous load factor assumption of 33% (ie only one third of seats occupied). Eurostar's actual load factors are around 60%. In their recent 'Tread Lightly' campaign[14], Eurostar claim that their high speed services involve only 10% of the CO_2 emitted by aviation.

It is an acknowledged fact that these figures, based upon load factors of 60%, are considerably enhanced by the highly nuclear (and therefore low-CO_2) content of French electricity. Using current UK electricity generation, a figure of around 20% would apply; this might rise to around 40% if the most onerous data relating to coal-fired generation were applied to power demand from new railways. See Item 4.5. But in terms of determining the way forward for UK transport, the French-influenced figures may be a more appropriate indicator of trends in power generation.

4.2 Environmental Performance of High Speed Rail

There is much ongoing debate with regard to the true environmental performance of high speed rail, and technology developments that will result in more efficient planes and trains. But three essential facts cannot be disputed:

- The energy use of aviation, and associated CO_2 emissions, are of an order of magnitude greater than those of rail.
- Higher speed inevitably implies higher energy use, and therefore higher emissions.
- While aviation is dependent on oil for its fuel, and is inherently CO_2 emitting, electrified railways can be powered by a variety of primary sources, either renewable or nuclear, as an alternative to the burning of fossil fuels.

[13] Bibliography Item 7.
[14] http://www.eurostar.com/UK/uk/leisure/about_eurostar/environment/tread_lightly.jsp

A particular environmental concern with high speed rail is its inherently higher energy use and consequent emissions, when compared with conventional rail. Energy use rises approximately with the square of speed; so trains operating at 300kph (1.5 times faster than conventional rail's maximum speed of 200kph /125MPH) will have over twice (2.25 times) the emissions. Although this is considerably mitigated by the better-engineered new lines with fewer stops and much lesser disruption from slower speed traffic, high speed rail still inevitably involves increased energy use.

There is a further concern in respect of 'embodied carbon' ie the CO_2 emissions and energy use implicit in the construction of any transport scheme, either an expanded airport or a new high speed line. These comparisons have still to be fully quantified; however, there is no doubting that rail is considerably more 'infrastructure heavy' on account of the need to construct along the full line of route, while aviation infrastructure is concentrated at the airports at either end (although the intervening atmosphere might also be considered to be infrastructure, of a sort?).

There are three key mitigations for high speed rail schemes:

- The 'embodied' CO_2 of construction is of an order of magnitude less than the emissions that will follow during the operating life of the infrastructure.
- The new high speed rail infrastructure has potentially a far greater utility in terms of the wider transport benefits that will accrue (ie high speed rail is far more than a simple substitute for short-haul aviation).
- It is reasonable to assume a feasible operating life of 100-200 years for a new high speed line – but, given growing Peak Oil concerns (see Item 4.4), it is difficult to see a useful life of more than 20 years for a third runway at Heathrow.

4.3 Environmental Best Practice

On a simplistic consideration of environmental sustainability, and avoidance of increased emissions, even high speed rail might be difficult to justify, let alone expanded aviation. But the implementation of high speed rail can facilitate the elimination of much higher-emitting short-haul aviation, and at the same time free up major new capacity on the existing rail network, to allow mode shift from (again) higher-emitting road transport. In doing so, a net reduction in emissions can be achieved. The actual operating speed of the high speed network should then be adjusted, to optimise the environmental benefits; this figure may either be lower or higher than the nominal 300kph limit to which HS1 has been designed.

This is the principle of environmental best practice, whereby proposed developments are optimised to achieve maximum environmental benefit – and should only be permitted if they can be demonstrated to do so. On this basis, Government policy must be directed to encourage high speed rail – and to abandon airport expansion.

But current Government policy is more ambivalent. It relies on mechanisms such as the EU's Emissions Trading System (ETS), by which sectors with growing emissions (eg aviation) will purchase permits to emit from reducing sectors such as general industry, in a structured framework of gently reducing aggregate emissions. It is valid to question whether industry's emissions are in reality reducing through greater efficiency – or merely being exported to countries outside the ETS zone (ie the European Union), where the same production may well be carried out with greater emissions, and a greater requirement for transport.

In any event, the ETS is being overtaken by events. With an emissions reduction target as challenging as the 80% cut required by the 2008 Climate Change Act, gains in one sector cannot be used to offset increases elsewhere. Meaningful reductions must be achieved in all sectors. This puts an imperative on coherent Government policy to maintain public confidence; without this, the fundamental changes in behaviour necessary to implement the required CO_2 reductions are unlikely to happen.

It is evident that much more rigorous 'carbon accountancy' is required, on a local and global scale, with every industry sector held responsible for the achievement of real emissions reductions.

4.4 Heathrow Expansion – the 'Peak Oil' Question

A possible drawback in the environmental argument against aviation – and other wasteful use of fossil fuels – is the lack of an absolute proven linkage between increasing atmospheric levels of CO_2 and global warming. Despite massive circumstantial evidence, and overwhelming consensus between climate scientists, many sceptics persist in their refusal to accept what seems obvious to most – that human activity, in the burning of fossil fuels and other unsustainable activities, has resulted in atmospheric changes that are causing the earth to heat up.

The sceptics argue that more proof is required, before society can accept the massive reductions in consumption necessary to fight global warming; and that until such proof is obtained, high-consuming 'business as usual' should continue to prevail. Against these arguments, it is useful to introduce the 'Peak Oil' scenario.

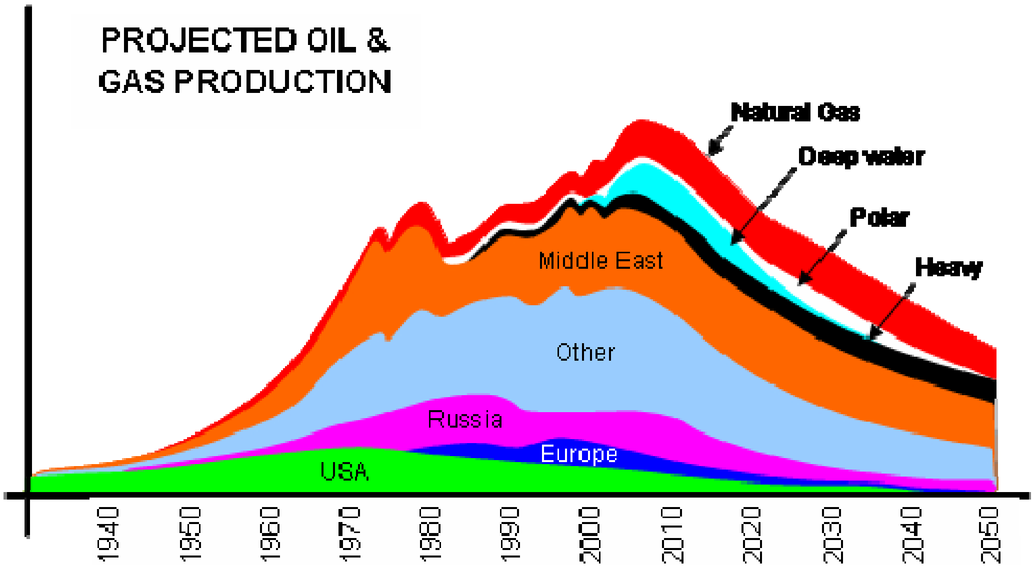

Figure 4.3 : Peak Oil Scenario (repro of image from www.newglobalfuture.com)

In contrast to any marginal level of uncertainty concerning the linkage between human-generated CO_2 and global warming, there can be no doubt that the earth's fossil fuel reserves – in particular oil – are finite, and are depleting fast, as world population and demand rises. See Figure 4.3. The American oil fields are already largely exhausted, North Sea production is now in decline, and other oil fields are sure to follow. This is not to say that the oil will ever run out, as such. What will happen is that extraction of the volumes required to sustain world demand will become increasingly difficult as existing oilfields are exhausted, and newer, more marginal oilfields (or alternative sources such as bio-fuels) come on stream.

This is the 'Peak Oil' scenario[15], first put forward by the American geophysiscist M. King Hubbert in the 1950's. Hubbert had observed that American oil production – and of course demand – was exceeding the rate at which new reserves were being discovered, and he was able to accurately predict that production would start to fall in the early 1970s. On a global level, there is now the same mismatch between production and discovery rates, and a similar situation will arise where supply cannot match demand. The best efforts of the oil industry to maintain production or find alternative fuel sources will not be sufficient, and prices will inevitably spiral.

The crisis brought about by a global rather than a local 'Peak Oil' scenario can hardly be overstated. Notwithstanding the considerable debate as to whether the world economy can sustain energy prices above a certain proportion of Gross Domestic Product, there will be a huge impact on transport (responsible for 66% of UK oil consumption); even more importantly, basic functions such as agriculture – as dependent upon oil as transport – will begin to suffer. Although prosperous countries such as the UK may be insulated from the worst effects of the likely world starvation, general destabilisation in the form of conflict and consequent refugee crises seems certain.

The impending climate change crisis is already spurring the development of alternative non-CO_2 energy sources such as nuclear and a variety of renewables such as wind and wave power, and also the development of a range of bio-fuel alternatives to 'drilled' oil; but the 'Peak Oil' scenario should impose an even greater imperative. The precise timing of the point at which demand begins to exceed feasible supply is the only matter of serious doubt. It is to be hoped that the critical point is several decades away, sufficient time perhaps to make the necessary structural changes; but certain projections indicate an imminent crisis within the next few years.

Whether the fuel supply crisis occurs within five or 50 years, Government should plan for such an eventuality, and put in place measures to convert the nation as fast as possible from its current dependency on oil. But in all of the consultations and policy statements, either on aviation or wider transport matters, no consideration of critical oil supply issues is evident. *Towards a Sustainable Transport System*[16], the Government's flagship document addressing 'green' transport issues, does not address this most primary of sustainability issues. For aviation, a threefold increase in passenger numbers is planned; but no comment is made as to where the fuel will come from. It is assumed that the oil, which has flowed freely for so long, will continue to flow.

In this context projects such as the third runway at Heathrow – which can only increase national dependency upon oil – should be tested against the viable lower-carbon, lower-energy alternative offered by high speed rail. Just as with the CO_2 question, a very similar concept of sustainability best practice can be applied in the assessment of any major transportation project. Such projects should only go ahead if the net result is a reduced rate of depletion of world fuel reserves. This is of course possible with electrified high speed rail, both through the modal shift achieved from more wasteful aviation and road transport, and from the growing use of non-CO_2 generating power sources for electricity generation.

[15] http://en.wikipedia.org/wiki/Peak_oil and many onward references.
[16] Bibliography Item 8.

4.5 High Speed Rail and the Power Generation Gap

Aside from any consideration of CO_2-induced global warming, and future fuel supply limitations through the 'Peak Oil' scenario, the UK is facing a more immediate energy crisis through restrictions in electricity generation capacity. This is brought about by continuing rising demand, and the projected closure of several aging coal-fired and nuclear power stations before new nuclear and renewable electricity generation can be brought on stream.

In this context, it is valid to question whether it is reasonable to enter into a programme of construction of new electrified high speed lines (and indeed, the projected electrification of more of the existing railway network) that will inevitably increase the railway's demand for electricity.

It could of course be argued, that the general structural changes necessary to realise the targets of the 2008 Climate Change Act will reduce electricity demand to a sufficient degree to free up generating capacity that can be dedicated to the railway.

However, this might be regarded as contravening the principle argued earlier in this section, that each industry sector must take responsibility for its own energy needs and CO_2 emissions, and not attempt to pass the problems elsewhere. It is of course not certain that the spare generating capacity will come about, if other sectors do not achieve the required reductions.

A major associated issue is that of 'carbon accountancy'. If the railway's demand for electricity is to expand, either through new high speed lines or electrification of existing lines, it may only be possible to satisfy that demand through the burning of extra coal. Thus, on a simplistic level, the railway's electricity would be the 'dirtiest' (compared with gas or nuclear generation), entailing the highest CO_2 emissions per unit of energy (usually measured as grams of CO_2 per kilowatt hour) and apparent environmental performance (in terms of grams of CO_2 per passenger kilometre) would similarly suffer.

So a strategy, both to account for the railway's increased total emissions, and possibly also to generate the necessary electricity, must be advanced.

High speed rail (if implemented as an efficient network extending as far as Scotland) has the potential to achieve major modal shift towards the railways, through the elimination of most UK domestic and European short-haul flights, and through significant reductions in car traffic and road haulage with capacity relief to the existing rail network. This modal shift will bring about a major reduction in oil consumption, and a net decrease in energy use through the greater efficiency of rail.

If there were no other means powering electrified railways, it would seem reasonable to 'ring-fence' a proportion of the oil saved through the implementation of high speed rail, and to use it to generate electricity for the railway. This could be accomplished relatively easily (and more efficiently/cleanly, by virtue of oil's superior calorific characteristics[17] over coal) through the conversion of coal-fired power stations that are due for decommissioning in the near future.

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[17] Wikipedia (http://en.wikipedia.org/wiki/Heat_of_combustion) gives a calorific value of 44.8 MJ/kg for diesel oil and figures ranging from 27.0 MJ/kg for anthracite and 15.0 for lignite coal grades. Assuming a median figure of 21.0 for more standard bituminous coal, and a constant conversion factor of 1kg of fuel to 3.1kg of CO_2, it can be deduced that the burning of a given mass of oil will produce around twice the energy for the same CO_2 emissions.

4.6 High Speed Rail and the New Low-Carbon Economy

It is important to consider the development of high speed rail in the UK in the context of post-Credit Crunch, carbon-critical economics. Under current largely finance-driven rationales, the argument seems likely to revolve around cost. The construction of new railways is always highly expensive, and (unlike ostensibly private investment in airports) seems inevitably to require public funding. So, given the apparent need for drastic cuts in Government expenditure in the aftermath of the Credit Crunch, the outlook for investment in high speed rail seems at best uncertain.

Government spending will follow its perceived priorities – and in the coming years, the overriding priority must be to achieve real and significant reductions in CO_2 emissions as part of the fight against climate change. The superior environmental performance of rail with respect to other modes will not of itself guarantee that projected investment programmes will be secure. The crucial factor will be the ability of rail to act as a vector for change, through mode shift from higher-emitting air and road transport. (Despite the totemic nature of aviation expansion, with cars, vans, lorries and buses responsible for around 92% of transport emissions, it is clear that this is where the major part of the inroads must be made).

But with capacity on the existing rail network already constrained, extra capacity is essential to accommodate the new passenger and freight flows. It is important to remember that with the current dominance of road transport over other modes, even a small change in roads' modal share will have a massive impact on the rail network's existing share, in proportionate terms. Hence the required enhancement of capacity must comprise a step change, rather than the incremental improvements that to date have been the norm.

And of all options available, investment in high speed rail is by far the best means of achieving the required increased capacity. It allows the higher speed (200kph) express passenger traffic to be removed from the existing main lines, which can now be devoted to the remaining freight and local passenger traffic, both of which operate closer to 100kph average. With speed differentials reduced by the fractioning off of the express passenger traffic to the high speed line, a disproportionate gain in capacity is possible on the existing lines.

The East Coast Main Line provides a particularly good exemplar of the possibilities. On two-track sections of this route, the express passenger traffic of 5-6 trains per hour leaves little room for either freight or stopping passenger traffic – perhaps a total of 2-3 'paths' per hour. But with the expresses transferred to the new high speed line, and the speed differentials largely eliminated, there is no reason why up to perhaps 12 freight or local passenger trains per hour could not be operated. If the new high speed line can be correctly aligned and engineered such that it can cover all three existing northern main lines (ie ECML, MML and WCML), a single new line seems capable of generating over 30 new train paths per hour.

In the coming months, as political parties of all hues develop their spending plans prior to the forthcoming general election, it is vital that the unrivalled capability of a developing high speed rail network to achieve major mode shift and CO_2 reductions – and thus help meet national legally-binding climate change objectives – is robustly argued. The key point must be made, that CO_2 (or the reduction thereof) is the new money.

5. High Speed Rail Replacement of Short-haul Flights from Heathrow – summary of review

The following key points have emerged from the review in the preceding pages:

- High speed rail as an alternative to short-haul aviation will deliver major environmental benefits, and would appear to offer perhaps the best opportunity for UK transport to contribute towards meeting the CO_2 reduction targets of the 2008 Climate Change Act.
- In the context of limited fossil fuel reserves, high speed rail is far more sustainable, capable of achieving a net reduction in the rate at which these reserves are depleted.
- High speed rail can compete effectively against short-haul aviation on inter-city journeys to a horizon of at least 1000km, or four hours.
- Any deficiencies in its performance in effecting short-haul connections from Heathrow to near-Europe (to a similar four-hour horizon) are mitigated by the greater service frequencies feasible with high speed rail.
- Sufficient of Heathrow's short-haul flights (circa 25%) are capable of conversion to high speed rail to alleviate any need to expand.
- Efficient connection between the high speed network and Heathrow is essential.
- This must be part of a wider strategy, to ensure comprehensive and efficient access to Heathrow from UK regions.

These points represent the fundamental rationale of the transportation case against Heathrow expansion. With Heathrow's short-haul flights converted to high speed rail, ; the result will be a compact yet decongested airport, better able to perform its true function as the UK's principal international gateway, and making a positive contribution to the fight against climate change.

This is the 'better, not bigger' Heathrow that campaigning groups have been calling for. But this is only achievable with massive investment in the alternative surface transport systems, and a degree of integrated planning never before witnessed in the development of UK transport. It will not be enough simply to build a single high speed line from London to the North with a connection to Heathrow, and expect short-haul aviation to wither away, or surface access issues to be fully resolved.

The new line, or more likely lines, must be viewed as a system, in its entirety capable of replacing short-haul aviation (not just from Heathrow, but also from other UK airports) and achieving a step-change comprehensive improvement in surface access. This is a formidable specification in itself. But at the same time, the primary purpose of high speed rail – to service high volume passenger flows between city centres – must also be adhered to. The merit of any proposal will be measured in how successfully it can address these quite possibly contradictory aims.

In the development of a solution, the first step should be to examine current proposals, to determine how they measure up.

6. Heathrow Rail Access Proposals : Airtrack and CrossRail

The problem of Heathrow's inadequate surface access, and its relative isolation from surrounding communities, has long been recognised. Just as Heathrow Express (and latterly Heathrow Connect) has provided connections to the Great Western Main Line immediately to the north, similar schemes have been advanced to link to the Windsor Line to the south. Over the years, the putative connection to the Southern network has taken many forms, including a direct northward spur into the airport from the Feltham area; but with the development of Terminal 5, these proposals have now crystallised into the Airtrack scheme. This forms part of BAA's surface access strategy supporting their proposed expansion of Heathrow.

6.1 Airtrack

The Airtrack scheme is illustrated in Figure 6.1. It will extend the railway westwards from the new underground station at Terminal 5, turning south to follow the M25 towards Staines. Part of its route will follow the alignment of the abandoned Staines West branch, and immediately north-west of Staines, it will connect to the existing Waterloo-Staines-Windsor Riverside line. At Staines, the Windsor Line currently connects only to the east, towards London; the present Staines Station is located at the junction; to provide the necessary links to the south (ie Woking and Guildford) and to the west (Bracknell and Reading) the former railway triangle will be restored.

Half-hourly services are proposed on each of the branches, from west, south and east, with all terminating at Terminal 5; this would amount to a 10-minute frequency on the section from Staines to Heathrow.

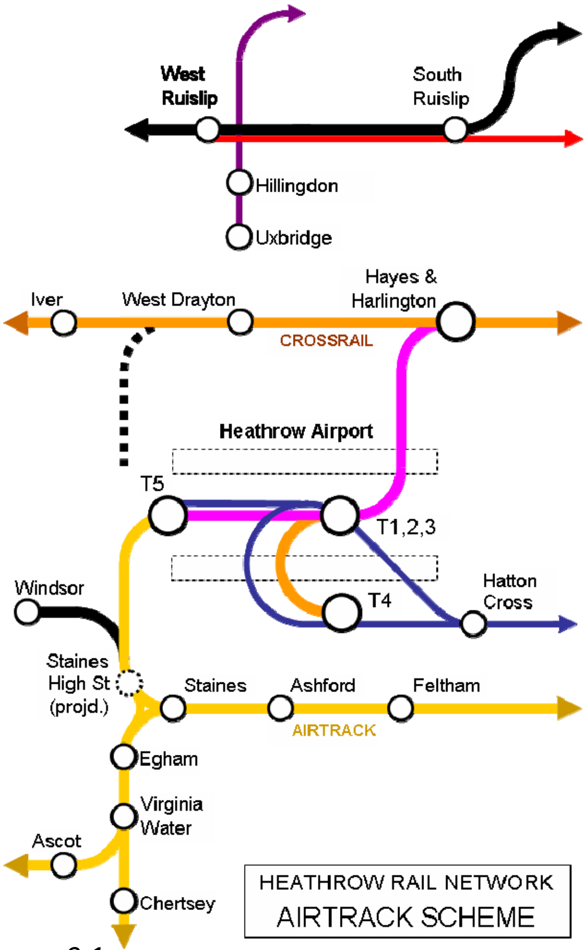

Figure 6.1

In earlier iterations of the scheme, a new station at Staines High Street was proposed. This was to be located at the north-western apex of the restored triangle, and would have allowed trains from the south and the west (naturally bypassing the present Staines Station) to call at Staines en route to Heathrow, and to connect with existing Windsor Line services. However, the latest BAA Airtrack consultation (October 2008)[18] has deleted the proposed Staines High Street station on the grounds of local environmental concerns / lack of business case. (This would leave the majority of Airtrack trains passing through, but not stopping at, the key rail hub of Staines). Instead, BAA now seem to be favouring the extension of Heathrow Express trains from Terminal 5 to a new bay platform at the existing Staines Station.

[18] Bibliography Item 18.

6.1.1 Level Crossing Concerns

A major concern with the Airtrack scheme has been the worsening of already severe congestion at level crossings. See Figure 6.2. The Waterloo-Staines-Reading line has by far the greatest number of level crossings of any of the London commuter railways, and the intensification of rail services that Airtrack will bring is certain to exacerbate road congestion issues. Problems are particularly severe between Staines and Egham, and in the Mortlake area, east of Richmond. At these locations, adjacent residential development effectively precludes bridging options, and options for other mitigations are extremely limited.

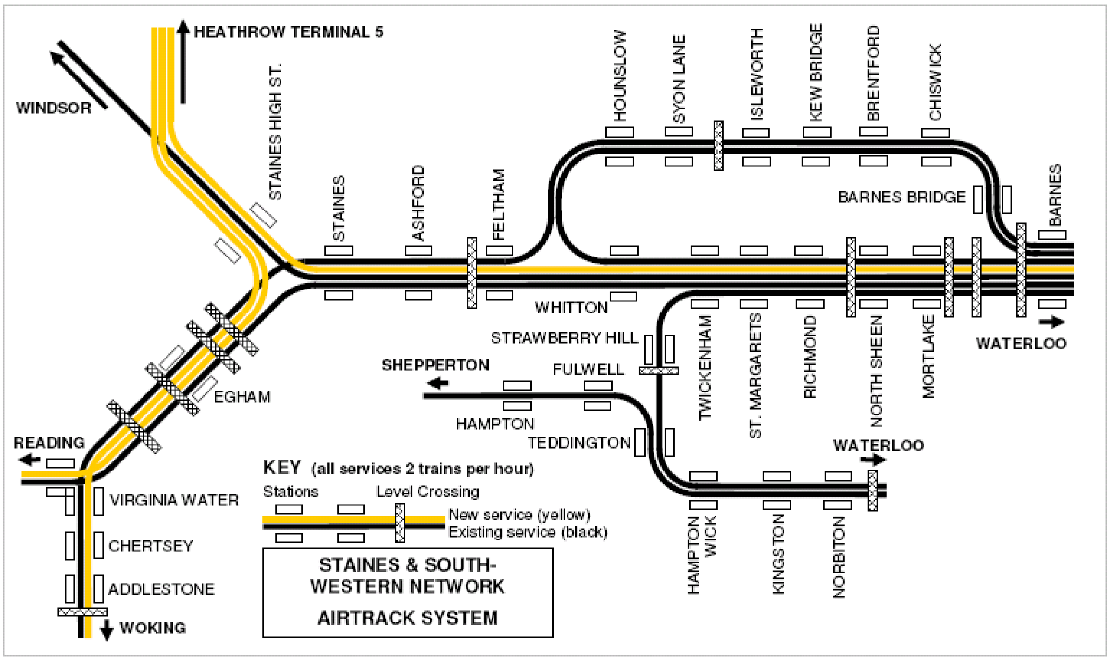

Figure 6.2

6.2 CrossRail

The CrossRail scheme will also impact upon local rail access to Heathrow. In the west London area, CrossRail will result in an intensification of local services along the Great Western corridor (along the Slow lines) to give a 14 trains per hour service. Four trains per hour will run to Terminal 4, superseding the present Heathrow Connect service; but Heathrow Express will continue in its present form as a premium express service from Paddington to Terminal 5.

So far as Heathrow is concerned, CrossRail will involve no more than a reorganisation of existing rail services; no significant local infrastructure works are proposed (and no improvements either to the GWML's poor links with intersecting or adjacent rail routes, in particular the North and West London Lines and the West Coast Main Line (WCML)). Trains will continue to operate towards Paddington, but will now extend through the new tunnel under central London, connecting to Great Eastern and SouthEastern networks. But although CrossRail services will extend along the GWML as far as Maidenhead (and possibly extend to Reading) there will be no direct westward connection from Heathrow. For this, it will still be necessary to change trains at Hayes & Harlington.

6.3 Surface Access Improvements with Airtrack & CrossRail

With the implementation of Airtrack and CrossRail, there will be significant improvements to Heathrow's local rail access. These improvements are illustrated in Figure 6.1. It is important to note that although CrossRail will link Heathrow to the City and to a vast range of destinations further east, to north and south of the Thames Estuary, it is only the stopping Heathrow Connect service (originating at Terminal 4) that will deliver direct connections. The premier non-stop Heathrow Express service from Terminal 5 will continue to terminate at Paddington.

Airtrack's connections to Clapham Junction, Woking and Reading will provide direct connections to the main line rail network to the south, south-west and west of London. Services to Reading will also connect to the CrossCountry network, to the West Midlands and thence to the North-West and the North-East. However, the relatively slow nature and poor quality of these services (four hours Reading-Leeds as opposed to two hours London-Leeds) will probably limit the range of the effective airport connection to Birmingham.

6.4 An Effective Local Network??

Although the enhanced airport connections that Airtrack and CrossRail will bring are to be welcomed, it is evident that collectively they do not comprise the optimum integrated solution with comprehensive network coverage. As noted above, the benefits accruing from the CrossRail scheme will be greatly limited by the lack of full integration with Heathrow Express.

The lack of any rail connections to the north of the Great Western Main Line gives rise to greater concern. Most of north-west London – home to many of Heathrow's passengers and workers – will still be left with little option but to use the private car, or taxi, to access the airport. And with no effective connection to the northern main lines (other than via the congested Piccadilly Line or the circuitous CrossCountry route) there is little change to the effective isolation of huge areas of the Midlands and the North.

The CrossRail project will do nothing to improve the GWML's poor links with intersecting rail routes, in particular the North and West London Lines. These lines cross at either end of the Old Oak Common railway yard and converge at Willesden Junction just 1km to the north; here they connect with the WCML and LUL Bakerloo Line. Despite the obvious potential for the CrossRail project to include a major interchange station at Old Oak Common, no such initiative is currently proposed. This may change with emerging proposals for a new high speed line terminal at this site (see Item 8.4 re the DfT HS2 project), but as yet, no details of proposed local connections have been released.

The links that Airtrack will create to the south of the airport would appear to be much superior to current connections. However, the service provided will be hugely weakened by the omission of Staines High Street station from BAA's present plans. Staines, located immediately to the south of the airport at the confluence of the various Airtrack branches, should be a powerful hub in the proposed network; but with most Airtrack trains passing through Staines without stopping, the synergies of enhanced local links and connections to other non-airport services will be lost.

Given these deficiencies, the BAA secondary proposal (also discussed in the October 2008 consultation document) of an extended Heathrow Express terminating at the existing Staines station, would appear to offer a far more effective connection to the local rail network (although the links to the national network at Woking and Reading would be lost).

6.5 Network Opportunities Ignored

Airtrack has now advanced to the point where parliamentary powers are being sought for its implementation. It is seen as an integral part of the surface access improvements necessary to cope with the increased local traffic that will be generated through the opening of the third runway, and associated sixth terminal. But in its current form, it would seem to represent a major missed opportunity.

With the fragmented nature of the current Airtrack and CrossRail proposals added to the existing Heathrow Express operation to Terminal 5, Heathrow can be seen to be placed at the terminus of three separate branch lines.

This is hugely inefficient from an operational point of view, with separate fleets of trains to maintain and extra 'down-time' of trains waiting in terminating platforms. More importantly, however, it fails to exploit the wider network opportunities, to link communities to the north and south of the airport. Even under the current limited proposals, the potential journey opportunities are apparent; these would include Staines to Southall, Woking to Slough, and many other routes hitherto unachievable by rail.

There is of course no technical impediment to through running. Dual-voltage rolling stock, capable of running on the Southern 750V DC 'third rail' system and on the Heathrow Express 25kV AC overhead system (the common standard for the UK main line network north of London), has a long history of successful operation on Thameslink, and elsewhere. And with more developed comprehensive rail access to Heathrow, the local network opportunities start to multiply.

6.6 Current Heathrow Rail Access Proposals : Heathrow Hub

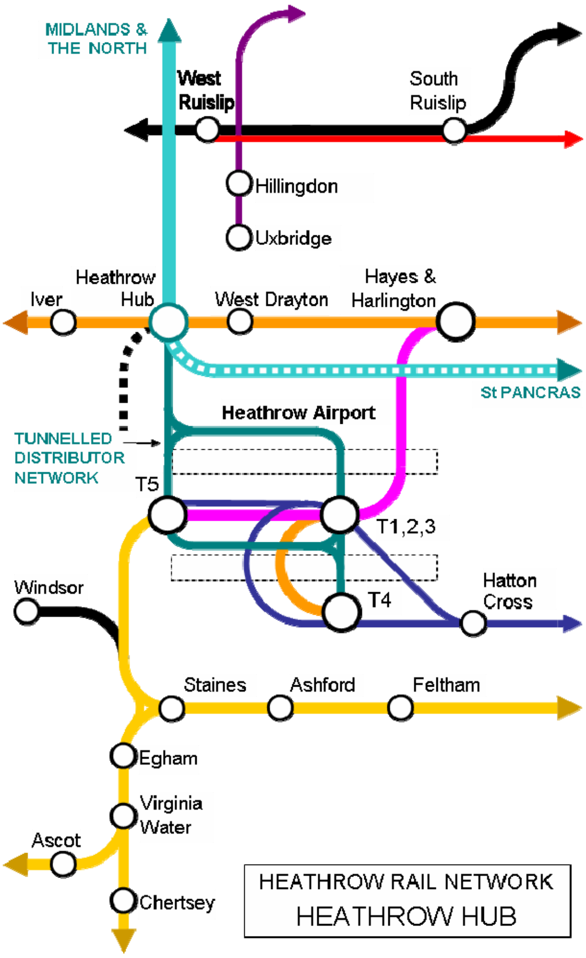

Figure 6.3

Heathrow Hub will comprise a major new multi-platform station, to be constructed on the Great Western Main Line just beyond the current limits of London's suburban development, close to the M25. It has been proposed[19] by the Arup consultancy to be Heathrow's interchange with Great Western rail services to the Thames Valley, Wales and the West Country, with HS1 to near Europe, and with the projected high speed line extending north-westwards into the UK provinces. A rapid transport system in a network of new tunnels will achieve comprehensive access from the new station to all airport terminals. A schematic layout of Heathrow Hub is illustrated in Figure 6.3.

With Heathrow Hub established as the key intermediate station between Reading and Paddington, there is no doubt that it will considerably enhance airport access for communities on the Great Western network.

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[19] Bibliography Item 12.

But it is fair to note that ever since 1997, the opportunity has existed to create an equivalent airport interchange facility between Great Western and Heathrow Express services at Hayes & Harlington Station, at a fraction of the proposed cost of Heathrow Hub. With Heathrow Express accessing all airport terminals, there would be no requirement for new underground construction within the confines of the airport; the required interchange facility for conventional rail traffic could be realised much more expeditiously, and at a fraction of the multi-billion cost that is projected for Heathrow Hub.

Hence it seems reasonable to conclude that Heathrow Hub does not constitute a cost-effective means of achieving either (UK) intercity or local rail access to Heathrow.

6.7 Current Heathrow Rail Access Proposals : Greengauge21's 'HS2'

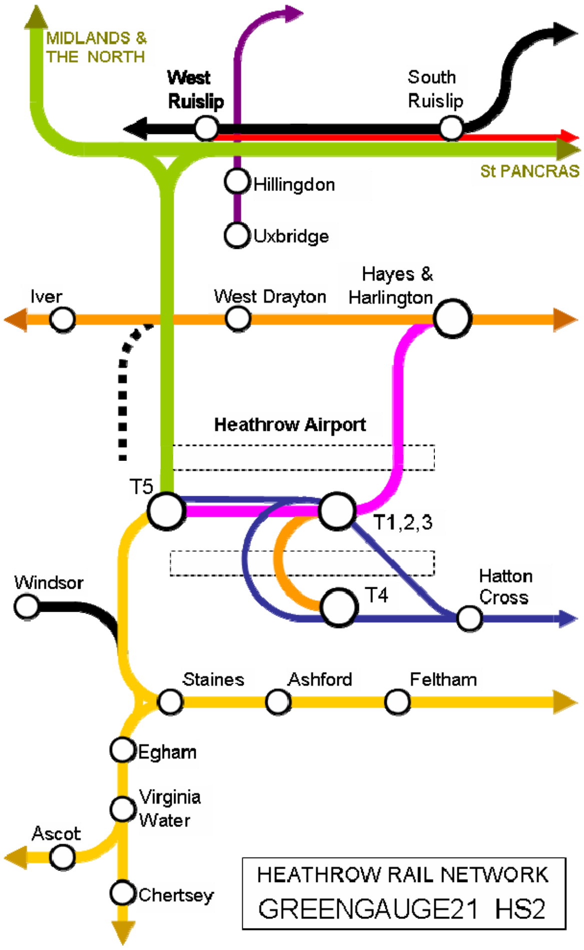

Figure 6.4

For completeness, the proposed Heathrow branch of Greengauge21's *HS2 Proposition*[20] is also illustrated in Figure 6.4. It can readily be appreciated that this is exclusively a high speed railway, and will not deliver any enhancements to Heathrow's local rail network.

[20] *High Speed Two – a Proposition by Greengauge21* (June 2007). Bibliography Item 6.

7. Heathrow Rail Access : the Compass Point Alternative

The limited benefits that current proposals such as Airtrack and CrossRail will bring to Heathrow's rail access, both locally and nationally, are the direct result of a failure to apply the necessary 'joined up thinking'. Each proposal on a specific corridor has been developed only with thought to that corridor alone; there has been no holistic consideration of Heathrow's total surface access requirements, or to the synergies that a more comprehensive network approach might bring.

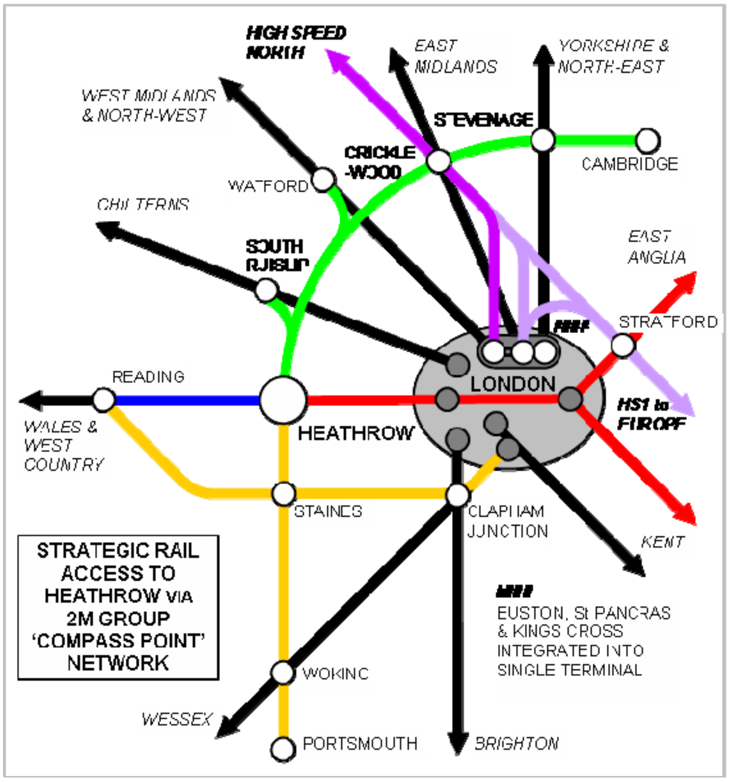

Figure 7.1

The fragmented nature of the Airtrack and CrossRail proposals would not appear to fully satisfy the need for improved surface access to the UK's 'key international gateways'; this was one of the chief recommendations of the recent Eddington Transport Study.

Heathrow Airport is probably the prime exemplar of these issues, and its surface access deficiencies on all axes other than London-centric have already been described at length. This study has also quantified the very significant traffic volumes that should accrue to any rail systems running to the south, west or north of the airport.

This potential is acknowledged in the current Airtrack proposals, addressing the southern axis; it is reasonable to assume similar potential to the west and to the north. As with the Airtrack proposals, new routes to the west and the north should perform the dual function of local links, and connections to the national network.

This is the fundamental principle of the Compass Point proposal – instead of the fragmentation implicit in the various current proposals, an integrated system of local railways would radiate from Heathrow to north, south, east and west and link to the main lines of the national network. See Figure 7.1.

7.1 Integration of Existing and Proposed Services

All existing and proposed services – Heathrow Express, CrossRail and Airtrack – would be integrated, and augmented with further services on new axes. Terminating services would be largely eliminated; instead, trains from north and east of the airport would run to the south and the west, at the enhanced frequencies that become possible with through running.

The Compass Point proposal envisages 'a train for every plane'. This implies trains passing through the central terminal area at 3-minute frequencies (or 20 per hour) in either direction to match the 90-second frequency of planes landing or taking off. See Figure 7.2. This is at last taking surface access seriously – a conveyor belt of trains radiating in all directions to complement the conveyor belt of arriving aeroplanes.

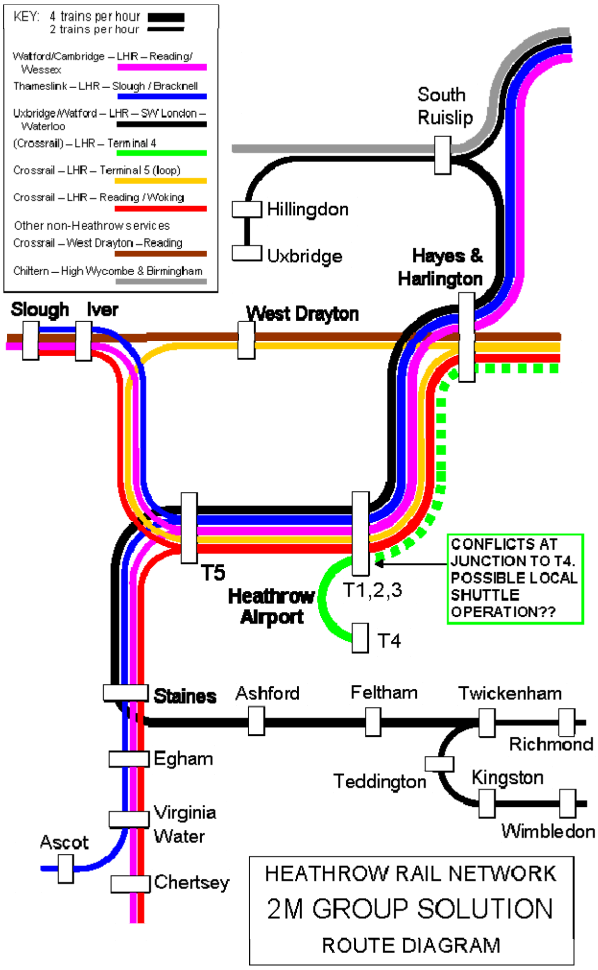

Figure 7.2

With each plane loaded with an average of 140 passengers, a similar number (after transfers are deducted, and friends/relatives of arriving/departing passengers plus airport workers are added) could potentially be boarding each train. With communities either side of the airport linked by frequent, through-running trains, loadings will be greatly augmented through the new journey opportunities created.

7.2 Infrastructure Requirements

Most of the necessary infrastructure is either already in place, or planned.

Most importantly, at the core of the proposed Compass Point network, the tunnels of the Heathrow Express system already connect to all airport terminals. Relatively little further development should be required to make the already excellent (but currently underused) infrastructure fit for its new role.

The principal concern lies with the conflicts that will arise at the junction at Terminals 1,2,3, between traffic on the single track branch to Terminal 4 and the intensive traffic on the 'main line' to Terminal 5. It may be best to operate the Terminal 4 branch as an isolated shuttle, and concentrate all through services on the main line.

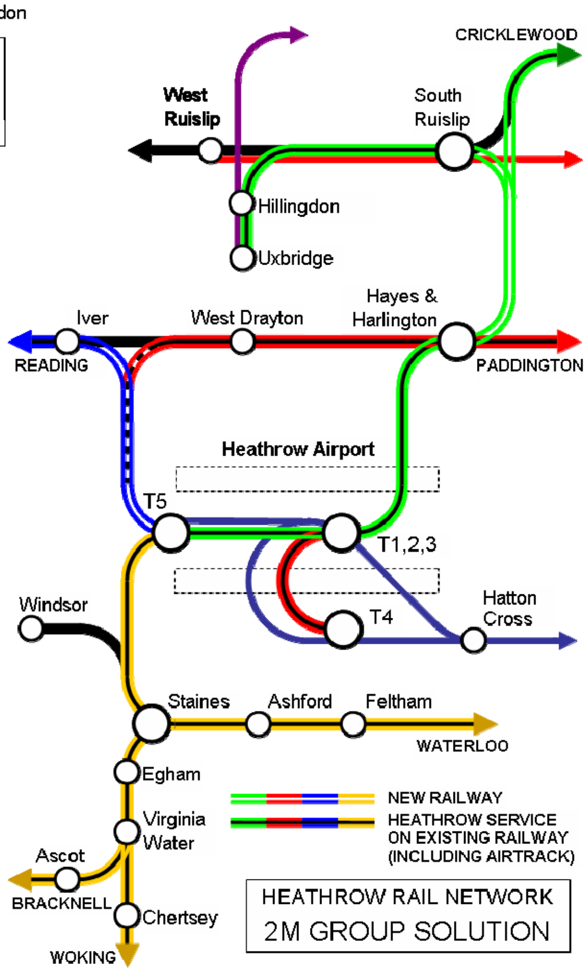

Figure 7.3

7.2.1 Eastward Development

To the east, the necessary improvements to the poor onward links at Paddington will be achieved through the long-awaited realisation of the CrossRail project. With the new tunnel under central London, through running to the South-Eastern and to the East Anglian commuter networks will become possible. Here the challenge will be to integrate CrossRail's local metro-style service with the premium limited-stop Heathrow Express service.

At the same time, the opportunity must be taken, to address major deficiencies in the CrossRail project, in particular the major imbalance between west and east-sided flows and the lack of connections with intersecting rail routes eg North and West London Lines. These issues are explored fully in Section 9.5.

7.2.2 Westward Development

To the west, the new section of line from Terminal 5 to the Great Western Main Line is already schemed in outline. The Airtrack scheme allows for the provision of a junction (at Bedfont Court) and from here, the line would curve to the north, passing under the M25 and connecting to the existing freight branch near Colnbrook. This line (the former Great Western Staines West branch) comprises only single track, which will have to be doubled to accommodate the proposed traffic – eight passenger trains per hour plus the occasional freight train. At most locations, this would not comprise a serious issue; the only exception is where the line passes through the middle of the M4/M25 interchange. Here, it will be necessary to 'double stack' the two lines in a deep-set concrete box, to remain within existing railway boundaries.

North of the M4, a new spur will deviate to the west to join the GWML Slow Lines near Iver. Here, services from the Compass Point network would merge with CrossRail services. A proportion will terminate at Slough and the remainder at Reading; this latter hub will comprise the principal interchange with longer-distance services.

Although the majority of services will follow the new chord to the west, a limited service (two trains per hour) will follow the original alignment of the Staines West branch, to pass underneath the GWML and swing to the east to join the Slow lines near West Drayton Station. This will allow CrossRail / Heathrow Express services to operate in a loop through the Heathrow terminals, and return to the main line without the need for time- (and capacity-) consuming reversals. In allowing the inclusion of West Drayton station into Heathrow's network, it will also bring major benefits, particularly for locally-based airport workers.

7.2.3 Southward Development

To the south, the Airtrack scheme will provide the basis for this arm of the Compass Point network. No radical changes are proposed to the scheme already advanced; the designed alignment between Terminal 5 and Staines will be adhered to, the railway triangle at Staines will be restored, and from Staines the new services will radiate along the existing lines towards Reading, Woking and Waterloo. The main differences lie in two principal aspects: enhanced service levels (in line with the 'train for every plane' operating philosophy), and alternative station proposals at Staines.

A service frequency of 10 trains per hour south of the airport (as opposed to 6 with Airtrack) would seem certain to further exacerbate the level crossing congestion problems already highlighted in the current Airtrack scheme. These issues are particularly acute at level crossings in the Egham and Mortlake areas, where it is proposed to increase train frequencies from four to eight trains per hour (Egham), and from 8 to 10 tph (Mortlake).

The Compass Point proposals would simplistically involve a further two trains per hour in both Egham and Mortlake areas.   To mitigate these problems, two complementary solutions are suggested:

- The existing two trains per hour stopping service on the Addlestone/ Chertsey/ Virginia Water/ Egham line will no longer run to all-stations to Waterloo, but instead via Heathrow and to central London via CrossRail.   This will be of much greater use to local people, many of whom work at the airport, and connections to the Richmond area will be maintained through interchange at Staines.
- As an alternative to increased train frequency in the Mortlake area the extra two trains per hour could be routed via either the Hounslow Loop or the Kingston Loop.   This will enhance airport connections to major centres such as Wimbledon and Kingston, ignored by the current Airtrack scheme.

The enhanced service frequencies proposed are only achievable with full integration between the new airport services and the existing South-West Trains service (as opposed to the crude bolt-ons that comprise the current Airtrack proposals).   An indicative service pattern is shown in Figure 7.4.

An efficient hub at Staines is crucial to the proposed integrated operation.   A new station at Staines High Street (as per original Airtrack proposals) will deliver considerable benefits, but the resultant two-station operation will be fragmented, and preclude many interchange opportunities (eg a Waterloo-Staines-Reading service will not connect with a Woking-Staines-Heathrow (& beyond) service).

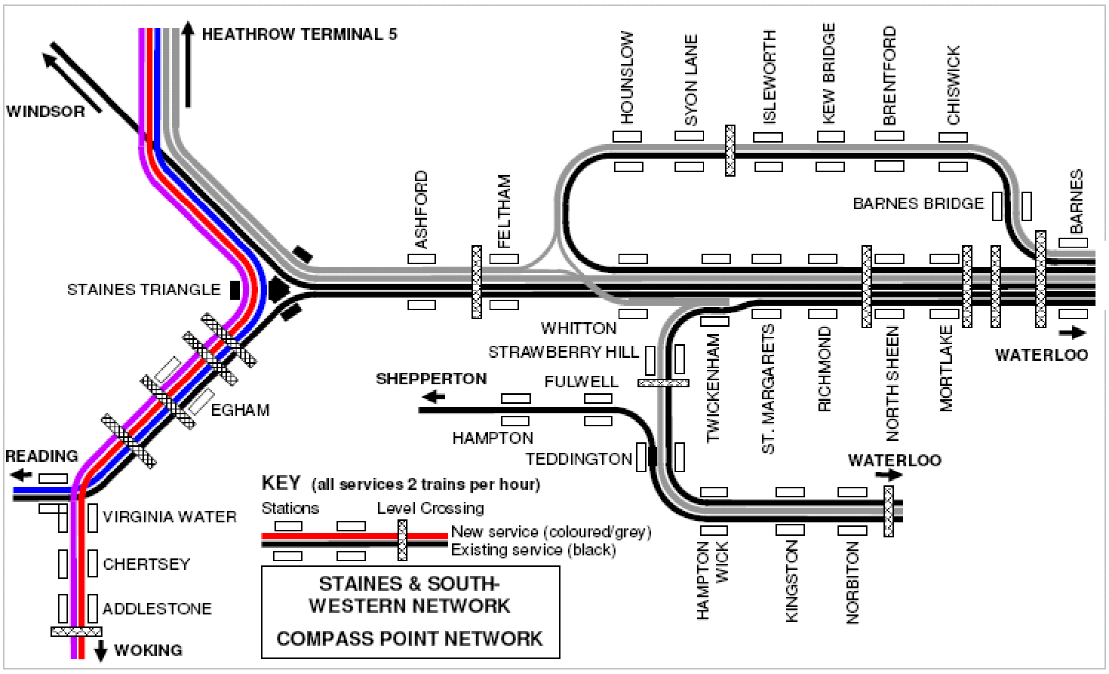

Figure 7.4

Interchange opportunities would be maximised with a new station constructed on the railway triangle at Staines.   This would avoid any local issues that might exist with the Staines High Street site, and would provide the town with a considerably more central station than the current site.   The major problem here is the severe curvature of the railway tracks, an unavoidable consequence of the geometry of the railway triangle. Innovative engineering will be required to mitigate the stepping distance (mind the gap!!) issues that currently preclude new platform constructions on tightly-curved track.

7.3 Northern Orbital Arm

The eastern, southern and western arms of the Compass Point network will involve little, if any 'new railway' that has not already been envisioned in other, already-established proposals. Thus far, the proposals advanced in this paper principally represent an integration and a rationalisation of existing schemes, and as such they would offer major improvements. But the most important gains – those of comprehensive local links and connections to the key main lines to the north – can only be achieved with a more fundamental redrawing of London's railway map.

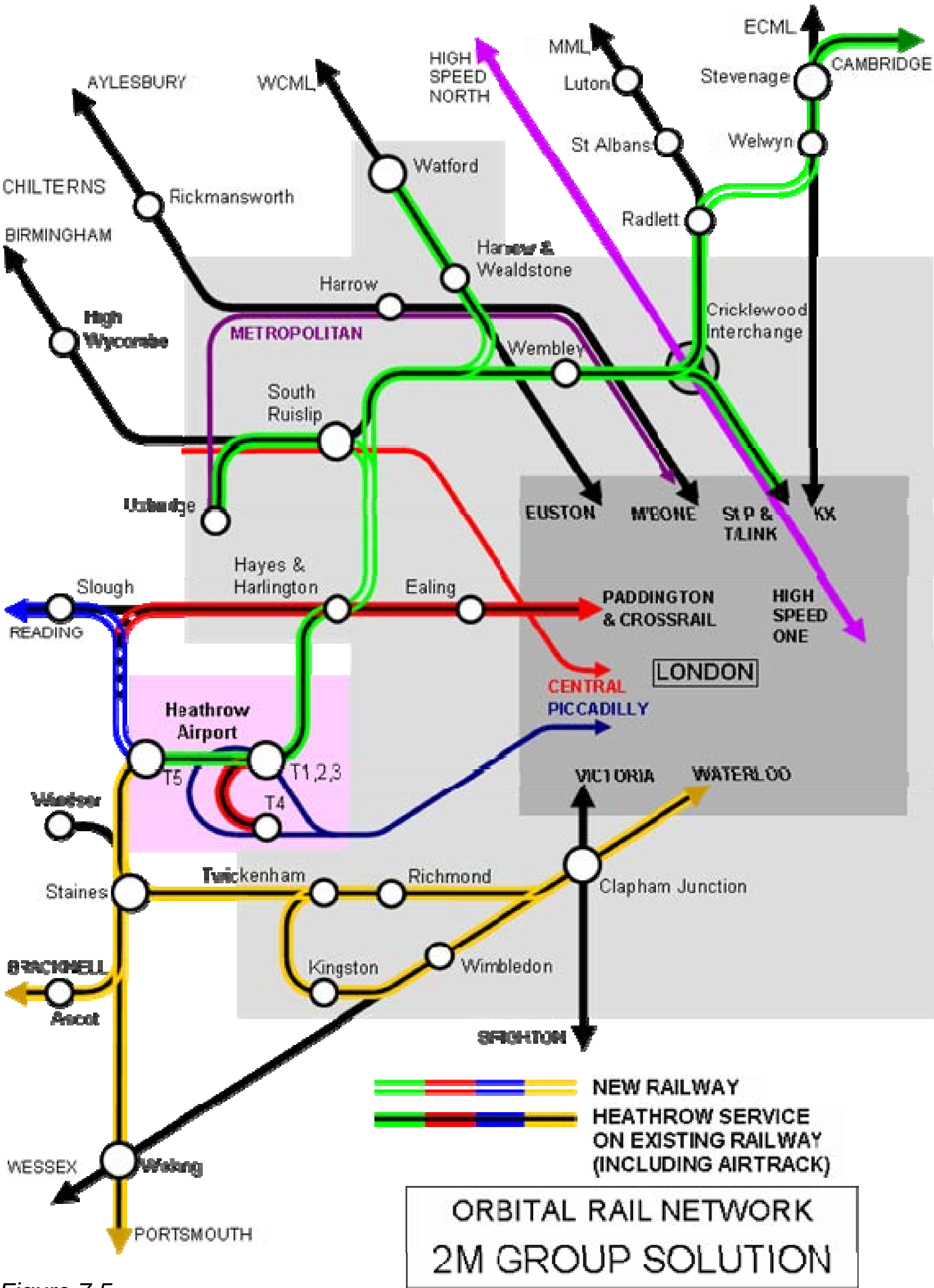

Figure 7.5

Various propositions have been advanced, to achieve main line rail access to Heathrow. Mostly, these have involved services from the WCML running into Heathrow by means of existing connections in the Willesden/Acton area, and then running westwards along the GWML. These propositions have never been developed, principally on account of the capacity constraints on the GWML which will only become more intense with the advent of CrossRail.

But a further valid criticism is the unbalanced nature of these proposed connections. It is surely as important to achieve connections to the Midland Main Line (MML) and to the East Coast Main Line (ECML).

Any worthwhile proposal for northern links from Heathrow must address capacity concerns on the GWML corridor, must achieve comprehensive main line connections – to WCML, MML & ECML – and additionally should offer optimised local connections. The only existing proposal that comes close to meeting this specification is the author's own Grand Junction Link scheme[21], for an orbital railway around the western fringes of the Greater London conurbation; this would be focused on Heathrow, and would provide links from Gatwick in the south to key western and northern main lines. These proposals have now been developed, with some modifications and simplifications, into the currently schemed Compass Point network.

With no simple means of enhancing capacity on the GWML (which in any case is oriented on an unfavourable east-west axis) it is proposed instead to follow a more northern, orbital alignment that will facilitate connection to the various main lines radiating from central London termini. Mostly, it is intended to follow existing rail corridors, with only limited new construction.

7.3.1 Local Links : Uxbridge and Wembley

A particular advantage of a direct northerly route from Heathrow is the improved links that can be provided to adjoining communities such as Ruislip, Northolt and Uxbridge. With new connecting spurs, it is proposed to direct local services from the airport via the Chiltern Line into Uxbridge (Met) station. With intermediate calling points at Hayes & Harlington (GWML) and South Ruislip (Chiltern), Uxbridge would be reconnected to the national rail network for the first time since the Beeching closures.

Another important local connection would be provided by virtue of Wembley – and the national stadium – being placed on the orbital route connecting Heathrow to the northern main lines. This would for instance allow foreign supporters flying to the UK to attend international sporting events to travel direct to the stadium without a circuitous journey via central London – and likewise travellers from the North en route to cup finals etc would have a greatly simplified journey, with a single change from either MML or ECML.

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[21] *Rails around London : In search of the Railway M25* (May 2001): by Colin Elliff, published by Institution of Civil Engineers (in Transport Journal). This proposes an orbital rail network around the west side of Greater London, focussed on Heathrow. Current proposals for the Heathrow Compass Point Network supersede certain aspects of the Grand Junction Link scheme detailed in this paper, which should be read for information only. See Bibliography Item 1.

7.4 Proposed Route of Northern Orbital Arm

The proposed route of the northern orbital arm is illustrated in Figure 7.6, and is summarised in the following bullet points:

1. The northern orbital arm will follow existing Heathrow Express route from central Heathrow terminals to Hayes & Harlington station on the GWML.
2. From a grade-separated junction east of Hayes & Harlington, the new alignment will run alongside A312 Hayes Bypass as far as White Hart roundabout at Yeading. After a short tunnelled section under suburban development, the new railway will cross the A40, and approach Northolt Junction from the south *(total new build length: 6km).*

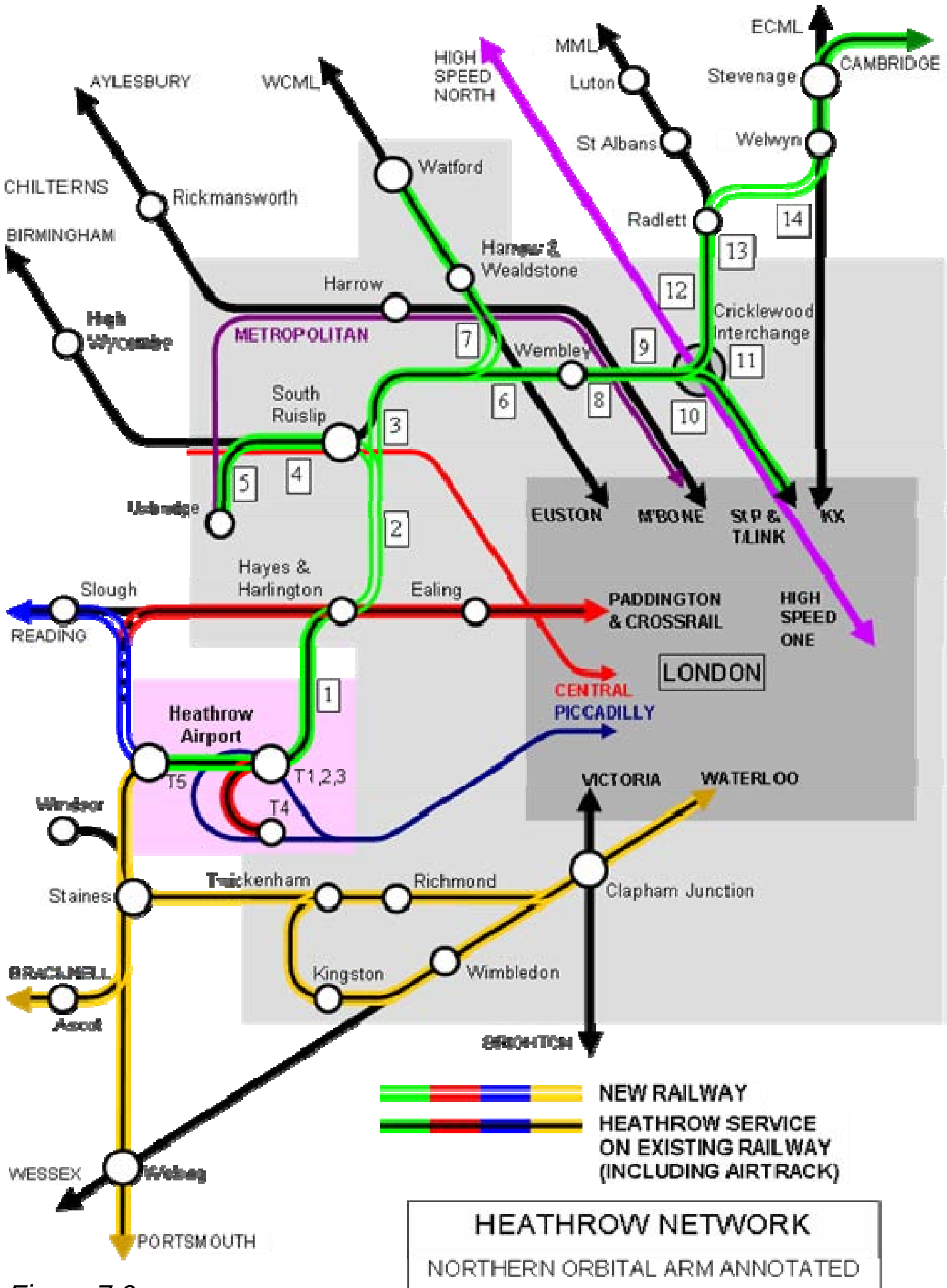

Figure 7.6

3. Northolt Junction currently comprises a complex intersection of Network Rail lines, with the LUL Central Line also present. The junction will be remodelled to accommodate the new flows from the south.
4. To the west, a spur will connect to the Chiltern network at South Ruislip and continue towards Uxbridge.
5. A further connection will be required near West Ruislip, to access the LUL Metropolitan Line into Uxbridge.
6. Heading north-east from Northolt Junction, the northern orbital arm will join the existing two-track Chiltern Line, and follow this route though Wembley as far as Neasden. With much of the line constructed to a four-track formation (although only two tracks were ever installed) there is considerable opportunity to enhance capacity if required.
7. Near Northolt Park, a spur will head to the north in tunnel under Harrow on the Hill, and join the WCML (DC Slow Lines) at Northwick Park, continuing to Watford Junction *(total new build length: 4km)*.
8. Neasden is the location of the junction between the principal Chiltern route from Birmingham, and the northern branch from Aylesbury. There is also a south-facing connection to the Cricklewood-Acton Wells freight-only branch, and additionally the LUL Metropolitan Line is also present.
9. At Neasden, the northern orbital arm will diverge from the Chiltern Line to the west of the junction (thus avoiding conflicts with the Aylesbury branch and the LUL Metropolitan Line), and follow a new spur to join the freight line towards the Midland Main Line at Cricklewood.
10. At Cricklewood the MML corridor accommodates four main lines, two freight lines, a train servicing depot and a considerable area of redundant sidings. This provides the ground plan necessary for the construction of a major interchange station. This would comprise a highly advantageous location, close to both the North Circular Road, and to its junction with the M1.
11. The new station at Cricklewood will offer interchange not just with the MML, but also with any new high speed line to the north (High Speed North or otherwise), constructed along the M1 corridor.
12. The northern orbital arm will head northwards from Cricklewood along the MML through Hendon and Mill Hill. Much of this route already comprises 6 tracks, to north of Hendon, but this will have to be continued through Mill Hill to accommodate both orbital and high speed services.
13. North of Mill Hill (and before the tunnels at Elstree), the high speed line will deviate to follow the M1. The Northern orbital arm will continue along the Slow Lines of the MML through Elstree & Borehamwood as far as Radlett.
14. At Radlett, a new alignment will swing to the east, and follow the M25 as far as London Colney. It will then continue eastwards to join the ECML near Hatfield at a grade-separated junction, from which point it will head north towards the key interchange at Stevenage *(total new build length: 10km).*

In summary, an entire west-to-north quadrant of an orbital railway can be created for a total new build length of 20km, with major junction construction at several sites.

7.4.1 Capacity Issues

There will be significant capacity concerns, but minor compared with the alternative problem of squeezing extra services onto the GWML corridor. Principal capacity issues are noted as follows:

- The northern orbital arm would be completely separated from GWML and WCML. This avoids the greatest potential capacity issues.
- Uxbridge Station already handles an intensive Underground service from both Metropolitan and Piccadilly Lines, on only 3 platforms approximately 120m in length. With this being less than the likely eight-car length of train that would generally operate on the Compass Point network, Uxbridge would seem unable to cope with either the length of the trains or their desired 15-minute frequency. These issues might be addressed by termination of perhaps half the services at South Ruislip, and by splitting eight-car trains into four-car units.
- As noted, there are likely to be capacity issues in adding eight trains per hour to the five already operating on the Chiltern Line. This is particularly significant in view of the requirement for speedy (perhaps 20-minute) and frequent transfers between Heathrow and the high speed line interchange at Cricklewood. With much of the railway originally constructed to allow for future four-tracking, it should be relatively easy to utilise this passive provision to create any extra capacity that may be required.
- Beyond Cricklewood Interchange, line capacity issues generally ease. On the MML section from Cricklewood to Radlett, an extra four trains per hour need to be accommodated. This should not pose serious problems, given that most MML intercity services would migrate to the high speed line.
- From Radlett to Cambridge, including 24km along the busy ECML between Hatfield and Hitchin, only two extra trains per hour are proposed. But while the majority of the ECML in this area comprises 4 tracks, this section includes the critical two-track bottleneck across Digswell Viaduct and through Welwyn North Station and the tunnels to the north. Capacity here is already critical and it may not be possible to sustain the addition of orbital services from Heathrow without major infrastructure works.
- It should be noted that if high speed rail to the north can be implemented simultaneously with the introduction of the Compass Point network, sufficient express traffic from the ECML would be transferred to the new high speed line to negate the capacity constraint at Welwyn. Similar capacity relief would apply on the MML.

7.5 Compass Point Network : Benefits for UK Rail Network

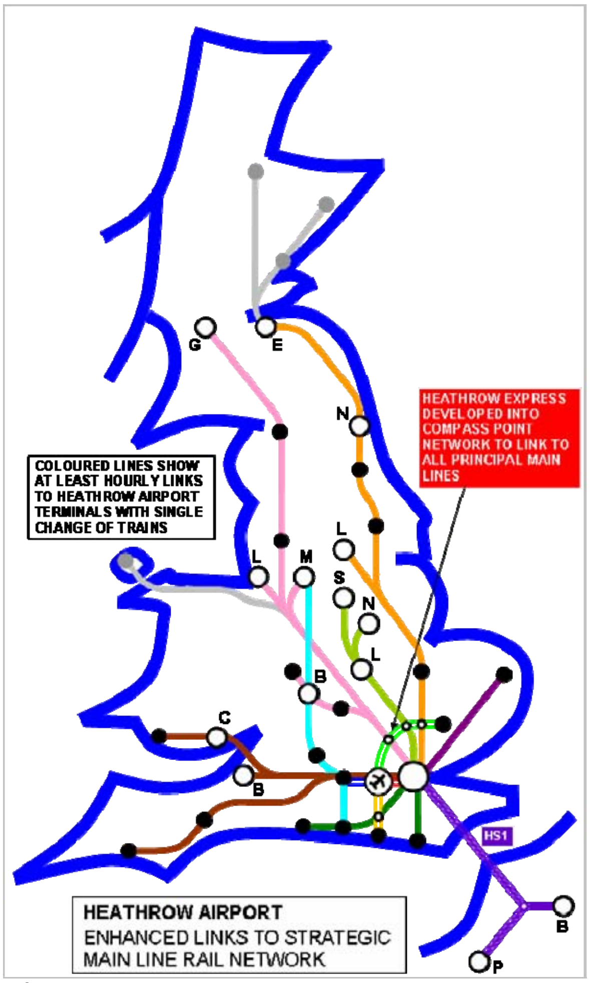

Figure 7.7

Most if not all principal UK centres already have at least hourly intercity services to London, a proportion of which currently stop at the outer-suburban hubs – Stevenage, , Watford, Reading and Woking. With the Compass Point network offering the potential for simple onward cross-platform connections to Heathrow (and beyond), these stations (and Cricklewood on the Midland Main Line) would become key calling points, with their status as outer-suburban hubs enhanced. These links are depicted in Figure 7.7.

The Compass Point network, if fully implemented, would at last provide effective and comprehensive links from the UK's premier international gateway to the UK hinterland. This would achieve the 'hub and spoke' model to which the aviation industry aspires – but with rail acting as the spokes, and achieving a level of connectivity not possible with aviation.

The logic of the Compass Point network is self-evident. Limited construction of new railways will achieve for Heathrow comprehensive connectivity on all axes, offering attractive sub-4 hour journey times to all major English and Welsh provincial centres. The new orbital journey opportunities created eg Cambridge to Reading, Watford to Portsmouth, Uxbridge to Richmond will offer a real alternative to road travel, particularly on the M25 axis, and bring major congestion relief. All this will bring major economic and environmental gains – and is achievable totally independent of high speed rail.

But although conventional rail can bring huge advantages in connecting Heathrow to its surrounding suburban area, and to the wider main line rail network, it is not sufficient in itself to extend the viable range of the rail network as far as Scotland to provide timings competitive with short-haul flights. If the associated environmental impact of Heathrow expansion is to be avoided, it is still necessary to develop high speed rail in the UK to complement improved local rail access.

8. UK High Speed Rail Development

The concept of a UK high speed rail network has long been discussed; but with the opening of High Speed One (HS1) to St Pancras in November 2007, there has been a marked intensification of the debate. Several definitive studies and schemes are now in existence, plotting the northward progression of high speed rail from London, potentially as far as Scotland. Prominent among these are the following:

- *High* Speed *Line Study* (2004): by Atkins, on behalf of SRA. Recently updated (March 2008) as *Because Transport Matters*. Bibliography Items 2 & 12.
- *High Speed Two – a Proposition by Greengauge21* (June 2007). HS2 concept developed with publication of *The Next Steps for high speed rail in Britain* (November 2007), promoting further high speed corridors. Bibliography Items 5 & 8.
- Various publications and press releases by Arups promoting Heathrow Hub concept (March 2008 *et seq*). Bibliography Item 11.
- *High Speed North : Joining up Britain* (July 2008): by the author, on behalf of 2M Group. High Speed North concept detailed further in article *High Speed Rail : Where are the Engineers?* (October 2008). Bibliography Items 14 & 16.

The Atkins work tends more towards a development of the concept of high speed rail and should not be regarded as promoting any specific scheme. Greengauge21's HS2, Arup's Heathrow Hub and the author's High Speed North comprise the major candidate schemes currently under consideration. The Government's HS2 Company is currently developing proposals that are likely to broaden the debate, when published.

It should not be surprising that these various proposals offer alternative strategies for the development of high speed rail in the UK, or that they are underpinned by radically different philosophies. But as high speed rail progresses onwards from outline concept, a decision will have to be made as to the particular strategy that should be adopted. Naturally, this has to be an informed decision, based on agreed robust criteria. In engineering terms, such criteria comprise a specification, which should be at the heart of any major project.

High speed rail represents a potentially huge engineering project, by far the most radical development of the UK rail network since the nineteenth century. In a broader transportation sense, it will be the most significant development of any description since the motorway building of the 1960's. It is vital that the massive multi-billion pound investment is correctly specified, and directed to deliver the optimum solution, prioritised for the greatest and most widespread benefits to UKplc.

But prior to any discussion of individual schemes, it is necessary to establish the principles of high speed rail development.

8.1 A Specification for High Speed Rail

With no current agreed specification for high speed rail, it is essential that one is formulated. The following suggestions indicate the broad criteria which should guide development. These issues are explored in greater detail in Appendix B:

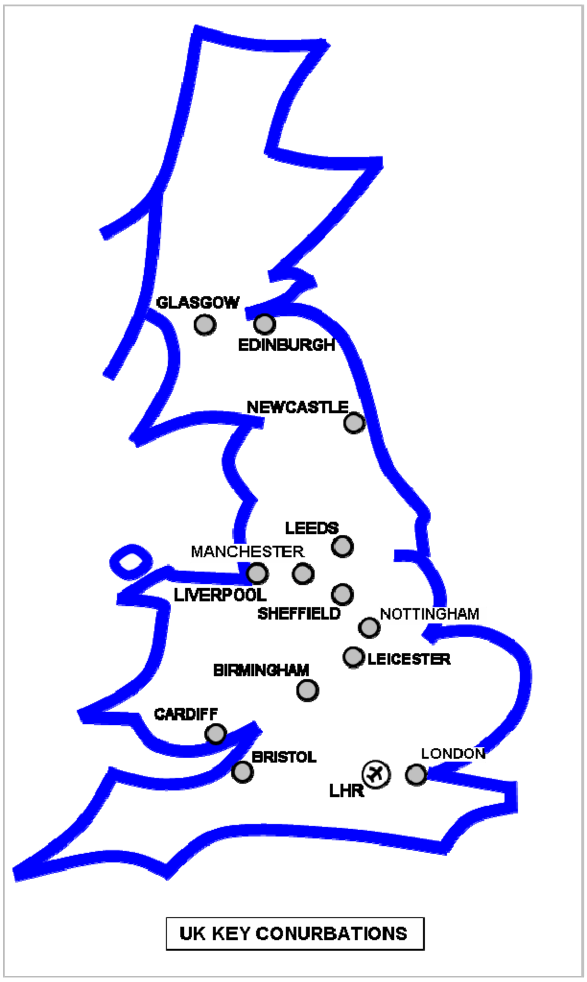

Figure 8.1.1

8.1.1 Coverage

Any high speed line system should build towards a comprehensive network covering all principal UK conurbations. Aside from London, the following 12 cities, all of around 400,000 population or greater, are suggested as comprising the hubs of the core network:

Birmingham, Bristol, Cardiff, Edinburgh, Glasgow, Leeds, Leicester, Liverpool, Manchester, Newcastle (upon Tyne), Nottingham and Sheffield.

See Figure 8.1.1.

8.1.2 City Centre Hubs

High speed rail operates at optimum efficiency as an intercity network handling high-volume flows between city centre hubs. All studies indicate that city centre access to an established hub at the fulcrum of an existing local public transport system is essential; by comparison, out-of-town parkways (even if located at airports) perform poorly, in terms of railway traffic generated, and general environmental and land use policy.

8.1.3 Dedicated New/Upgraded Railway

The core network must be able to accommodate modern duplex (double-decker) high speed trains emanating from the European network, operating at circa 300-350kph. These requirements of size (ie width and height) and speed are not compatible with any existing UK infrastructure (except HS1), hence it is necessary to either construct new lines or (largely for access to city centre hubs) to upgrade existing lines.

8.1.4 Network Development

Any high speed line proposal should comprise a logical incremental step in the ultimate formation of the required network. Although this is likely to be dominated by flows to London (with some continuing to the Continent) it is vital that the network is also configured to:

a) enable comprehensive inter-regional flows,

b) optimise regional rail access to Heathrow,

c) facilitate direct regional rail connections to Europe.

Such improved connections will optimise regional regeneration benefits and help redress the current economic ‘tilt’ of the UK towards London and the South-East.

8.1.5 Optimised Network

The aim should be to achieve the maximum network benefits (ie number of cities linked) for the minimum length of new construction. This in turn will minimise both costs and the CO_2 emissions associated with construction of the network.

8.1.6 Enhancement of Existing Network

It must be recognised that (aside from the deficiencies in rail access to Heathrow already discussed) there are other serious flaws in the existing UK rail network. The most serious is the lack of effective rail links between the conurbations of the North-West (ie Liverpool & Manchester) and Scotland (ie Edinburgh & Glasgow). These and other shortcomings should be addressed by the new high speed network.

8.1.7 Inclusive Routeing

The high speed network should be capable of delivery in an even-handed, incremental manner, not unduly favouring communities to either west or east sides of the Pennines, and thus maximising benefits. This is crucial to gaining the broad regional support essential for political acceptance.

8.1.8 Carbon Footprint / Sustainability

A huge project such as a high speed line network must be developed to contemporary carbon-critical design principles, to reduce emissions from the transport sector and rate of depletion of global fossil fuel reserves. For high speed rail, this is achievable by elimination of most UK internal aviation, and mode shift from road transport.

8.1.9 Environmental Impact

Environmental impact and demolition of property can best be minimised by following existing transportation corridors. This is essential for maintaining support from the environmental lobby, and also minimising NIMBY objections and consequent costs and delays.

8.1.10 Capacity Relief to Existing UK Rail Network

The proposed high speed line system should be oriented to optimise capacity relief to the existing network, on a maximum number of main line axes.

The UK rail network essentially comprises 7 key main line axes: East Coast (ECML), Midland (MML), West Coast (WCML), Great Western (GWML), CrossCountry, Transpennine, and Edinburgh-Glasgow. See Figure 8.1.2.

Establishing a new route exclusively along a single existing main line axis should be avoided, on account of the limited benefits that will accrue.

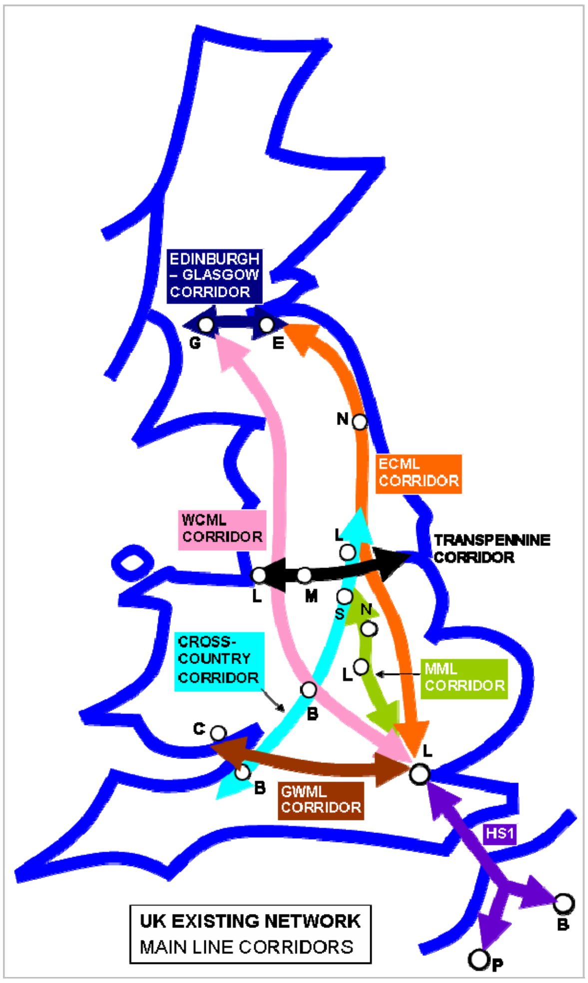

Figure 8.1.2

8.1.11 London Terminal Strategy

A practical site for a London terminal must be identified, with a strategy for dispersal of incoming passengers onto the wider Tube/suburban rail network, and for future-proofing against anticipated increases in passenger numbers. The strategy should also cover the route to clear the Metropolitan area with a minimised requirement for expensive tunnelled infrastructure.

A list of key selection criteria for the London terminal is set out in Appendix B. Similar (if lesser) considerations apply for other cities.

8.1.12 Compatibility with Heathrow developments

The HSL system should be configured to enhance rail access to Heathrow from the wider UK to:

a) eliminate requirement for internal connecting flights,

b) reduce local congestion,

c) achieve wider spread of economic benefits arising from proximity to Heathrow.

It is clearly desirable that the high speed line should call at Heathrow – but only if this can be shown to form part of a wider UK high speed solution, without compromising its fundamental viability or efficacy.

It is considered that these 12 points should constitute the fundamental requirements against which any UK high speed rail system should be assessed.

A simplified checklist *Ten Tests for High Speed Rail* is presented in Appendix F.

8.2 Greengauge21 : HS2 and beyond

Greengauge21 is an independent pressure group dedicated to the advancement of high speed rail in the UK. Their HS2 concept was launched in June 2007 with the publication of the paper *High Speed Two – A Greengauge21 Proposition*[22]. This proposes an initial stage of UK high speed line development, comprising an onwards extension of HS1 from London to the West Midlands, linking to the WCML north of Birmingham.

The purpose of HS2 is to provide journey time and capacity improvements along the 'North-West Corridor' between London, the West Midlands and the North-West. This is already the UK's busiest transport axis, and this is identified as the greatest priority for improvement. The shortcomings in Heathrow's surface access are also noted, and an additional requirement of 'interchange-free access to Heathrow' is introduced.

Greengauge21 have developed the 'HS2 proposition' to meet these requirements. This describes a 'candidate route' generally following the Chiltern/M40 axis from London to Birmingham and the WCML as an indicator of likely development of 'HS2', an extension of HS1 along the North-West Corridor from London.

The candidate route is described as starting from St Pancras (or Euston) and following the Chiltern Line corridor from London. A terminating branch will access Heathrow (Terminal 5) from the north (see Figure 6.4). The route will follow the Chiltern Line corridor through the eponymous hills, and then approach Birmingham from the south-east.

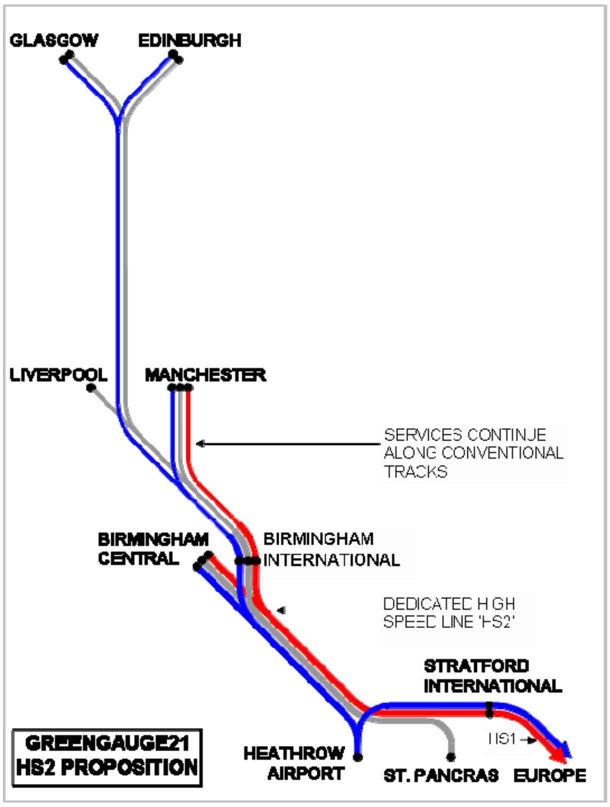

Figure 8.2.1, developed from Greengauge21 info

A branch will follow the existing Great Western line to the centre of Birmingham, probably terminating at Moor Street; but the main route will bypass the city on an M42 alignment, and join the WCML near Tamworth.

From here services will continue to the key WCML destinations of Manchester, Liverpool, Glasgow and Edinburgh (the latter via Carstairs in Clydesdale, rather than the usual ECML route). A station at Birmingham International Airport will provide northward connections from Birmingham.

An intricate pattern of services is proposed, as depicted in Figure 8.2.1. High speed services for WCML destinations will originate from either London, Europe (Paris, Brussels or Amsterdam) or Heathrow. The latter may be a continuation of a service to Heathrow from Europe.

The improvements that the Greengauge21 HS2 proposals would bring to Heathrow's connectivity to the national rail network are illustrated in Figure 8.2.2.

[22] Bibliography Item 6.

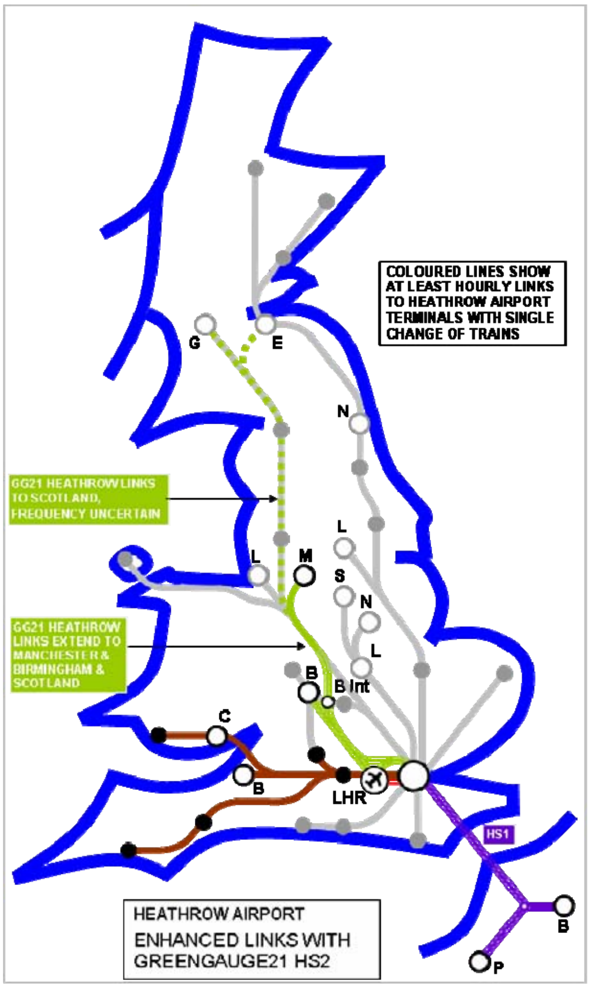

Figure 8.2.2

8.2.1 HS2 Service Frequencies

It should be noted that service frequencies on the proposed HS2 system are not defined. However, an approximation might be made as follows:

Possible HS2 service pattern (tph)	B'ham	Manchester	Liverpool	Edinburgh	Glasgow
Heathrow	2#	2		1	1
London	2	2	1	1	1
Continent (direct)	1	1			
Total	15 trains per hour				

Table 8.2.3

\# Figure based on Greengauge21 data for Birmingham City Council[23], matching figure assumed for Manchester.

8.2.2 HS3, HS4 and further High Speed Corridors

The candidate HS2 route proposed in *High Speed Two : A Greengauge21 Proposition* (June 2007) should not be regarded as the final form of any high speed line to the North-West. In November 2007, further proposals were published for a more comprehensive UK high speed system in *The Next Steps for high speed rail in Britain*[24]. This defined several 'high speed corridors' for further investigation. These are illustrated in Figure 8.2.4 (to right).

The 'Anglo-Scottish' high speed corridor would be an extension of either HS2 or HS3 (a term which appears to have gained common currency for an east-sided high speed line approximately following the ECML and MML corridors). It seems unlikely that more than one high speed line to Scotland would ever be built.

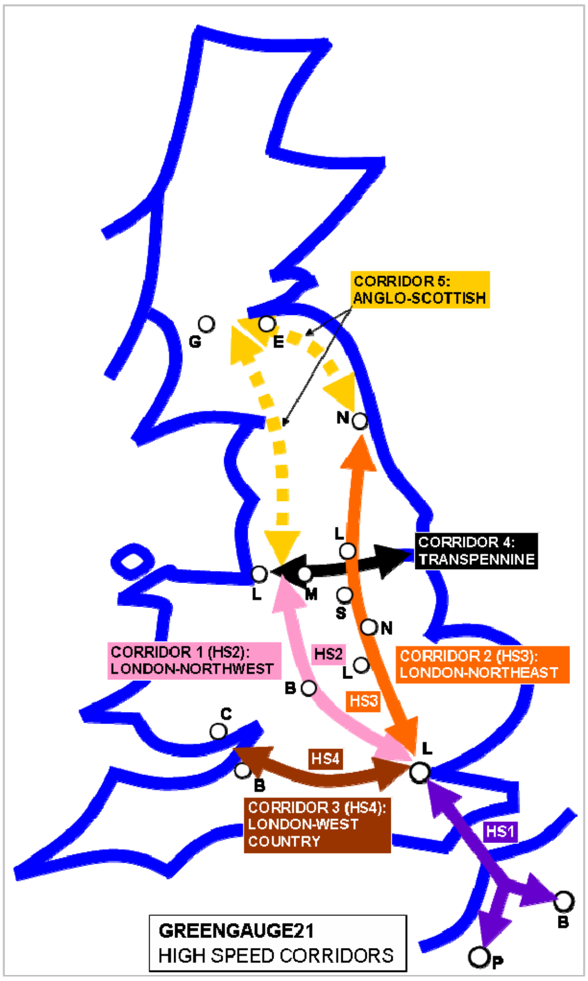

Figure 8.2.4

23 Bibliography Item 14.
24 Bibliography Item 9.

8.2.3 Concerns re Greengauge21 HS2 Proposals

The Greengauge21 strategy for UK high speed rail development raises several issues:

- Its initial concentration on the North-West Corridor effectively excludes east-sided communities, denied the advantages of direct links to Europe and Heathrow. These links – or even the prospect of such links – will give the West Midlands and the North-West powerful advantages in attracting inward investment, vital for recovery from recession. With the expense involved in new railway construction, and national resources that must be devoted to it, it is unlikely that an east-sided route could follow in less than 10 years. This will inevitably provoke intense regional opposition, and will prejudice the necessary political consensus for high speed rail development.

- Its focus on a single main line axis means that it can only bring capacity relief to that corridor. It should be noted that the WCML corridor has already been considerably enhanced, with over £11 billion spent on the recent West Coast Route Modernisation. This fact of itself will provoke further regional opposition.

- HS2 will tend to replicate the flaws in the existing West Coast network. All intermediate major conurbations – Birmingham, Manchester and Liverpool – are placed off the main line, and while all have strong southbound services (hourly or better) to London, northbound services are poor. There are only four direct trains per day between Manchester and Glasgow (both conurbations of over 1 million) and no direct services from Liverpool to either Edinburgh or Glasgow. This is a direct consequence of the WCML's avoidance of Manchester and Liverpool, and of a lack of significant intermediate population centres (with the exception of Preston).

  Greengauge21's HS2 seems unlikely to improve this situation. With high speed city centre alignments via Birmingham and Manchester prohibitively expensive, economics will dictate that HS2 will only provide relatively poorly-connected parkway stations (at Birmingham International and possibly Manchester Airport) to facilitate northbound connections.

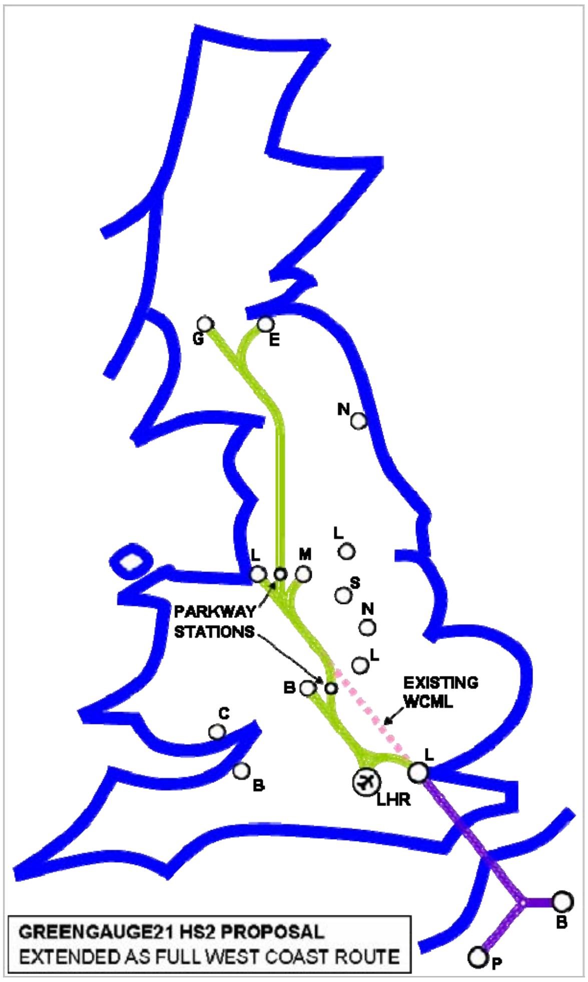

Figure 8.2.5

- A WCML-based route will bring about a London-centric system that will do little to provide the necessary interurban connectivity – or to reverse the continuing shift of the UK's economic centre of gravity towards London and the South-East.

- The self-imposed specification of 'interchange-free access to Heathrow' does not seem to be achievable, except possibly for passengers flying from Terminal 5. The terminus station – which will require a site large enough to handle frequent trains, up to 400m long, from Birmingham, Manchester, Paris, Brussels et al – is schemed to be sited at Terminal 5. Whether the station can be located sufficiently close (noting the intense surrounding development and the required size of the station) to allow easy transfer to the airport terminal remains to be determined. However, it will still be necessary for passengers en route to the other airport terminals – ie Terminals 1, 2, 3 & 4 – to interchange onto either Heathrow Express or the Piccadilly Line. For Terminal 4, two changes will be required.

- The M40/Chiltern corridor routeing that has been selected between Heathrow and Birmingham is certainly the most direct. But its passage through the Chiltern Hills will inevitably create huge difficulties. There are no easily achievable routes free of major environmental controversy. The alignment of the M40 is too tortuous to allow parallel high speed rail construction, and the existing Chiltern Main Line does not offer the necessary straight and unobstructed alignment. The only solution would seem to be a long and very expensive tunnel under the Chiltern Hills.

- The necessity of running separate trains to all major 'West Coast' conurbations from both London and from Heathrow will make it difficult to achieve the desired combination of attractive frequency and high load factor. Taken as a whole, the services postulated in Table 8.2.3 would appear to come close to the full line capacity for a two-track high speed line, around 15 trains per hour. For many routes – particularly from Heathrow – there will be political pressure to run frequent but fairly empty trains, imperilling business performance, future capacity to expand and the crucial 'grams of CO_2 per passenger kilometre' measure of environmental performance.

- There does not appear to be the traffic to justify the proposed pattern of dedicated high speed services to Heathrow. See Figure 8.2.2 and Table 8.2.3. For instance, Greengauge21 propose two airport trains per hour to run non-stop from Birmingham city centre. Yet Greengauge21's own figures[25] show a total demand of 300,000 travellers per year on this route, or around 1000 per day (as opposed to 3,900,000 projected from Birmingham to central London). On a 16-hour day of airport operation, this averages at 62.5 passengers per hour. This is not a level of patronage that can justify such services, either from a business or environmental point of view. This would seem to demonstrate that uniaxial long-distance services (high speed or otherwise) are not the appropriate means by which rail can draw in large volumes of passengers to Heathrow.

- A similar concern applies for longer-distance services to Heathrow from Edinburgh and Glasgow. The passenger flows that will be attracted to these services can be assessed approximately from existing air flows to Heathrow, duly modified to take account of only of passengers transferring to longer haul flights (passengers en route to central London would have no reason to travel to Heathrow). 35 flights per day from Edinburgh and Glasgow airports loaded with perhaps 120 passengers on average amounts to 4200 per day. With around

[25] Research carried out by Greengauge21 for Birmingham City Council in support of HS2 Proposition, presented at conference on 13th June 2008 at Birmingham. Bibliography Item 14.

50% on Scottish flights are transferring to longer haul, this only adds up to 2100 passengers per day from both Edinburgh and Glasgow. This figure would increase by perhaps 50% with limited pick-ups en route – eg at Preston and Birmingham International – and greater efficiencies might be achieved by combining both Scottish services at Carstairs. But it is difficult to see sufficient passenger number accruing to make an hourly limited-stop service viable.

Although there is inevitably a high degree of speculation involved in the calculation of passenger flows between Heathrow and North-West Corridor destinations in the foregoing paragraphs, there is a degree of consistency with Heathrow's surface access statistics, as discussed in Item 2.3. With suitable adjustment to allow for suppressed demand on south, west and north axes (ie clear of central London) a passenger flow of approximately 35,000 per day can be adduced to wider UK destinations. Much of this figure – probably well over two thirds – is bound either for relatively local destinations which cannot be covered by high speed rail, or for more distant locations not convenient for the limited number of stops on a high speed system. The remainder, of around 12,000 passengers, might then equally distribute to West Coast, East Coast and Great Western axes (or HS2/HS3/HS4). This accords with the foregoing calculations which have attributed between 3000 and 4000 passengers per day from the North-West Corridor (excluding Scotland).

8.2.4 Concerns re Greengauge21 'Next Steps' Strategy

A more balanced approach might be achieved with further high speed rail development along the five corridors defined in Greengauge21's *Next Steps* document. But major regional political issues seem certain to arise in the order in which the lines are built. Assuming a 'West Coast' HS2 to be built first as far as Manchester and Liverpool, there would be intense pressure for an 'East Coast' HS3 to follow, before further-flung goals such as Scotland are reached. This would inevitably delay or even imperil the eventual realisation of a comprehensive UK high speed line system.

The proposed strategy also appears to be excessively London-centric. Of all the corridors under consideration, only Transpennine would offer effective inter-regional connections. With the competing pressures of developing high speed lines to the North-West (HS2) to the North-East (HS3), to Scotland (HS2 or HS3) and to the West Country (HS4) – all of which are likely to have better business cases than Transpennine – there seems to be little prospect of a genuine UK high speed network developing.

Of particular concern is the omission of a CrossCountry corridor from Greengauge21's deliberations; of all UK main line axes, it is CrossCountry that does most to tie the system together to form an effective network.

In summary the Greengauge21 proposals appear to offer an incomplete vision for a UK high speed rail future and would not provide an effective and timely alternative to expansion at Heathrow.

8.3 Arup : Heathrow Hub and beyond

The Arup proposals for UK high speed rail development are similar in concept to Greengauge21's HS2, oriented towards the North-West Corridor and placing Heathrow at the heart of a future UK high speed system. The principal point of difference from HS2 is the creation of Heathrow Hub, a rail interchange located on the Great Western Main Line north of the airport, just beyond the current limits of London's suburban development and close to the M25.

Heathrow Hub received a level of official endorsement in the recent Government announcement of support for Heathrow expansion.

HEATHROW HUB : SCHEME LAYOUT

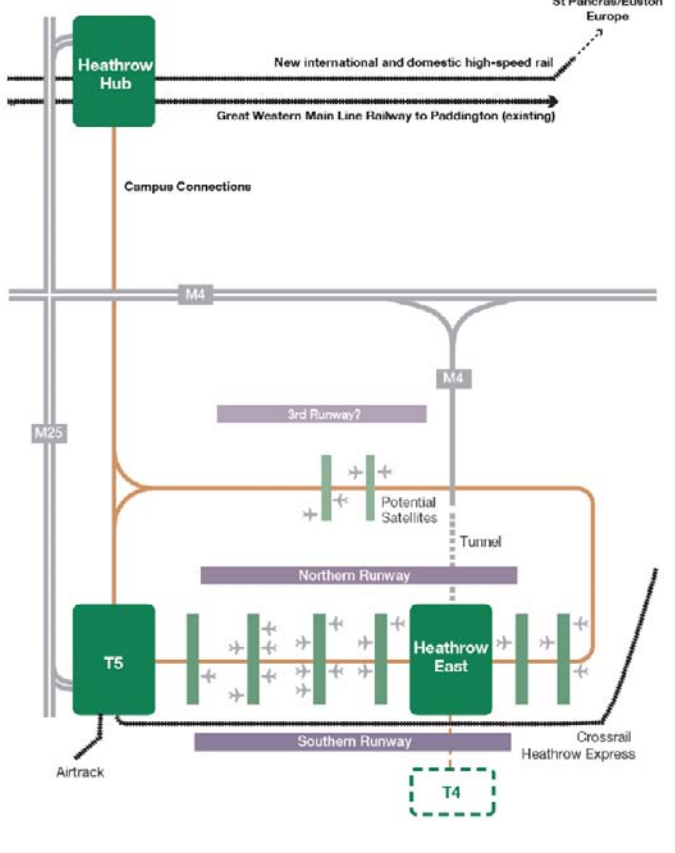

Figure 8.3.1
(reproduced from Arup publicity material)

The initial phase of the Heathrow Hub project will comprise four principal elements, as indicated in Figure 8.3.1[26]:

- a 25km long tunnel from central London.
- a multi-platform interchange station on the GWML between West Drayton and Iver.
- further electrification of the GWML, extending to Oxford and Basingstoke.
- a new tunnelled system of distributor railways/people movers to provide access to the various airport terminals.

A £4.5 billion cost[27] has been estimated for the first three elements of the Heathrow Hub scheme. The works for the tunnelled distributors are not included. Comparison with the cost estimates in Appendix E indicates a figure of around £2.5 billion for the tunnel and the hub station; with another £250 million allowed for the electrification works, it would appear that the £4.5 billion figure includes DfT 'optimism bias' (of 66%). Allowing a notional price of £1 billion for the tunnelled distributor works, a price of around £3.5 billion might be adduced for Arup's proposed high speed rail access to Heathrow.

Prior to onward development of high speed rail to the north, Heathrow Hub will function as the western terminus of HS1, with the Eurostar service from Paris and Brussels extending from St Pancras. This will allow interchange with Great Western local and intercity services to Wales and the West Country; but the primary purpose of Heathrow Hub is to facilitate high speed rail access to Heathrow Airport.

[26] Various Arup publicity material. Bibliography Item 12.
[27] *Modern Railways* (July 2008). Bibliography Item 22.

8.3.1 Heathrow Hub : Network Development

There is no definitive blueprint for how the northward development of the high speed system would proceed. Publicity material[28] (see Figure 8.3.2) indicates a route to the North-West and to Scotland almost identical to Greengauge21's HS2, and a route to the east side of the Pennines, deviating from HS2 in the Warwick area.

However, all indications are that development of a route to Birmingham and Manchester is seen as the initial priority. It should be noted that links to Wales and the West Country are also shown, but these are indicated as a connection to the HS1/HS2 system at Heathrow Hub, not as a new railway or as a through route.

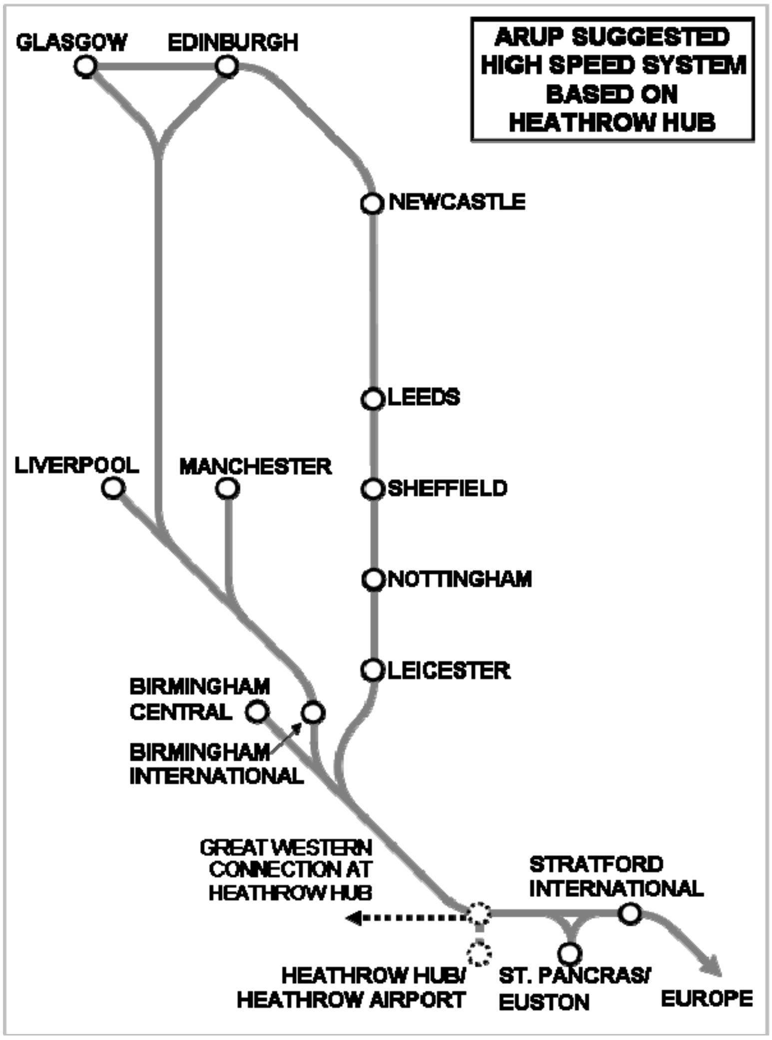

Figure 8.3.2
(developed from Arup publicity material)

With no defined northward route, any commentary on this aspect of the Arup proposals is of necessity speculative. The issues surrounding a North-West Corridor route via Heathrow have already been discussed in the review of the Greengauge21 HS2 proposals. If the east side of the Pennines is to be preferred[29], then the comment must be made that a (say) Yorkshire to London routeing via Heathrow is unnecessarily circuitous, with journey times for the many (over 90% of passengers[30] will be en route for London or the Continent) lengthened by 10 minutes or more for the sake of the few (less than 10%) en route to Heathrow.

The ability of the combined system of east and west routes to comprise a viable inter-regional network is assessed in Section 10. It should be noted that the system depicted in Figure 8.3.2 might deliver a degree of CrossCountry connectivity, but Transpennine flows would not be addressed in any way.

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[28] Bibliography Item 12.

[29] The recent Atkins study *Because Transport Matters* indicates that with the improvements achieved under the West Coast Route Modernisation, an east-sided high speed route to the East Midlands and Yorkshire will deliver greater economic benefits. Bibliography Item 13.

[30] Figures projected from Greengauge21 research. Bibliography Item 14.

8.3.2 Heathrow Hub : Specific Concerns

It is possible to make a number of observations about the detailed impact of the Heathrow Hub proposals:

- Given Heathrow's current poor rail access, with no effective links to any of the northern main lines, it seems perverse that the first development of high speed rail beyond London will achieve better airport access for the residents of Paris and Brussels than for (say) Manchester or Leeds. See Figure 8.3.3 to left.
- Even when extended to Birmingham and Manchester, only very limited improvements to Heathrow's rail connectivity will be achieved. See Figure 8.3.4 below.

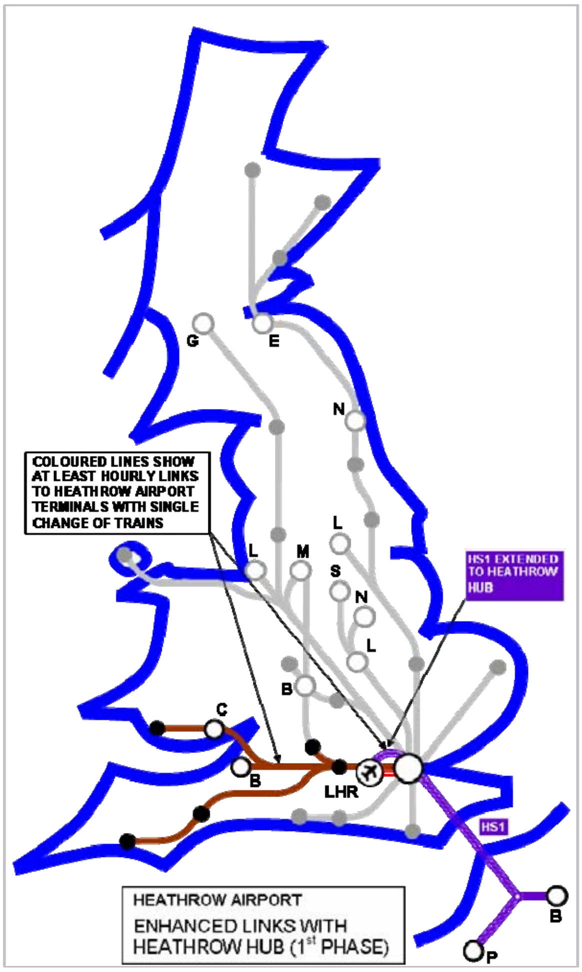


Figure 8.3.3

- The new tunnelled distributor network, linking Heathrow Hub with the various airport terminals, is an effective duplication of the Heathrow Express system which already achieves superior access to all airport terminals. Of itself, this new distributor network represents a huge engineering project, and it will only be realised with major disruption to airport operations. Its rationale appears to stem from the location of the Heathrow Hub site, of necessity occupying a large area of Green Belt land (an issue in itself) clear of existing suburban development – and clear of the existing Heathrow Express route that might otherwise have provided access to airport terminals.

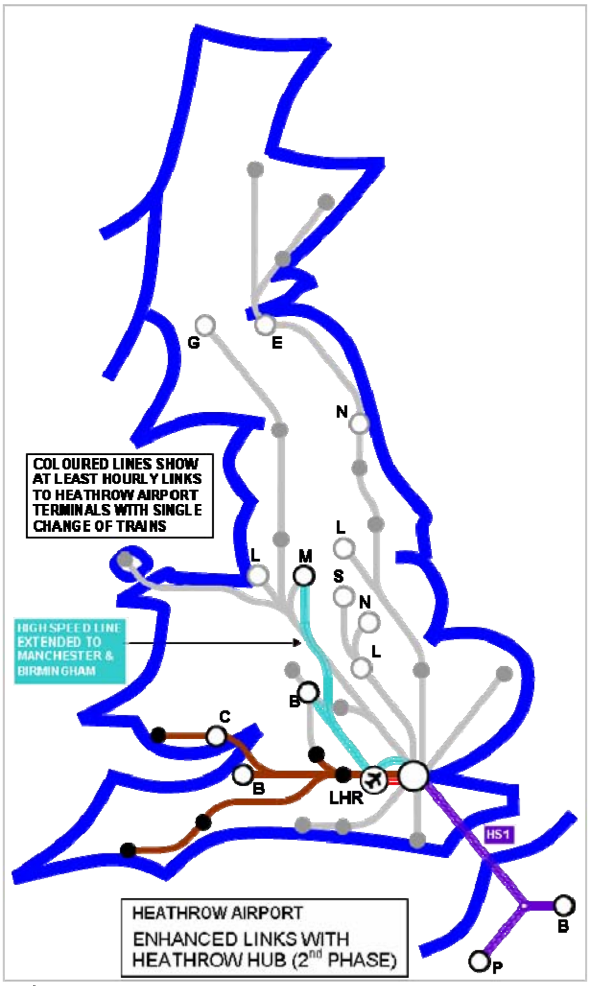


Figure 8.3.4

- The expansive nature of the station site is of course the consequence of the desire to make Heathrow (Hub) the focus of a future UK high speed system. But if the requirement were merely to facilitate airport access from the Great Western network, then the interchange could be located at a suitably upgraded Hayes & Harlington station, to make the connection to Heathrow Express. With no new railway (or other transport system) to construct, this could be achieved at a fraction of the cost of Heathrow Hub.
- To devote £3.5 billion to an extension of HS1 that does not even leave the Metropolitan area appears to be badly missing the fundamental point of high speed rail – to improve intercity communications – and indeed may imperil further developments, HS2 or otherwise. Less than twice this sum of money could pay for a high speed line 200km long from London to Leicester and Birmingham (assuming a simpler M1/M6 routeing not predicated upon Heathrow) that would deliver far greater benefits. See Appendix E.

8.3.3 Viability of Heathrow Hub

A more fundamental question now emerges, that of the basic viability of bringing a high speed line to Heathrow Airport. So far, this issue seems to have been taken as an axiomatic truth, and has not been seriously examined. With the Heathrow Hub concept so enthusiastically endorsed by the Government, the only critical reaction has come from the environmental lobby, who have simplistically assumed that it will serve to funnel more passengers into Heathrow, leading to a greater demand for flights.

But this assumption (entirely understandable) also needs to be challenged. The only passengers arriving via Eurostar trains extending to Heathrow Hub will be from Paris and Brussels. This will be a relatively small proportion of the total passenger load, most of whom will disembark at St Pancras. There is no definitive data from which this proportion can be precisely calculated, but a rough estimate can be made from the Greengauge21 data[31] for trips from Birmingham to London.

This indicates that only 7% of Birmingham – London passengers on HS2 would be en route to Heathrow. The figure is as high as 7% because of Heathrow's attraction as a hub airport with a far wider range of flights than Birmingham's own airport. But for residents of Paris and Brussels, with their own hub airports (and Amsterdam's Schiphol) much closer, there would seem to be little incentive to make a long train journey to Heathrow. A proportion of 3.5% has been assumed of the existing Eurostar service of 48 trains per day (two per hour from Paris, one from Brussels, over the 16 hour period during which Heathrow is open each day). With Eurostar trains having 750 seats, and typically operating at 60% load factors, this amounts to a total of 756 current Eurostar passengers per day remaining on the train beyond St Pancras.

It might then be optimistically assumed that all current air flows from Paris and Brussels to Heathrow are converted to rail. This amounts to 32 planes per day generally of Boeing 737 / Airbus A320 size (circa 150 seats), typically operating at 80% load factor. This amounts to 3840 passengers per day. These journeys fall into three categories:

- Intercity trips from Paris/Brussels.
- Onward connections from intercontinental flights landing at (say) Paris CDG.
- Connecting flights to intercontinental departures from London.

Only a Eurostar passenger falling into the final category would need to stay on the train beyond St Pancras. If an equal three-way split is assumed, a further 1280 passengers would become beneficial users of the extended Eurostar service.

[31] Bibliography Item 14.

Finally, it is reasonable to consider Eurostar passengers wishing to take advantage of the new connection to the Great Western network at Heathrow Hub.   Numbers can best be estimated from the existing air flows from Paris and Brussels to Bristol and Cardiff (again a complete air to rail conversion is assumed, for a rail journey of around four hours).   With a total of ten flights per day (assumed to be a mixture of 737s and smaller aircraft operating at 80% load factor), another 900 daily passengers might accrue.

This suggests a combined total of 2936 passengers per day using the Eurostar service extending beyond St Pancras to Heathrow Hub.   'Fringe users' eg Great Western passengers en route to Heathrow, who could equally well transfer to Heathrow Express at an enhanced Hayes & Harlington station, or passengers on any domestic Heathrow-bound service which might instead be routed into the airport via Heathrow Express are not counted.   This accords with standard principles of marginal cost accounting.

If an interest rate of perhaps 6% is assumed, then the daily cost of servicing the £3.5 billion investment (as previously calculated in Item 8.3) can be calculated as £580,000. Spread among the 2936 daily beneficial users, this works out at around £200 per person.   This sum – which must be regarded as a minimum, given the optimistic assumptions that have been consistently used in calculating passenger flows – would have to be charged either as a fare, or as a subsidy.

8.3.4 Comparison with High Speed North

It is readily conceded that the figures in the preceding calculation are somewhat speculative, albeit based upon educated guesses and extrapolations of existing research; they do not comprise a rigorous business case analysis of the type required to develop robust benefit-to-cost ratios, et al.   But if the same arbitrary criteria are applied to other schemes, it is reasonable to assume a good degree of accuracy in the comparison (if not in the absolute figures).   Hence it is possible to assess the fundamental viability of the Heathrow Hub proposal by comparison with a similar cost breakdown for an intercity high speed rail scheme not predicated upon Heathrow access.

A first stage of the High Speed North scheme (described in greater detail in Section 9), extending northwards along the M1/M6 axis to Birmingham and Leicester, has been estimated as costing around £7 billion.   The new line on this orientation would bring capacity relief to both West Coast and Midland Main Line corridors.   Taking the Greeengauge21 figures of 3.9M high speed rail passengers from Birmingham to central London, and extrapolating to take account of Manchester, Liverpool, Leicester, Nottingham and Sheffield, a total traffic figure of 15M passengers per annum might be assumed.   These figures translate to an 'interest' cost of £1.1M per day, and around 40000 passengers per day – or a £30 cost per person.   This is less than one sixth of the cost of the notional 'fare' to Heathrow Hub – and easily sustainable within the fares that would be charged.

This would seem to demonstrate that the inherent strategy in the Heathrow Hub scheme (and in the Greengauge21 HS2 scheme) – to make Heathrow the focal point of UK high speed rail development, in preference to wider intercity network coverage – is flawed.   It is based on the false premise of major high speed rail flows to Heathrow.

For the rest of the UK, Heathrow Hub has the serious disadvantage of delaying and compromising the roll-out of high speed rail to the regions.   Instead it places the crucially-important first UK route on an excessively westerly alignment only of use to serve the North-West Corridor and invites major controversy in adopting a route through the Chilterns.   Overall it seems to offer poor value for money.

SUMMARY OF THE REMIT AND OBJECTIVES OF HIGH SPEED TWO

On 15 January 2009 the Secretary of State for Transport announced in 'Britain's Transport Infrastructure: High Speed Two', the setting up of a new company to look at a possible new railway line between London and the West Midlands.

HS2 was set up shortly after as a private company limited by guarantee. It is chaired by Sir David Rowlands and Alison Munro was seconded from the Department of Transport as Chief Executive. The rest of the HS2 team comprises further secondees from the DfT and from Network Rail

HS2's remit is to develop proposals for a new railway line from London to the West Midlands taking account of environmental, social and economic assessments. It will also provide advice to Ministers on the potential development of a high speed line beyond the West Midlands at the level of 'broad corridors, considering in particular the potent to extend to Greater Manchester, West Yorkshire, the North East, and Scotland.

HS2 will make recommendations on options for a terminus station or stations serving London and possible options for an intermediate parkway station between London and the West Midlands. It will also provide a proposal for an interchange station between HS2, the Great Western Main Line and Crossrail with convenient access to Heathrow airport. HS2 will also provide suggested means of linking to HS1 and the existing rail network. .

HS2 will produce a confidential report to Ministers by the end of 2009 that should be sufficiently developed to form the basis for public consultation in 2010 should Ministers decide to take this project forward. The advice will also include financing and construction proposals as well as a proposition for how best to move through the planning process within an indicative outline timetable

Figure 8.4.1 – DfT HS2 Company Remit and Objectives (reproduced from HS2 July newsletter)

8.4 Department for Transport / 'HS2' Company

The Department for Transport has recently established the 'HS2' Company to examine options for the development of high speed rail in the UK. It is due to report in December 2009, and as yet, no definitive proposals have been published. But the *Summary of the Remit and Objectives of High Speed Two*[32] defines the immediate objective of a high speed link between London and the West Midlands, with consideration of onward development, specifically Greater Manchester, West Yorkshire, the North East and Scotland.

The HS2 Company is also remitted to investigate options for a London terminus (or termini) and, very specifically, to provide a 'proposal for an interchange station between HS2, the Great Western Main Line and Crossrail, with convenient access to Heathrow Airport'. HS2 will also 'provide suggested means of linking to HS1 and the existing rail network'. See Figure 8.4.1.

8.4.1 Possible Routeing Strategy

The interchange station cited in the HS2 Company's remit is clearly the well-trailed proposal for a major station to be located at Old Oak Common on the Great Western Main Line, 5km west of Paddington. This appears to be setting the favoured route of the new high speed line to follow the M40/Chiltern corridor en route to Birmingham, probably with a bypassing alignment for the extension further north.

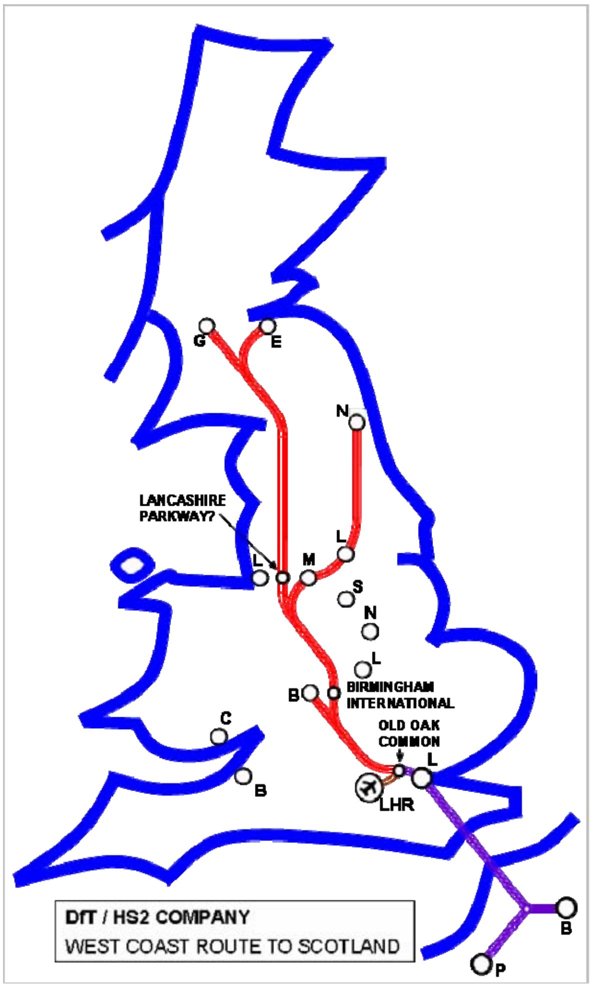


Figure 8.4.2

Issues surrounding such a route have already been examined in detail in other sections of this study, and do not require further discussion. The more important issue is the question of onward routeing to destinations further north. As noted, Greater Manchester, West Yorkshire, the North East and Scotland (presumably Edinburgh and Glasgow) have been cited as primary destinations. But the real significance is in the regions that have been omitted from the list.

Aside from Liverpool/Merseyside (which could easily be served by a short spur from the main high speed route to Manchester) the most glaring omissions are the East Midlands and South Yorkshire regions. Noting the inclusion of West Yorkshire and the North-East, directly to the north of these 'excluded' regions, the only possible routeing strategy that can be deduced is an intention to connect Leeds and Newcastle to the developing high speed network line by means of a Transpennine route, extending from Manchester.

[32] Bibliography item 20.

This then suggests two possible configurations of a UK high speed system:

- a west-sided 'WCML' alignment to Scotland, and a subsidiary Transpennine branch to Leeds and Newcastle (see Figure 8.4.2).
- a 'reverse-S' Anglo-Scottish route, via West Midlands, Manchester, Leeds, Newcastle, Edinburgh and Glasgow (see Figure 8.4.3).

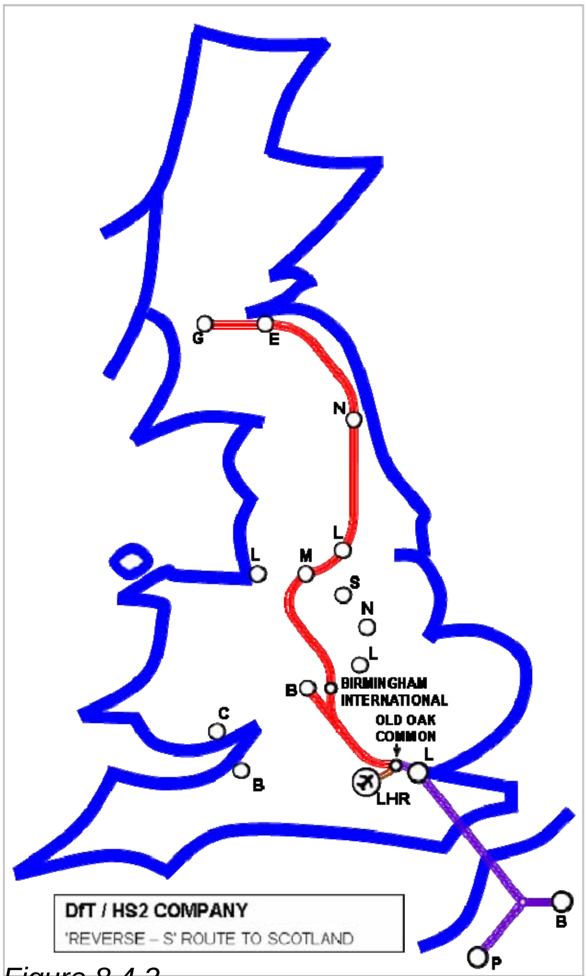


Figure 8.4.3

Such a routeing strategy would raise several concerns:

- The obvious exclusion of the East Midlands and South Yorkshire would raise intense regional opposition, and would threaten the necessary national consensus essential to make high speed rail happen. Although congestion on the Midland Main Line (which serves both regions) is not as severe as on the WCML axis to Birmingham and Manchester, these regions would gain greatly from having direct access to the high speed line network, with enhanced links to London and onwards to the Continent.

  If oriented correctly, the high speed line might enhance the regions' links to other parts of the UK. Such improved connectivity would assist greatly in attracting inward investment and in promoting recovery from recession.

- The circuitous routeing inherent in the west-to-east Transpennine crossing would add approximately 80km to the distances, and up to 25 minutes to the journey times to Leeds and Newcastle – and to Edinburgh and Glasgow, if the 'Reverse – S' option were chosen. See calculations in Appendix E, and tabulations in Section 10. Whilst all of these timings represent a considerable improvement on what is currently possible on the existing main line network, it is evident that much improved timings could be achieved through a direct 'east coast' routeing.

- In the case of the 'Reverse – S' option, these increased timings would have the serious effect of increasing the journey time from London to Glasgow by at least 15% (above the next slowest route) to well over 3 hours. This would to a significant extent imperil the competitive position of high speed rail over short-haul aviation on this key Anglo-Scottish route. It would of course be possible to make good this timing deficiency by the expedient of running the trains faster (from circa 300kph to 350kph); but this 15% increase in speed would imply an increased energy usage – and carbon footprint – of around one third. This would have serious implications for the 'green' credentials of high speed rail.

- The issue of unduly increased timings to the time-sensitive Scottish destinations would of course be eliminated if the more direct 'west coast' route from Manchester were selected. The problem with this option is the more precarious business case, with no significant population centres north of Preston, and the split between Edinburgh and Glasgow routes at Carstairs, that would compel the running of separate trains to the two Scottish cities. This split would also affect the achievable load factor, and thus imperil environmental as well as business performance.
- Major problems would arise in the placing of both Manchester and Leeds on through routes to time-sensitive destinations further north. There are no feasible surface alignments for high speed traffic through either city, and the result would either be highly expensive tunnelled alignments to reach city centre hubs, and still more expensive construction of underground stations – or alternatively environmentally and operationally undesirable parkway stations on the outskirts. Even this latter option might be very difficult to achieve in the crowded suburbia to the south-east of Manchester, where it is presumed that a high speed line would have to pass, en route to a suitable crossing point of the Pennines.

It is to be hoped that the HS2 Company can develop a routeing strategy that will avoid the above issues.

8.4.2 Possible London Terminal at Old Oak Common

As already noted, the most significant aspect of the HS2 Company's work so far to emerge is a reported preference for a London station, to be located on the Great Western Main Line at Old Oak Common, 5km west of Paddington. This comprises a largely redundant railway site with ample space to construct a multi-platform station. Figure 8.4.4 indicates an approximate location for the Old Oak Common terminal.

The station is primarily intended to provide an interchange between HS1, HS2, the Great Western Main Line and Heathrow Express/ CrossRail. Certain press reports indicate that there is consideration of it also comprising the effective London terminus of HS2.

The following commentary is not intended to pass judgement on the work or intentions of the HS2 Company – which of course has yet to report to Government – but rather, to consider the Old Oak Common proposal in its reported possible role as London's domestic high speed station, as a 'negative exemplar' to illustrate the vital importance of a well-connected centrally-located terminal.

Figure 8.4.4 demonstrates the major problems with the Old Oak Common proposal, if it were to comprise London's domestic high speed terminal – its remote location with respect to central London, and its relatively poor links to London's local rail network. A further problem is its isolation from London's arterial road network.

The scale of the potential problem can be appreciated from a simple comparison with St Pancras International, agreed by all as comprising a rail terminal of the highest quality, and already achieving commensurate commercial success. This is centrally located, served by Thameslink and five different Underground lines, and fronts onto Euston Road, one of London's principal thoroughfares.

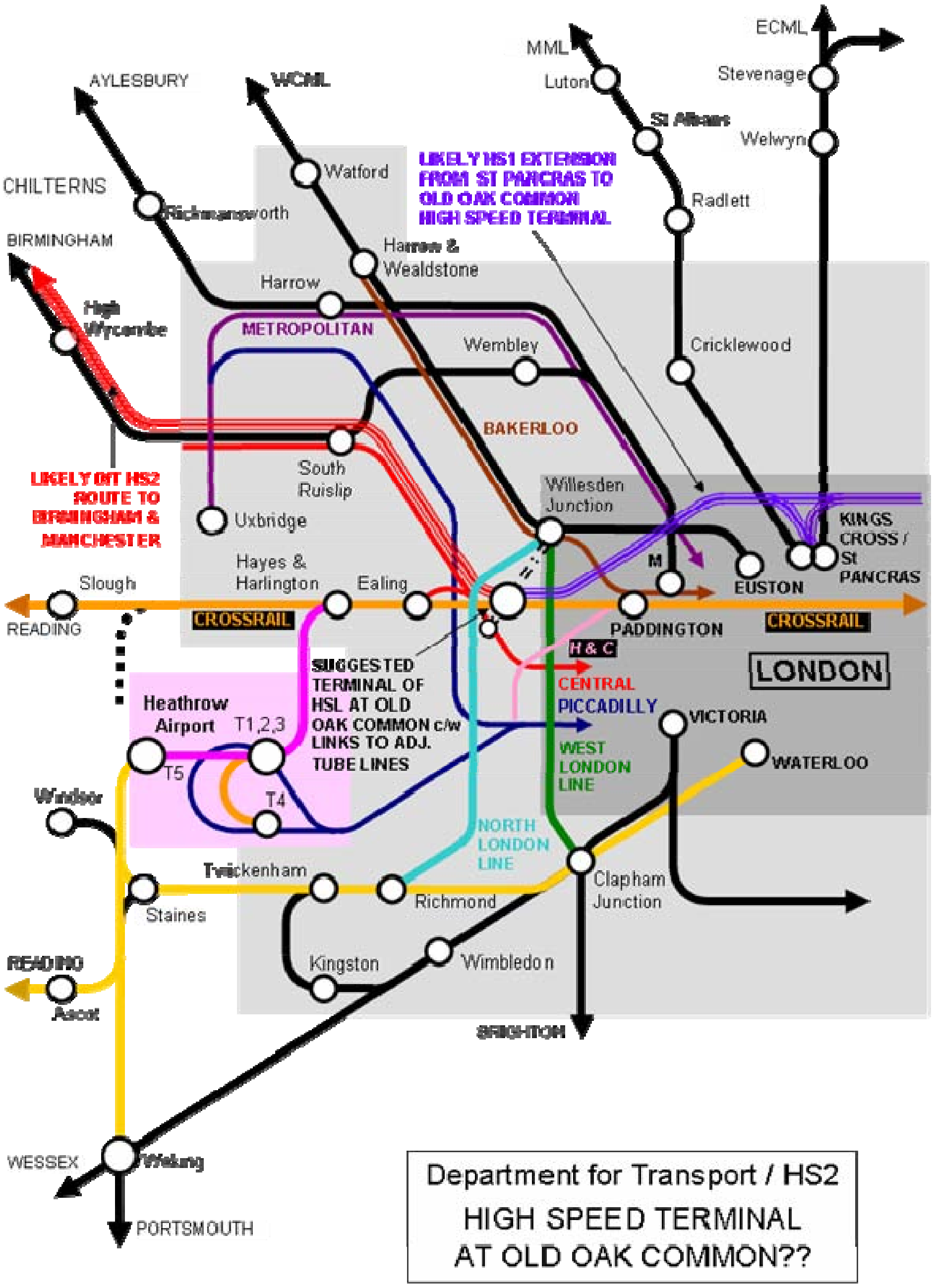


Figure 8.4.4

The Old Oak Common site would compare poorly against St Pancras:

- Its location is 5km further west than Paddington, already the least central London rail terminal.
- Its main link to the wider London and suburban area would be via the future CrossRail. There are no Tube lines passing through the site – of the local lines (ie the Central, Bakerloo, Piccadilly and Hammersmith and City) the Central would appear to pass closest, between North Acton and East Acton stations. At this position, at the extreme west end of the suggested station site, the North London Line crosses the Central Line, and some interchange might be possible here. So there would appear to be a maximum of two high-capacity connecting lines, as opposed to six at St Pancras.
- The proposed site is almost completely rail-locked, and remote from major local roads. Consequently, local bus and taxi links would be poor.

The importance of a high quality feeder network has to be stressed. A domestic high speed terminal serving the Midlands, the North and Scotland might be dispatching and receiving 15 to 20 trains per hour. With 750 or more passengers potentially aboard each train (note the extra capacity of duplex rolling stock which might carry up to 1000 passengers per train), an hourly throughput of 15000 passengers might be anticipated. This is a major proportion of the capacity of the proposed CrossRail system, on which 24 trains per hour (assuming that the current curious east-to-west imbalance is addressed – see Figure 9.5.3) will operate. This presumes of course that CrossRail will be built.

Assuming that 80% of the passenger load will emanate from central London – and allowing for the possibility that the Central Line might be out of operation, and neglecting North London Line and bus connections – an average of 500 high speed line passengers might join each CrossRail train en route to central London. Given the other commuting demands on CrossRail, it seems certain that a domestic high speed terminal located at Old Oak Common would cause serious capacity problems.

Other issues to consider are:

- connection to European services at St Pancras,
- possible through operation of domestic high speed services to Europe,
- connections to Heathrow,
- connections to Great Western Main Line.

For the former two requirements, it would seem essential that a direct (and tunnelled) link to St Pancras and HS1 is created. For the latter, good airport connections would be achieved with Heathrow Express (and CrossRail).

In summary it would appears that the best attribute of a high speed terminal located at Old Oak Common would be its airport links and its onward connections to Great Western Main Line destinations. Although these are desirable, it is important that these benefits are not achieved at the expense of compromising the high speed solution for Midlands, Northern and Scottish cities.

Alternative non-high-speed uses for the Old Oak Common site are explored in Section 9.5.

8.5 Summary of Review of High speed Rail Schemes

Even if a Heathrow-oriented ‘HS2’ route to the North-West were to become a reality as a busy intercity railway, it is evident that the airport would be the destination for a relatively small proportion of the passengers – and that in several permutations of routes from east-sided cities (see Section 10 and Appendix E), there is the danger that the many will be delayed en route to central London and Europe, for the sake of the few.

Also the likely initial network coverage (ie a single route from London to Birmingham and other WCML destinations) would be small, excluding as many communities as would be included. The £14.5 billion that would be spent on an expensively-engineered route through the Chilterns (the spreadsheets in Appendix E show a £13 billion cost for Arup’s proposed route from London via Heathrow Hub to Birmingham and Manchester, to which perhaps £1.5 billion should be added to account for works at Heathrow – see Item 8.3) would pay for a more sensibly-configured high speed network (ie High Speed North) with comprehensive coverage of all key ‘Initial Objectives’ (see Item 10.2) ie Manchester, Birmingham *and* Leeds, plus Leicester, Nottingham, and Sheffield.

It is evident that Heathrow has a massive influence on 'HS2' routeings, be it via Heathrow Hub (Arups) or with a separate terminating spur (Greengauge21), or from a more centrally located Heathrow interchange at Old Oak Common (DfT HS2 Company). From this, all the other shortcomings flow. It leads directly to a requirement to pass through the Chilterns and dictates an excessively west-sided route to the north which cannot serve communities on either side of the Pennine divide in an even-handed manner. None of the 12 points in the 'high speed specification' set out earlier is satisfactorily met (see Table 10.10), and the airport is still left without the comprehensive rail access that it requires.

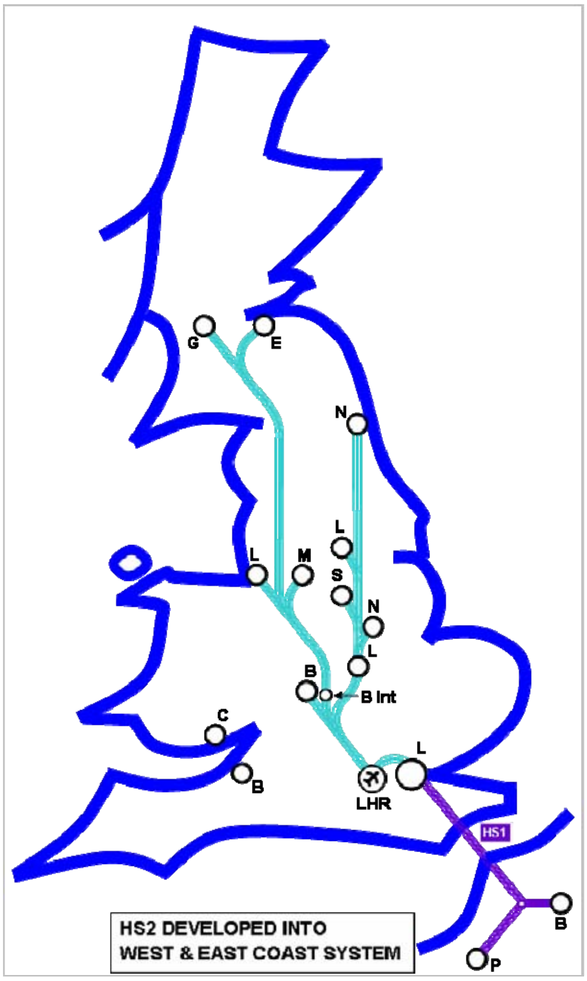


Figure 8.5.1

In most of the recent landmark reports upon high speed rail issued this decade, Y-shaped systems similar to that depicted in Figure 8.5.1[33] have been described as the 'Full Network' option. This appears to be the best on offer – yet it is readily apparent that the London-centric system proposed is a network in name only, failing to provide the required enhancement of inter-regional links.

A different strategy needs to be adopted. The necessary improvements to Heathrow's rail access must first be scoped and schemed. It then becomes possible to configure a balanced high speed network to rational intercity priorities, achieving optimised network for minimised route mileage, cost, and environmental impact. This is the fundamental philosophy behind the High Speed North proposal.

[33] The system illustrated in Figure 8.5.1 is based on a rationalisation of the Arup high speed network depicted in Figure 8.3.2. A West Coast route to Scotland is illustrated, based on current Arup / Greengauge21 preferences for initial route development via the North-West Corridor; the duplicating sections from Newcastle to Edinburgh and Glasgow have been deleted. Based on the author's own route development work, the time-sensitive east-sided spur to Newcastle is assumed to bypass the centres of both Sheffield and Leeds, with parkway stations provided. On the same rationale, a route through the centre of Leicester is assumed.

9. High Speed North

High Speed North has been conceived with the primary aim of facilitating the development of a UK high speed intercity rail network. Its coverage is of necessity limited to the Midlands, the North and Scotland; a separate scheme – High Speed West – will be required to address the needs of Wales and the West Country (see Section 9.9 and Figure 9.9.5). But with 10 of the 12 main UK provincial population (and economic) centres located in a generally northerly direction from London, it is clear this is the axis that must be addressed first.

High Speed North is intended to provide the following principal benefits:

- An enhanced UK rail network linking all principal Midlands, Northern and Scottish centres with journey times of three hours or less.
- An extension of the European high speed network to all these centres.
- Improved capacity to the existing network, through existing express passenger traffic diverted to the new high speed network.
- General economic gains accruing from improved connectivity and reduced congestion.
- Environmental gains – including a general decarbonisation of UK transport – achieved through mode shift from higher-emitting road and air transport.
- Further environmental and economic gains achieved through achieving efficient and comprehensive network coverage for minimised route mileage, and minimised emissions in both construction and operation.
- Minimised environmental impact through the routeing of new lines along existing transportation corridors.

9.1 Network Coverage

The ideal intercity network would be one in which it is possible to achieve direct and frequent communication between all key UK centres. With the classic UK rail network based upon several main lines radiating from London (eg ECML, MML, WCML & GWML), with the various inherent flaws already noted, comprehensive intercity communication even along the main line corridors has always proved difficult to achieve. Communication between the various radial main line axes is only possible with transverse networks, in particular Transpennine and CrossCountry.

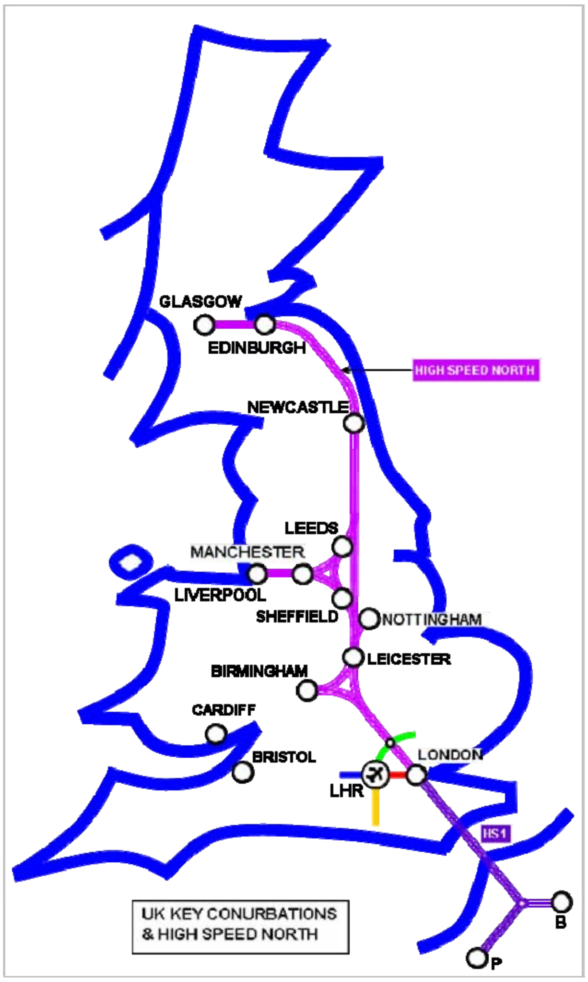


Figure 9.1.1

This pattern has prevailed since the railway building of the nineteenth century, an ad-hoc process of incremental growth in which there was no strategic overview of network development. But the advent of high speed rail presents a unique opportunity to develop an improved network, exploiting a particular peculiarity of UK geography:

- A single line following the M1 corridor to Yorkshire, and then the A1 and M8 corridors into Scotland, passes through or adjacent to all east-sided key centres (ie Leicester, Nottingham, Sheffield, Leeds and Newcastle) en route to Edinburgh and Glasgow.
- Birmingham and Manchester are located within 50km of this line.
- Liverpool is located within 100km, and is on the same east-west line as Manchester.

With high speed compressing a distance of even 100km to less than 30 minutes, and gradients across mountain barriers no longer the key consideration that they were to the Victorian railway engineers, an alternative model of intercity rail development now becomes possible. Rather than configure an inevitably London-centric network of limited inter-regional connectivity, following existing radial main line corridors, it becomes possible to adopt a more efficient 'spine and spur' format. See Figure 9.1.1.

This would comprise an east-sided Anglo-Scottish spine route generally aligned with the M1/A1 corridor and the major east-sided conurbations, with two west-facing spurs, one following the M6 into Birmingham, and the other crossing the Pennines from Yorkshire via the abandoned Woodhead corridor first to Manchester and then Liverpool.

But even with an east-sided Anglo-Scottish spine route closely aligned with all the intervening conurbations, it is still a major challenge to achieve city centre access for the through routeings. It will not be acceptable to adopt the practice of a south-facing connection to a city centre hub (at which point the service from London terminates) and a parkway station on the suburban fringes – as per the HS2 solution for Birmingham, and possibly Manchester. Individual city-centre solutions will be outlined in the Route Descriptions in Appendix D.

9.2 Benefits of Spine and Spur Format

The proposed spine and spur format allows several crucial benefits:

9.2.1 Maximised network for minimised route length:

With all Midlands, Northern and Scottish key centres linked to the same route, the potential network is maximised; and with only a single north-south route and two relatively short spurs to be constructed, the length of new railway is minimised. Associated CO_2 emissions ('embodied CO_2') and construction cost are likewise kept to a minimum. The comparisons in Appendix E illustrate clearly that a spine and spur-formatted network vastly out-performs any Y-shaped 'full network' options.

9.2.2 East vs West dispute eliminated with inclusive routeing:

A further benefit arises from the elimination of the east vs west dispute that will accompany high speed line development predicated upon either WCML or ECML axes. With a single spine route, and spurs, it becomes possible to achieve even-handed development of high speed rail to communities on both sides of the Pennines *and* direct Transpennine routeings. This – and the reduced cost arising from a more efficient network – will greatly promote the political consensus necessary to make high speed rail a reality.

9.2.3 Problems of WCML high speed route avoided:

Greater operating and environmental efficiencies are possible through an east-sided route that eliminates many of the inefficiencies already described in a WCML-aligned route. It is no longer necessary to despatch separate trains, without major intermediate calling points, for Manchester, Liverpool, Edinburgh and Glasgow. The spine and spur routeing allows trains for Manchester and Liverpool, and Edinburgh and Glasgow, to be combined, with the possibility of further east-sided calling points. This makes the desired combination of high load factors and high frequency much easier to achieve.

9.2.4 East-sided routeing to Manchester?

Although it would be physically possible to align a west-sided high speed route to Manchester through the centre of Birmingham, practical considerations of cost and disruption/intrusion have dictated a bypassing route in all schemes so far advanced. This dictates separate services to Manchester and Birmingham, leaving the latter city poorly served in respect of northbound journeys with only a 'parkway' connection at Birmingham International.

So there is no inherent benefit in a west-sided routeing to reach Manchester. There is no reason not to consider an east-sided route, if greater efficiencies can be delivered by combining ECML, MML and WCML flows as far north as Yorkshire (and enabling a Transpennine high speed axis), rather than the more obvious M1/M6 split at Rugby. See Figure 9.2.1.

It should be noted that an east-sided route to Manchester (Transpennine via Woodhead) is only 10km longer than the west-sided WCML route via Crewe, and offers the possibility of a reserved 'Eurogauge' alignment to Manchester Piccadilly.

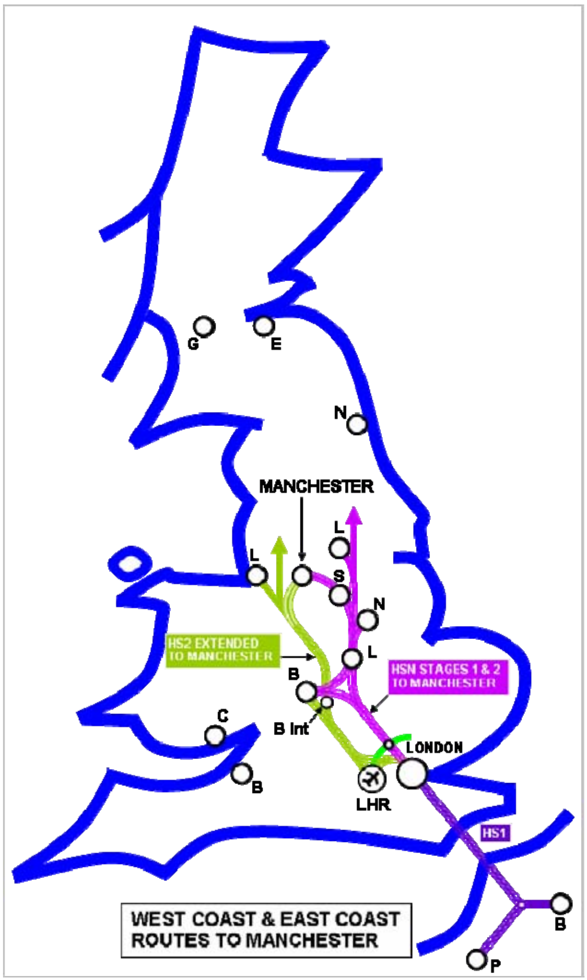


Figure 9.2.1

When even 200kph operating speeds are considered, such a difference amounts to around three minutes. This is of relatively little significance in itself, and a much lesser determinant on total journey time than the pathing conflicts (and restriction on operation of Eurogauge rolling stock) that will arise on (say) a south-sided approach to Manchester on existing tracks via Wilmslow and Stockport.

It must be emphasised that the preference for a Woodhead-oriented high speed route to Manchester is predicated upon the earliest practicable realisation of a UK high speed network. This does not preclude later development of more west-sided routes to Manchester (and Liverpool), possibly oriented via Birmingham, as illustrated in Figure 9.9.5, Section 9.9.

9.2.5 Simpler and more efficient network achievable with spine and spur:

An east-sided spine-and-spur system can be configured with only five branches (to Glasgow, Leeds, Liverpool, Nottingham and Birmingham) as opposed to the nine required for a west-sided Anglo-Scottish HS2 system with an accompanying east-sided spur (as previous plus Manchester, Sheffield, Newcastle and Edinburgh). See Figures 8.5.1 and 9.2.3. Separate trains, at least hourly but possibly more frequent, will be required to access all these nine separate destinations. This is inherently inefficient. Not only will the conflicts between frequency and load factor occur (impacting on both business and environmental performance), there will also be difficulties in accommodating the service aspirations of all these cities within the context of the limited capacity of a high speed line, commonly reckoned to be of the order of 16 trains per hour for a two-track railway.

9.2.6 Through services to Europe achievable with east-sided spine and spur network:

Possibly the most critical capacity problem will stem from the natural aspiration of all key cities to have direct through services to European destinations. It is clearly not practicable to have as many as nine services per hour from northerly points funnelling through the Channel Tunnel en route to Paris, Brussels and beyond. The result will be either less frequent services, or services only available from the parkway station on the outskirts; both of these outcomes will be unpalatable to local politicians. But with only five branches inherent in the east-sided spine and spur network (or four, if continental services to Nottingham and Leeds are combined), it becomes far easier to satisfy local aspirations for frequent services to the Continent (and to London).

9.2.7 Capacity improvements on all northern main line corridors:

By following an M1 alignment from London to Yorkshire, rather than any of the classic main lines, the new line covers WCML, then MML, then ECML routes - and can thus provide capacity relief to all three. See Figure 9.2.2. This would not be simply a train-for-train replacement. Capacity problems on existing main lines can largely be attributed to the speed differentials between intercity passenger services – operating typically at 200kph – and stopping passenger services and freight – operating typically at 100-125kph. If 200kph services can be diverted to a new high speed line, speed differentials on the existing line are reduced, and capacity increases.

So with perhaps 16 tph diverted from WCML, MML and ECML, it is reasonable to expect an aggregate increase in capacity of over 30tph on the existing main lines. This will maximise the opportunity for environmental gains from modal shift (ie road to rail).

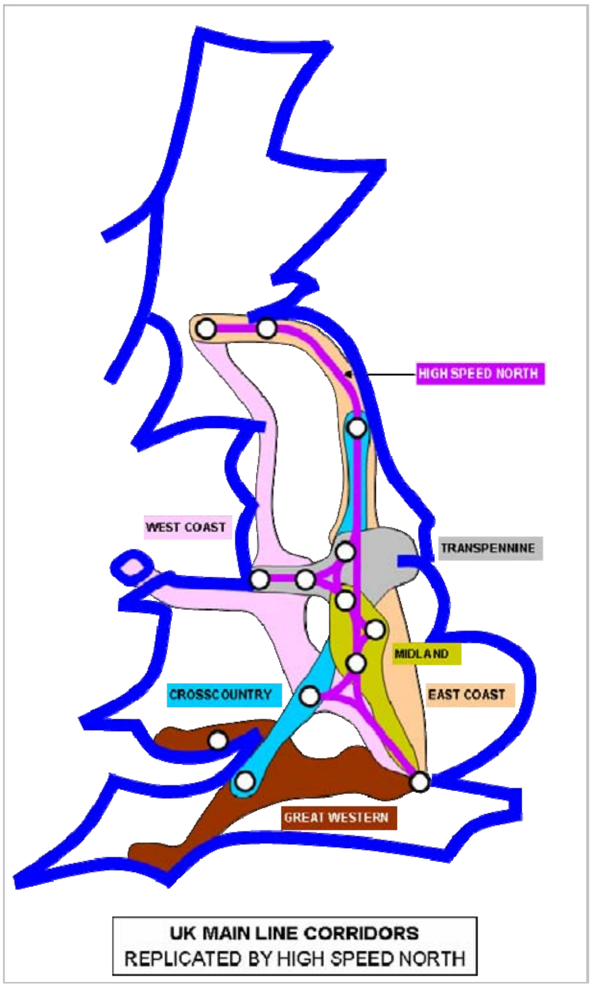
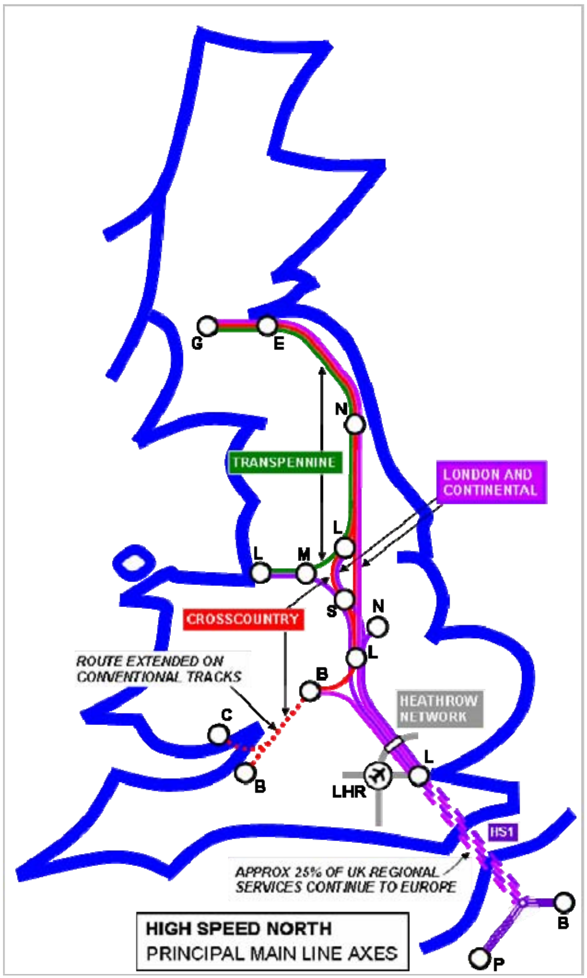


Figure 9.2.2



9.2.8 CrossCountry and Trans-Pennine corridors also covered:

A north-facing connection from the Birmingham spur will effectively replicate the northern end of the CrossCountry main line axis, allowing major acceleration of services to Yorkshire, to the North-East and to Scotland. Similar benefits will accrue to the Transpennine routes; these are under particular congestion pressure, and a new west-to-east route will deliver huge benefits for local passenger and freight services. But most importantly, a new intercity route will be created, providing enhanced links across the Northern Way region from Liverpool through Manchester and Leeds to the North-East. This will have a major regeneration effect on northern economies, and, along with the proposed CrossCountry services, will greatly mitigate the 'economic tilt' effect of an otherwise London-centric network.

Figure 9.2.3

9.2.9 Enhanced links between the North-West and Scotland:

An extension of the Transpennine high speed corridor into Scotland will address probably the greatest flaw in the UK's existing intercity network – the lack of adequate connections between Liverpool/Manchester conurbations and the Central Belt of Scotland. Along the WCML axis there are insufficient intermediate population centres to provide the necessary traffic volumes to support a frequent intercity service; this results in a poor level of northbound service from Manchester (ten daily trains to Edinburgh, four to Glasgow) and no direct service of any description between Liverpool and Scotland.

A step change in service levels becomes possible with Liverpool, Manchester, Leeds, Newcastle, Edinburgh and Glasgow all placed on a single arc. At its extremities ie Liverpool to Glasgow the journey time will approach three hours, and the route will be admittedly circuitous, but the essential 'critical mass' to assure a frequent service will be achieved through all the intermediate cities served.

9.2.10 City centre access promoted by non-London-centric flows:

The straight and unobstructed alignments necessary for high speed line construction can only be created through urban areas at major expense and disruption. These considerations, plus that of maintaining journey times to further (and more time-critical) destinations, tend to preclude the routeing of the high speed line through city centres. This is particularly the case for major cities such as Birmingham, Manchester and Leeds, for which all schemes so far advanced have opted for bypassing alignments. If these cities (and others) can be placed on spurs clear of the main line, but with viable northbound as well as southbound connections, a much improved network is achieved.

9.2.11 Environmental impact minimised through close alignment to existing transportation corridors:

The M1/M6 alignment from London to Leicester and Birmingham is typical of the routeing strategy of the spine and spur network. A route following major population centres can exploit the corridors already established by the motorway (or sometimes railway) links between these centres, and the new line can be constructed without significantly increasing environmental impact. The necessary straight, or near-straight alignments are found more commonly in the favourable topography of the east side of the country where the spine route is proposed to be located. This will have consequent benefits in the avoidance (or at least minimisation) of local controversy, and the reduction in both costs and timescales, and the early realisation of environmental gains.

9.3 Technical Standards

Conventional 'steel wheel on steel rail' technology is proposed. Although state-of-the-art systems such as maglev may be inherently technically superior, considerations of interoperability (with existing UK and European networks) and feasible city centre access ultimately render these systems impracticable. These issues are discussed in greater detail in Appendix C. It is considered that the two-century-old conventional railway technology comprises the best solution.

To ensure that the key UK provincial centres are accessible to modern 'Eurogauge' rolling stock (ie duplex/doubler decker carriages both wider and taller than British trains), it is proposed that the entire core high speed network is constructed to accommodate such trains. This will dictate either new railway or (typically on the approaches to city centre stations) upgraded existing line. In both cases, bridges, tunnels and track will be constructed (or modified) to suit these requirements.

Although environmental considerations may dictate a lower speed, to achieve the greatest net (ie across whole transport sector) reductions in emissions, the new line will be designed to facilitate 300kph (186MPH) running. The alignments will be designed to contemporary TSI standards. Most importantly, these dictate a maximum gradient of 1:40 and a minimum track radius of 4200m. Close to stations, lower speed limits and tighter radii may be specified. Generally, the new line will comprise double track, set out to generous clearances to accommodate high speed aerodynamics, and electrified to 25kV AC overhead. This is the system in use on HS1, and (Eurogauge issues aside) is compatible with UK main line electrification.

On southern sections (ie the trunk route south of Leicester) the provision of quadruple track is likely to be required. Although it is theoretically possible to accommodate the likely service of around 16-20 trains per hour on double track, considerations of operating resilience at the confluence between spine route, Birmingham spur and existing Trent Valley WCML route will dictate four tracks. This will offer a level of spare capacity that might be exploited as part of a wider strategy to develop a UK Eurogauge freight network. This possibility is documented in greater detail in Item 9.8.5.

All terminals on the core network will be designed to accommodate Eurogauge trains of 400m length, in line with established European norms for high speed rolling stock. With existing (and ageing) Eurostar Class 373 trains not compatible with contemporary operating systems on the developing European high speed network, a new generation of higher-capacity state-of-the-art high speed trains will be essential.

9.3.1 High Speed Services operating beyond Existing Network

To maximise the spread of the benefits of the high speed line, a significant proportion of high speed line services will extend to destinations remote from the core network. See Section 9.9, Figure 9.9.4. This will require trains no larger than existing main line rolling stock, but capable of 300kph operation. Another major limitation is the length of existing station platforms, generally in the region of 250m maximum.

The existing Eurostar trains (which are likely to be displaced from HS1 services in the medium-term future) would meet the requirements for speed and size – but at 400m long, would not fit existing platforms. Modifications would be essential – perhaps to allow 400m long operation on the high speed line, before splitting into two 200m long sections, and continuing onto the classic network. However, the fleet of Eurostars is only relatively small, and aging. There will be a need for more, and newer trains.

The rationale of the current IEP programme for new 140MPH (225kph) capable intercity trains must be questioned. With the advent of high speed rail in the UK, it would seem more prudent to design these new trains to the full 300kph+ standard.

9.4 High Speed North : Key Features

The key aspects of High Speed North, that differentiate it from other proposals, are summarised as follows, and are described in greater detail in the following sections:

- Euston proposed as domestic high speed terminal, with underground travelator connection to the adjacent Kings Cross/St Pancras hub.
- Cricklewood proposed as interchange with Heathrow network and wider suburban area; also allows interchange between high speed services.
- Abandoned Transpennine Woodhead corridor proposed as east-sided access to Manchester and Liverpool, to optimise network.
- Major enhancements proposed to Scottish network to accelerate journey times to Aberdeen and other Northern cities.

A more detailed summary of the proposed route is presented in Appendix D as a bullet-pointed list.

9.4.1 South to North Development??

The route descriptions commence at London in the south, and proceed northwards. This is largely for consistency of narrative style, but it also reflects the author's belief that the priority for congestion relief and improved access to Europe will dictate that the new high speed line will generally develop in a northbound direction.

However, it is acknowledged that there are powerful arguments to develop on a broader front, and realise local benefits from improved links across the Pennines, and between Edinburgh and Glasgow. With this debate still to be resolved, no particular imperative for south-to-north prioritisation should be read into the descriptions in Appendix D.

9.4.2 Plotting of Proposed Alignment

The proposed route of High Speed North has been plotted for its full length onto Ordnance Survey 1:50000 Landranger mapping, and as such should be considered to represent a credible scheme along largely clear alignments, mostly alongside existing transportation routes, generally either motorways or main line railways. From this platform, provisional cost estimates can be made, and the planning process begun. For reasons of brevity, copyright/licensing and local sensitivities, the precise detail of the proposed route is not published in this document.

9.5 Euston Station : London's Domestic High Speed Terminal??

The twin requirements of large ground plan and location at a local public transport hub effectively limit the options for London's domestic high speed terminal to an existing main line station site well connected to the Tube network. Although St Pancras might be considered ideal from the connectivity point of view (not least the onward international connections), the site is restricted in size, and can only practicably accommodate the Eurostar/HS1 traffic to the Continent. The adjacent Kings Cross station is too short, limited by the tunnels to the north, and Euston Road to the south. It is not believed that any other suitable station site exists in the wider Kings Cross / St Pancras Railway Lands, which are now proscribed by an intricate interlayered system of flyovers, diveunders, tunnels and canals (and would in any case be remote from the established Tube hub).

The choice of domestic terminal therefore falls upon Euston Station, approximately 600m to the west. In plan area terms, it is by far the largest of the north London termini (it was intended originally to be the terminus of not only the London and Birmingham Railway, precursor to the WCML, but also of the Great Western Railway). Although its platforms are not currently of the required 400m length, this can be achieved within the existing station site by extending the buffer stops towards Euston Road.

This will of course require complete reconstruction of the existing station, but that is due to happen anyway under the forthcoming redevelopment[34]. Planning is still at an early stage, and has so far been mostly concerned with the impact of a large cluster of high rise buildings on the London skyscape. Such a redevelopment can only be enhanced by the synergies of co-location with a major transport hub (for which most of the facilities will be constructed at, or below ground level). It is considered vital that due modifications are made to current development plans for Euston.

9.5.1 Euston : Tube Connections

The principal drawback to Euston's potential selection as London's domestic high speed terminal lies with its public transport connections. In terms of Tube links, crucial for onward dispersion of incoming passengers, these can at best be ranked as 'mediocre', with only the Northern Line (both City and Charing Cross branches) and Victoria Line accessing the station. These facilities are already under pressure, and it is plain that collectively they would be inadequate as the primary conduit for the access/egress of up to 15000 passengers per hour.

One possible improvement might be to replace the inconveniently located Euston Square Station on the Metropolitan/Circle Line, and to construct instead a new underground station directly in front of Euston. This would fit with the general southward development of the station, to accommodate longer trains. However, the gains will only be limited, and the potential for disruption to Tube operations high.

A superior strategy would be to establish a dedicated underground connection, by travelator or similar, between Euston and Kings Cross/St Pancras. Travelator connections at least 600m in length already exist at many airports, including Heathrow, and other public transport interchanges. This would permit effective integration between the three stations, with the following particular advantages:

[34] Euston redevelopment proposals are documented on www.eustonarch.org/future.html#5.

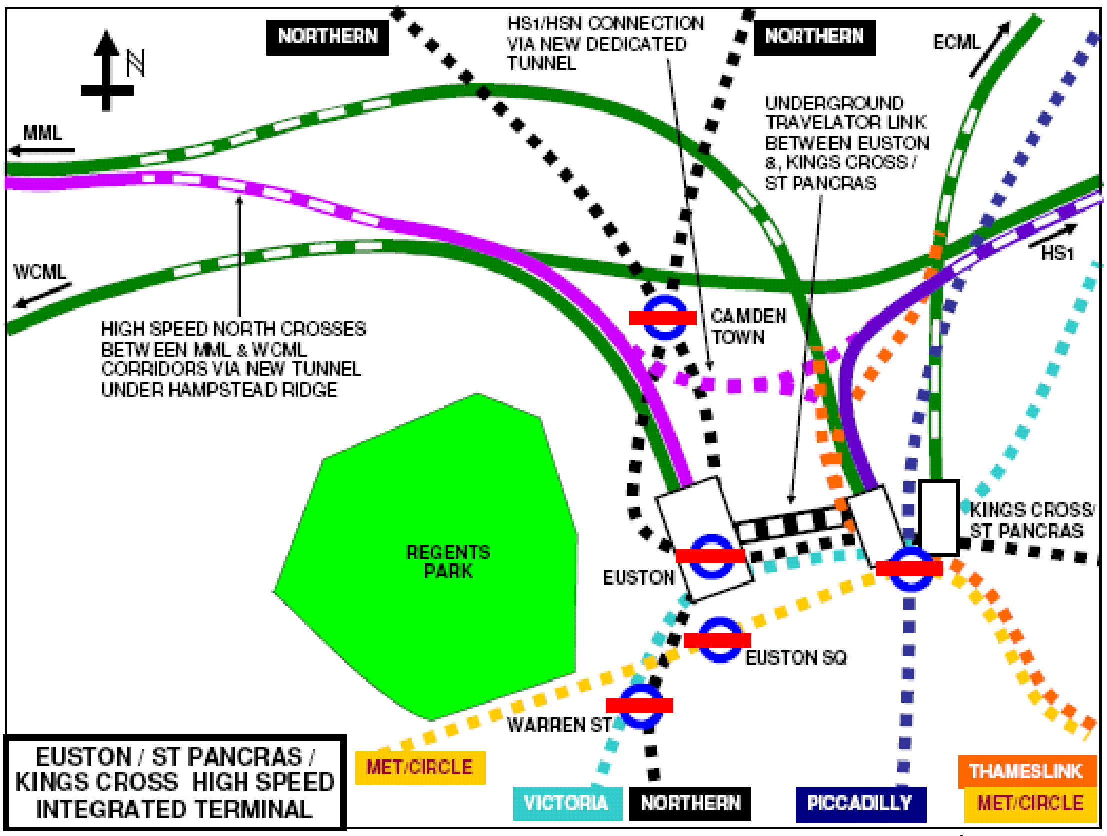


Figure 9.5.1

- Improved transfer to local public transport networks – now Thameslink, Piccadilly Line and Met/Circle Line are accessible, in addition to Victoria and Northern Lines.
- Transfer available between domestic and Continental high speed services (although this could probably be better accomplished at Cricklewood Interchange).
- Effective integration between all northern main line termini – now high speed and classic services to Midlands, Northern and Scottish destinations would all depart from an interconnected virtual mega-terminal, with departure information and platform numbers fully coordinated.

9.5.2 Euston: Displacement of Commuter Services to CrossRail

The establishment of Euston as London's domestic high speed terminal is of course only feasible if a strategy can be developed to displace existing railway operations without undue disruption or inconvenience. Currently, the following services operate from Euston:

- Intercity services to Birmingham, Manchester, Liverpool, North Wales and Scotland – nine trains per hour.
- Semi-fast services to Hemel Hempstead, Milton Keynes and Northampton – seven trains per hour.
- Local services to Watford Junction (Watford DC Slows) – three trains per hour.

Displacement of the services listed above appears to be surprisingly easy. Intercity services would naturally migrate to the high speed line, and present no problem, *per se*; the local services, and many of the semi-fasts could be transferred onto CrossRail.

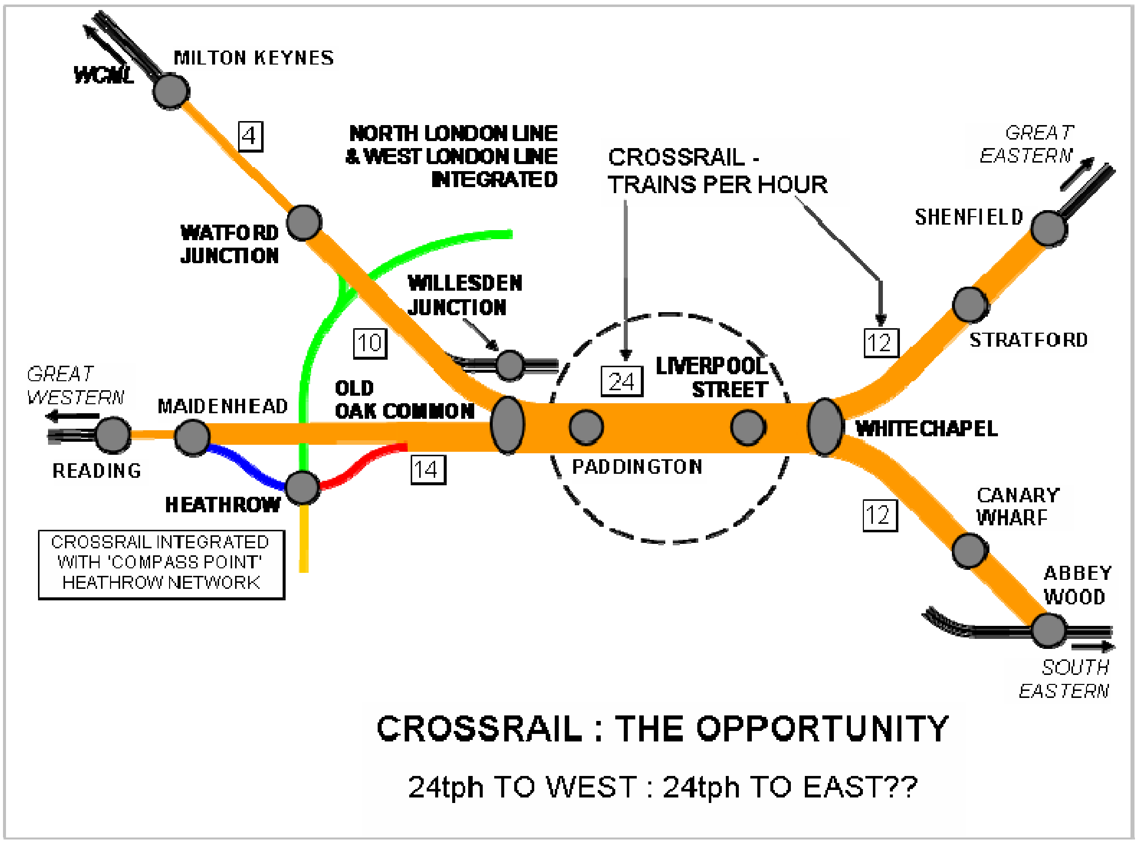


Figure 9.5.2

In physical terms, this requires no more than a short length of new railway to link West Coast and Great Western corridors at the point of closest approach, approximately 2km between Willesden and Old Oak Common. This connection could be established at relatively minor cost, and with minimal impact on local communities.

The proposed enhanced CrossRail network is illustrated in Figure 9.5.2.

A bigger problem will be the necessary change in the CrossRail scheme, in particular in the mindset of its promoters. Currently, CrossRail is configured with 2 eastern arms, to Shenfield in the north-east and to Abbey Wood in the south-east, but with only a single western arm to Slough and Maidenhead, and a stub connection to Heathrow Terminal 4 (see Section 3). This unbalanced arrangement goes against the normal practice in developing Metro systems. In the case of CrossRail, it has resulted in a proposed service pattern of12tph on each of the eastern branches, combining into a 24tph service through the central tunnelled section between Whitechapel and Paddington – yet only 14tph continuing beyond onto the GWML. See Figure 9.5.3.

No adequate explanation has yet been offered as to why the termination of 10 trains per hour at Paddington, rather than their natural extension onto the WCML or other western main line axis, represents best value for the proposed £16 billion investment in CrossRail.

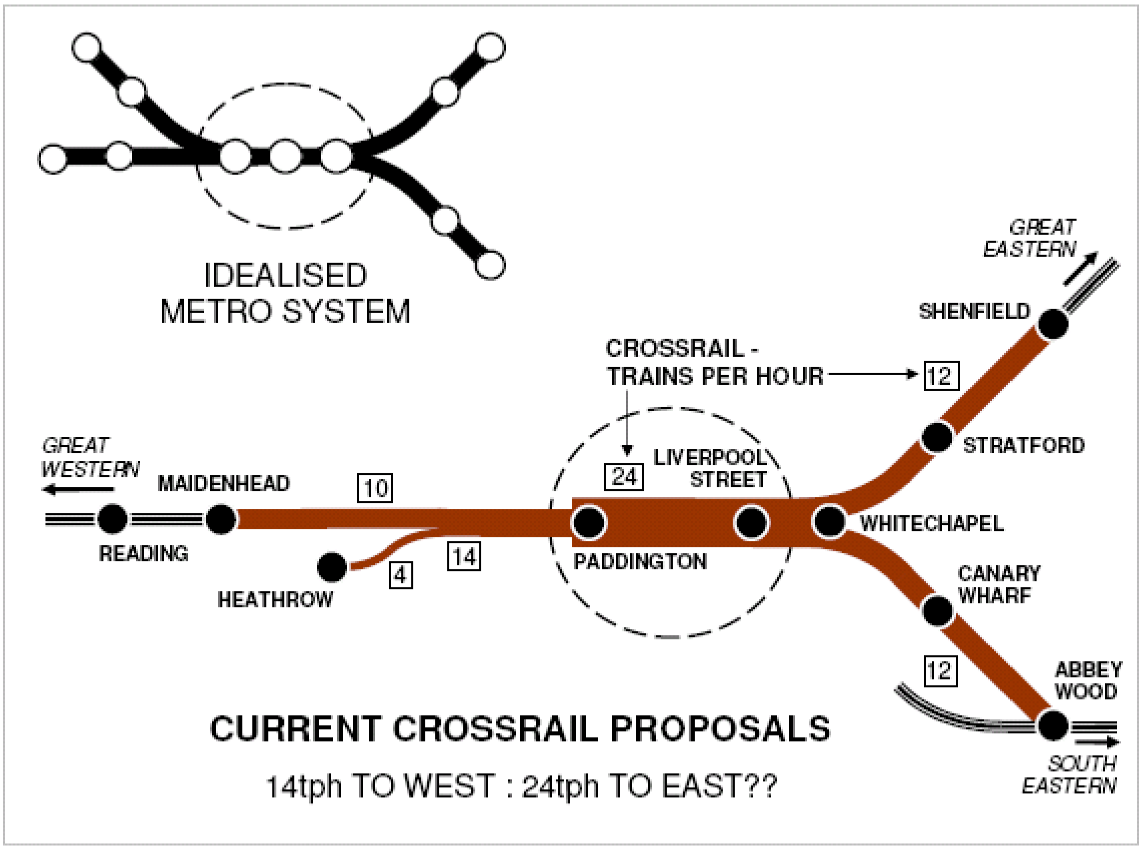


Figure 9.5.3

It must be emphasised that the advantages potentially accruing through diversion of Euston's commuter flows onto CrossRail are completely independent of those that will be realised through the station's strategic value as the only practicable centrally-located north-facing site for a domestic high speed terminal.

The possibility, that CrossRail might still not be constructed at the time of opening of the new high speed line, must be considered. This would undoubtedly cause much additional congestion at Euston, posing severe but probably manageable problems (whereas the alternative Old Oak Common proposal would seem to be completely dependent upon CrossRail).

9.5.3 CrossRail : West London Hub at Old Oak Common

The logical point of convergence between Great Western and WCML commuter flows would be at the rail depot site at Old Oak Common. This is the location believed to be under serious consideration by the HS2 Company as London's domestic high speed hub, a possibility discussed in detail in Item 8.4.

A much better case appears to exist for the development of the Old Oak Common site as a hub in London's local rail network. As well as allowing transfer between the two western arms of CrossRail, this would also permit connections with the North and West London Lines – both of which pass by Old Oak Common, and converge at Willesden Junction approximately 1km to the north. Neither of these lines currently connect to existing services along the Great Western corridor (including Heathrow Express/ Connect); this situation is set to continue under current CrossRail proposals.

With little extra infrastructure works, it would be possible to reconfigure local services to create a powerful hub at Old Oak Common. The following changes to existing service patterns are proposed (in addition to the convergence of the WCML and Great Western arms of CrossRail):

- West London Line and North London Line east of Willesden Junction integrated.
- Richmond branch of North London Line (ie west of Willesden Junction) diverted onto CrossRail.

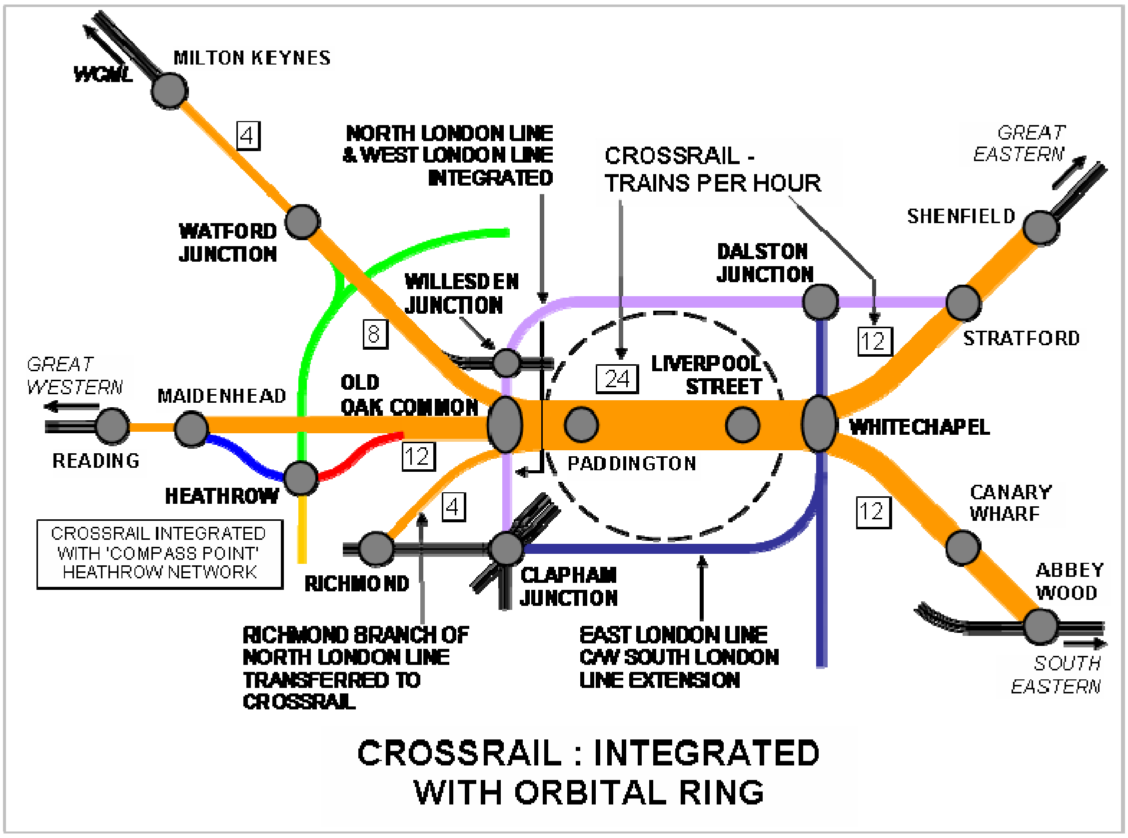


Figure 9.5.4

The integration of West and North London lines would greatly simplify the orbital rail ring around central London, complementing the development of the South and East London lines that will soon link Clapham Junction and Dalston Junction. The extension of a branch to Richmond would honour earlier promises to include the town in the CrossRail scheme, and would provide a further valuable connection to the South Western commuter network. Figure 9.5.4 illustrates the schematic network that would result.

9.5.4 Euston : Access to M1 Corridor

It seems to have become an accepted precept of high speed rail development that (as with HS1) any new line to the north must be constructed in tunnel for most if not all its length within the Metropolitan area, approximately as far as the M25. This is the strategy adopted by the promoters of Heathrow Hub, and a similar approach appears to have been taken in the various options developed in the SRA's *High Speed Line Study*. (It should be noted that Greengauge21's selection of the Central Line corridor as the route from London greatly reduces the need for tunnels on the main line, but with the tunnelled branch taken into account, the total requirement is similar).

But this assumption needs to be challenged. Construction of tunnels is many times more expensive than for a surface railway, and there are major safety and evacuation issues, that tend to compound with length. They are also unattractive to passengers. So tunnels, especially long ones, should if possible be avoided. They become a necessity in urban areas when no practical surface alignment exists – as seems to be the case for the westerly route to Heathrow Hub.

In the case of a north-westerly alignment from Euston to the M1 corridor, a much simpler solution seems to be possible. The 'Kilburn Incline' out of Euston is sufficiently wide to allow a phased reconstruction to modern (Eurogauge) high speed line standards; a new length of tunnel 2km long on an S-bend alignment is required under the Hampstead ridge, to link from WCML to MML corridors; and the high speed line can then be constructed along the infrequently-used MML freight tracks through Cricklewood to reach the M1.

9.5.5 Euston : the Opportunity

The success that Eurostar has experienced since transferring its London operations from Waterloo to St Pancras, in particular the attraction of greater through flows from the North, demonstrates the importance of a well-located, well-connected and imposing terminal. The establishment of Euston as London's domestic high speed terminal has similar potential for success. It has all the necessary attributes – size, location, public transport connections (assuming the travelator link described earlier), development opportunity and proximity to St Pancras – for the creation of a truly world-class integrated transport facility.

9.5.6 Euston vs Old Oak Common

A direct comparison can be made between Euston and Old Oak Common, to assess the suitability of either as London's domestic high speed terminal (should the latter be selected by the DfT's HS2 Company). The eight criteria set out in Appendix D will be considered to allow a fair comparison to be made. A further specific criterion, of reliance on timely completion of the CrossRail project, has been added.

Location / Criterion	**Old Oak Common (OOC)**	**Euston**
Groundplan:	No problem.	Required 400m platform length achieved by pushing buffers towards Euston Road as part of forthcoming reconstruction.
Accessibility to local networks	Poor. Only CrossRail and Central are directly accessible, plus Bakerloo at Willesden if travelator link installed (as per Euston proposals). Bus access very poor.	Good. With travelator link to Kings Cross / St Pancras, 5 Tube lines and Thameslink can be accessed, plus many bus services on Euston Road & Eversholt Street.
North-facing Location	Poor. Westerly location of OOC places development of HSL on excessively west-sided track, with environmental issues in Chilterns and further north, political/inclusivity issues on east side of Pennines. Major tunnelling required for link line to HS1 at St Pancras.	Good. Only short length of tunnelling required to access optimum M1 corridor northward. If integrated with Kings Cross / St Pancras, a high speed line from Euston would reach the same destinations as the existing lines – thus optimising integration.
Proximity to HS1 at St Pancras	Poor. Tunnelled extension of HS1 from St Pancras seems necessary	A dedicated travelator link could provide excellent connections between Euston and St Pancras.
Connection to Heathrow	Good, assuming Heathrow Express services stop at OOC.	Good – but connection achieved at Cricklewood Interchange.
Architecture/ Imposing Location	It is hard to imagine a facility of similar quality to St Pancras being created at OOC.	Achievable with appropriate planning of Euston redevelopment.
Integration with existing main line services	Good integration with Great Western, but poor with northern main lines.	Poor with Great Western, but good with northern main lines.
Availability	Little problem perceived in displacing existing rail uses of site.	Reconfiguration of CrossRail desirable to allow displacement of commuter traffic. This would seem to benefit both CrossRail project and commuters.
Reliance on CrossRail	Viability of OOC terminal totally dependent upon timely completion of CrossRail project.	With no diversion of commuter services to CrossRail, Euston will be undesirably congested, but still a viable terminal location.

Table 9.5.5 : Comparison between Old Oak Common and Euston as terminal sites

On the basis of the above comparisons, it would seem clear that Euston comprises a far superior, and far more appropriate location for London's domestic high speed terminal. It is, after all, much closer to travellers' likely final destinations, or to the next means of getting there, with a wide choice of Tube lines, bus routes, taxis – and of course, the option to walk. But these benefits will only be realised with a commitment to integrated planning of the UK strategic transport system, and a willingness to re-examine the existing deeply-flawed CrossRail scheme.

9.6 Cricklewood Interchange

The possibility of an interchange station at Cricklewood between the Heathrow Compass Point network and an M1-oriented high speed line to the North has already been raised (see Items 7.3 & 7.4). Three principal functions are envisaged for Cricklewood Interchange:

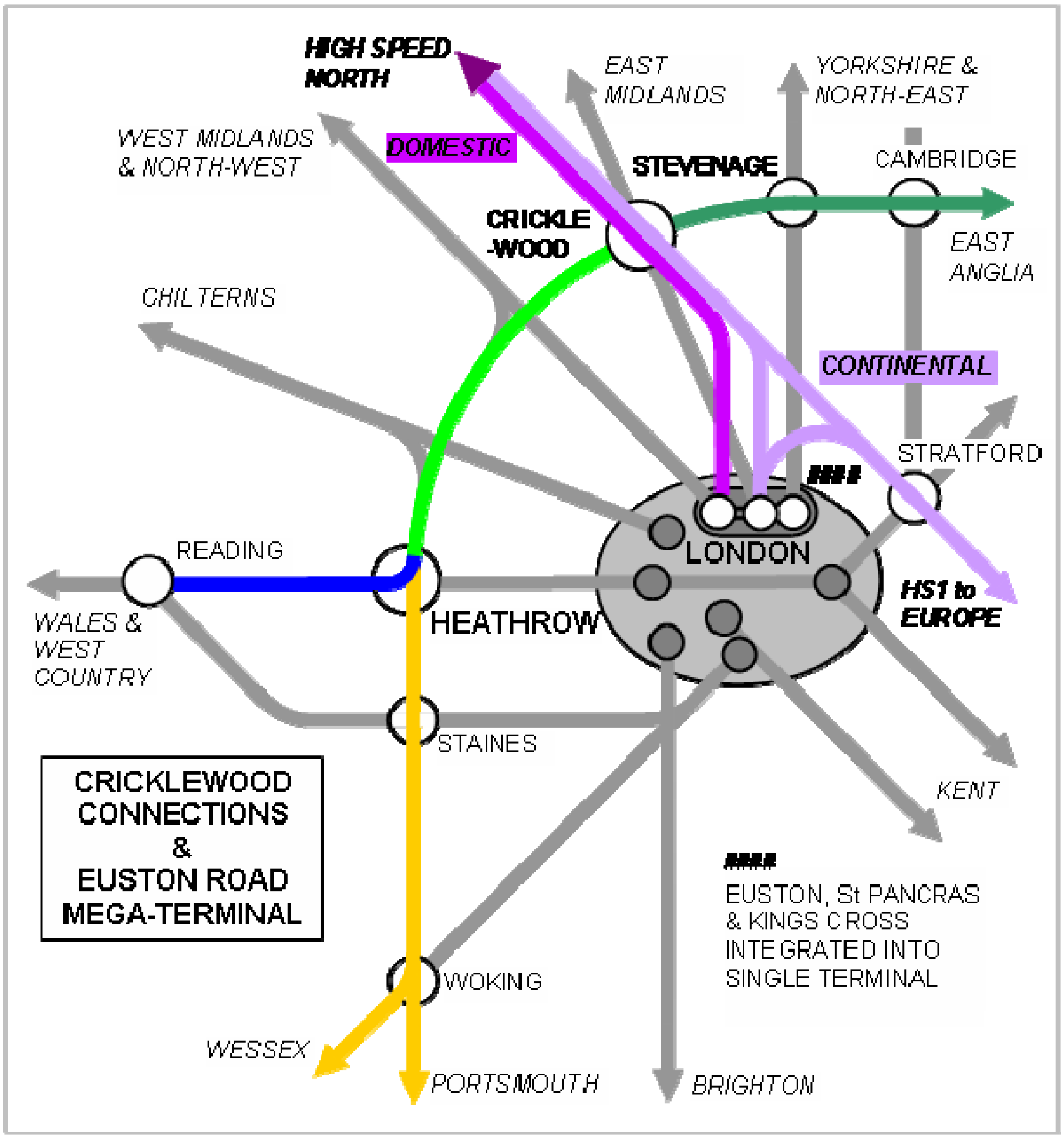


Figure 9.6.1

- ***Heathrow connections***
  With the proposed development of Heathrow's local network, the central airport terminals would be no more than 20 minutes' journey from Cricklewood. With frequent services provided (at least six trains per hour) the journey would not be of an order of magnitude longer than that required between airport terminals, or (say) from an airport terminal to Heathrow Hub (estimated by Arups at 10 minutes). It is reasonable to claim that Cricklewood would be an effective extension of the nation's premier international airport onto the nation's premier railway (ie bringing Heathrow to the high speed line rather than vice versa). However, it would not simply deliver passengers to Heathrow from its UK hinterland; it would also effect connections with European services running through Cricklewood.

- ***Onward Home Counties connections***
  The through running of the proposed Heathrow network will allow direct onward journeys to a wide variety of Thames Valley, and south-west suburban / Wessex destinations, including Reading, Portsmouth and Southampton. Similarly, East Anglian connections in the opposite direction are possible to Cambridge and (with electrification) to Norwich.

- ***Interconnection between high speed line services***
  A mixture of domestic and international high speed services will operate on High Speed North. Domestic services will terminate at Euston, while international services will either 'bounce' into and out of St Pancras, or run past St Pancras, and stop instead at Stratford International. With no other station proposed between London and the 'M1/M6' junction to the Birmingham spur, Cricklewood will perform a vital function in allowing interchange between domestic and international high speed services.

There are other more local advantages:

- Proximity to the North Circular Road (to the north) and to Edgware Road (to the west) will greatly facilitate road access, with impact on local communities minimised.
- An efficient network of local bus connections appears to be possible.
- Regeneration of the Cricklewood area, which has historically been economically disadvantaged and blighted through its proximity to the North Circular Road[35].
- Interchange with the Heathrow network will permit direct access for travellers from the Midlands and the North to Wembley Stadium, avoiding circuitous routes via central London.

Cricklewood's key advantage is that it comprises one of the largest clear railway sites in the Metropolitan area, mostly unoccupied save for the presence of an East Midlands Trains maintenance depot (which should be capable of accommodation within wider plans for the site). The Cricklewood site would thus appear to be ripe for development into a multiplatform interchange station that can only bring major benefit to the surrounding area.

[35] A redevelopment masterplan for the Cricklewood/Brent Cross area can be accessed on www.dft.gov.uk/foi/responses/2009/march/foi4734/foi4734brentcross.bxc.pdf. It would appear that the Cricklewood Interchange proposals could be accommodated with no fundamental change to the rationale of the scheme.

9.7 High Speed Rail via Woodhead

The proposed Transpennine high speed routeing to Manchester and Liverpool might at first sight seem a strange and circuitous strategy. All other proposals have adopted the more obvious WCML alignment. But, as has already been demonstrated, WCML-aligned proposals seem inevitably to lead to an inefficient and excessively London-centric system, and tend to perpetuate the flaws of the existing rail network.

A further problem is the difficulty, disruption and expense that will accompany the construction of a Eurogauge-cleared high speed route to a centrally located terminal in Manchester. Approaching from the south, this will have to follow existing intensively trafficked rail corridors or pioneer a new route through suburban areas.

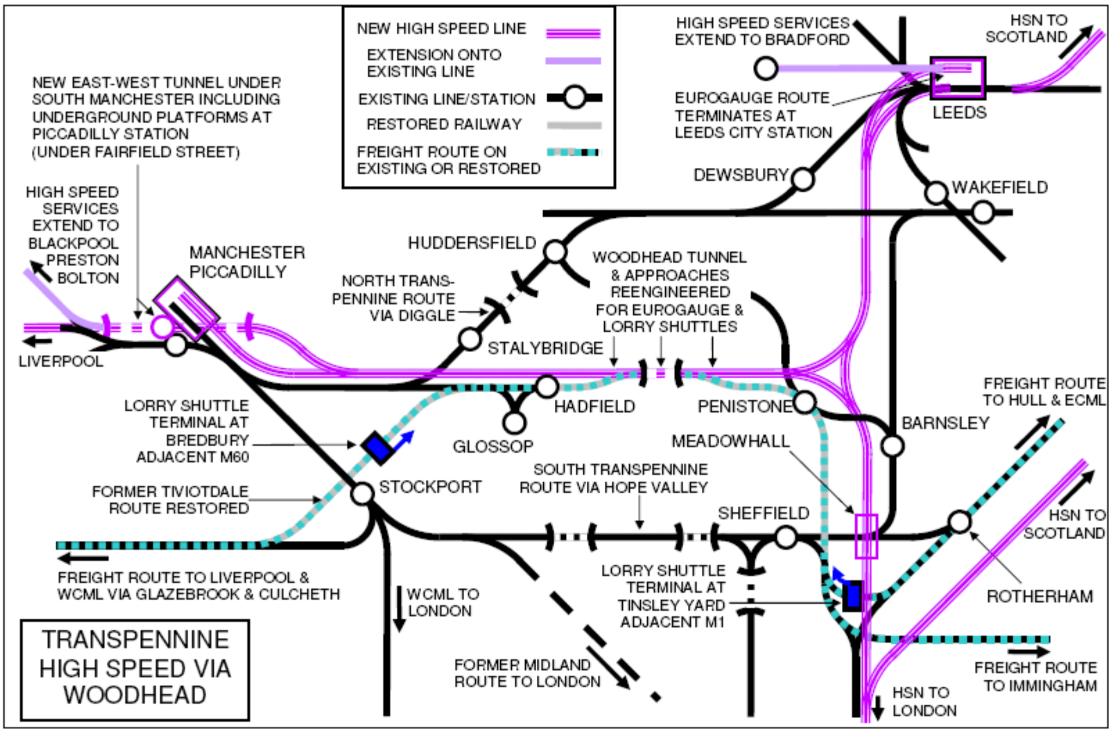


Figure 9.7

An east-sided Transpennine approach into Manchester via the (currently) abandoned Woodhead rail corridor would allow the following crucial advantages:

- A reserved Eurogauge high speed alignment, mostly on redundant trackbeds alongside existing tracks, is practicable for the full route length into central Manchester. This will maximise potential for European services to Manchester.
- The route would have largely conflict-free access to new 400m long terminus platforms, constructed immediately to the north of Piccadilly Station trainshed (the city's principal rail hub).
- Although the route to London via Woodhead is around 10km longer than via the WCML, and environmental and alignment issues would limit speeds to circa 200kph from Woodhead Tunnel to Manchester, it avoids the slower speeds and far greater potential for disruption on the south-sided approach through Wilmslow and Stockport, mostly on existing tracks. Quicker and more reliable journeys are possible along reserved tracks.
- A Transpennine high speed spur, connecting with an east-sided Anglo-Scottish high speed spine, allows Manchester comprehensive links to all other Midlands, Northern and Scottish principal conurbations. The Scottish links are of particular value, noting the existing poor direct services via the WCML.

- An extension to Liverpool is a logical follow-on from the Woodhead-aligned Transpennine spur into Manchester. With Liverpool on the same east-west axis, it could also enjoy upgraded Transpennine services, extending as far as Glasgow, and offering frequent and direct (if circuitous) services that do not currently exist on the existing network.
- The required tunnel, stretching approximately 5km from Ardwick to Castlefield, would incorporate new underground platforms at Piccadilly Station (below Fairfield Street), and allow high speed services not only to Liverpool, but also extending north-west to Bolton, Preston and Blackpool.
- The new tunnel would provide an additional two railway tracks across the south side of Manchester city centre. These could be used by conventional rail services also, on east to west and south-east to north-west axes. This would fulfil the requirements of the forthcoming 'Manchester Hub' project, but achieving a far better 'product' – an effective four-track railway across south Manchester – at similar cost and with far less surface level disruption and intrusion.

There are of course major issues surrounding the alignment of a high speed rail route along the Woodhead axis:

- There are several other competing rail projects – for Transpennine container freight, lorry shuttles and local passenger services – all vying to utilise a restored Woodhead railway corridor, and probably sharing tracks through the critical tunnelled section under the Pennine ridge.
- Aerodynamic considerations within tunnels, and the need for sensitive alignments closely following the existing railway alignment, will preclude full high speed (300kph+) running. 200kph appears to be the maximum achievable.
- The route within upper Longdendale passes through the Peak District National Park, which might be seen to preclude any significant physical developments.
- There is an ongoing controversy over the National Grid's proposals to relocate power cables from the original Victorian tunnels to the more modern 1954 tunnel, which has long been the focus of aspirations for railway restoration.

These all comprise challenges for which an integrated 'joined-up' solution is required. Limited track sharing is practicable, especially if grade-separated junctions can be provided where the reserved high speed alignments diverge, either side of the tunnel.

The principle of a multi-use railway is desirable, in that the lorry shuttles and enhanced freight services will provide a practicable and environmentally-friendly alternative to road haulage using unsuitable roads across the Pennines, and causing congestion, pollution and intense nuisance to local residents. Instead, it will become practicable and reasonable to impose lorry bans on the local Transpennine roads.

The resulting environmental improvements should leave the Peak District National Parks Authority favourably disposed to the limited environmental impact that would result from construction of new alignments (mostly in tunnel) suitable for 200kph operation. This appears to be the limit to which an environmentally acceptable alignment could be designed; note that full 300kph operation would save only four minutes on timings to Manchester. This is the principle of environmental best practice achieving minimised, and hopefully reduced net impact.

As for the issue of the National Grid cables occupying the 1954 tunnel, it now seems that reengineering of the vacated Victorian tunnels to the diameter necessary for Eurogauge high speed trains and lorry shuttles is by far the best overall solution – and that the cables, when transferred to the 1954 tunnel, should be left there.

9.8 Scottish Perspective

The benefits that high speed rail could potentially bring to Scotland can be best appreciated from an examination of its present transport links. Its relative remoteness from other major English conurbations, as well as from even the closest European centres such as Paris and Brussels, mean that aviation has become the principal means of communication on which it depends for its prosperity. The approximate modal split between air and rail on journeys from Edinburgh and Glasgow to London is 85%:15%. From Scotland to Europe, rail has no appreciable market share.

This can be attributed to the relatively slow speeds achievable on the rail network (over four hours between Edinburgh/Glasgow and London, and likewise to Birmingham) and to poor connectivity (insufficient direct services between Scotland and Manchester, and none to Europe). Instead, on most routes, aviation has come to predominate.

Selected flight & train frequencies to England / Europe from principal Scottish cities	London[36]	Manchester	Birmingham	Newcastle	Leeds	Liverpool	Leicester	Cardiff	Bristol	Southampton	Paris CDG	Amsterdam
No of flights per day												
Aberdeen	**19**	**7**	**4**	**6**	**3**	**0**	**3**	**0**	**3**	**4**	**3**	**4**
Edinburgh	**56**	**13**	**8**	**0**	**3**	**0**	**3**	**5**	**3**	**6**	**5**	**5**
Glasgow	**40**	**8**	**10**	**0**	**3**	**0**	**3**	**3**	**3**	**5**	**3**	**5**
Rail Journey Time												
No daily direct trains												
Aberdeen	**7**	**#**	**#**	**4½**	**6**	**#**	**#**	**#**	**#**	**#**	**#**	**#**
	3	**0**	**0**	**4**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Edinburgh	**4¼**	**3½**	**4**	**1½**	**3**	**4**	**5½**	**7**	**5¾**	**6½**	**7½**	**9½**
	18	**10**	**19**	**34**	**13**	**0**	**0**	**0**	**9**	**0**	**0**	**0**
Glasgow	**5**	**3½**	**4**	**2¾**	**4**	**4**	**5½**	**7**	**5¾**	**6½**	**8**	**10**
	8	**4**	**8**	**11**	**2**	**0**	**0**	**0**	**2**	**0**	**0**	**0**

Table 9.8.1 : Anglo-Scottish travel data, compiled September 2008 for inclusion in 2M Group submission[37] to Scottish Parliamentary Inquiry on high speed rail – but revised to reflect recent Manchester – Edinburgh/Glasgow service improvements.

But the departure lists of Scotland's key airports – Glasgow, Edinburgh and Aberdeen – reveal that only on the routes to London's various airports is the dominance of air accompanied by anything that could be described in railway terms as an intercity service, hourly or better. Elsewhere, service levels are relatively poor; only on the Edinburgh to Manchester route does the service level exceed 10 flights per day.

Two principal conclusions can be drawn from the current status of Scotland's communications with neighbouring countries. Firstly, (aside from questions of cost, a completely separate debate) it is journey times that are key to travel choices, and as matters stand rail cannot compete effectively with aviation. Secondly, these critical communications are almost completely dependent upon the use of oil as a fuel, and by consequence the emission of CO_2. If oil is to become unavailable through the 'Peak Oil' scenario, or if its consumption is to be restricted through CO_2 concerns, then Scotland's connectivity – and therefore prosperity – will suffer.

[36] All London airports ie Heathrow, Gatwick, Stansted, Luton and City.
[37] Bibliography Item 19.

9.8.1 High Speed Rail Benefits for Scotland

The benefits that an Anglo-Scottish high speed route will bring to the Edinburgh/ Glasgow to London axis are already well recognised, and the conversion of air flows on these routes has been cited as one of the principal justifications for the introduction of high speed rail. The 115 daily flights from Scotland to all London airports carry around 12000 people, or (with due allowance for peak loadings over a 16 hour day) around 1200 people per hour. Taking existing Scotland-London rail flows and the 15%:85% rail:air modal split into account, this might amount to a total of 1400 people per hour. Allowing for a 70% load factor, 2000 seats per hour would be required, or around three 750-seater Eurostars.

Other air flows to English regional airports should also be convertible, if rail can offer a quicker and more frequent service. Whether this can happen with Greengauge21's HS2, or similar routeings along the North-West Corridor, is open to question. As noted previously, these tend to bypass city centres, and a service from Scotland to Birmingham or Manchester is unlikely to achieve the desired mode shift, if it can only access a remote parkway station, with relatively poor local public transport connections.

Another matter of concern with a WCML-aligned London-centric system is that by being aligned in such a manner that it cannot attract substantial inter-regional flows, passenger numbers (mostly en route for London) at its extremities will tend to be low. This will have the effect of compromising the financial case for these sections, and a possible outcome is that the dedicated high speed line may not be constructed for the full length to either Glasgow or Edinburgh. This will affect timings, but more importantly, it will restrict operation of high-capacity Eurogauge trains to Scotland. This may well preclude any possibility of through services from Scotland to European destinations.

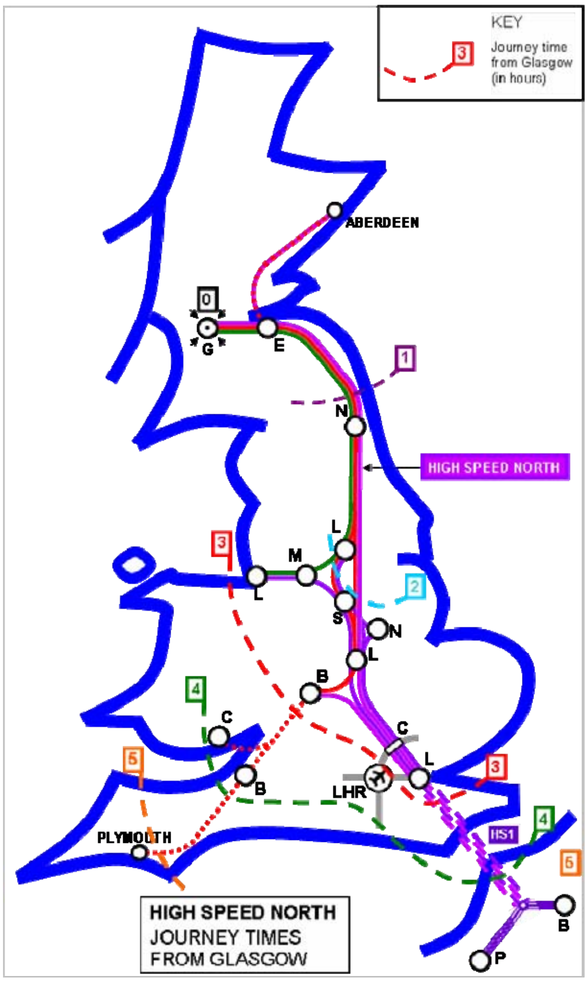


Figure 9.8.2

High Speed North, on the other hand, with its superior inter-regional links between city centre terminals, would seem to be much better placed to convert inter-regional air flows as well as on London-bound routes. It is practicable to offer at least hourly services from Glasgow and Edinburgh to all other 'Top 12' principal conurbations, with journey times under 3 hours for all destinations except Cardiff and Bristol. This capability – which cannot be matched with an HS2-type system – will tend to reinforce service levels at the extremities of the system.

All the services illustrated in Figure 9.8.2 would operate at hourly or better frequency, at journey times at last competitive with aviation. This would bring about a step change in rail communication to Scotland, that would seem to leave little or no future justification for internal aviation.

9.8.2 Harmonisation with Scottish Rail Developments

Aside from the normal considerations of accelerated journey time and improved connectivity, a key test for any high speed rail scheme is how well it harmonises with development aspirations in any particular locality. In the case of Scotland, the following key improvements are envisaged:

- High speed link between Edinburgh and Glasgow
- Improved journey times to Aberdeen and Inverness
- Extension of National Railfreight Network to Scotland

9.8.3 High Speed Link between Edinburgh and Glasgow

With existing journey times of almost one hour between Scotland's principal cities, major economic benefits are perceived from the establishment of a direct high speed link. Timings of around 20 minutes are achievable with conventional high speed rail, between city centre stations (ie Glasgow Central and Edinburgh Waverley).

It should be noted that the UK Ultraspeed consortium has been actively promoting a maglev link between Edinburgh and Glasgow, with a promised journey time as low as 12 minutes. However, any benefits that might accrue would seem to be lost in the greater difficulty and cost in accessing city centre termini – or in the more likely suburban location for the new 'parkway' termini. This is to say nothing of the lack of interoperability with wider high speed rail developments, either in the UK or in Europe. See Appendix C.

High Speed North's east-sided approach into Scotland (see Figure 9.8.3), first to Edinburgh and then Glasgow will naturally fulfil the requirement for an enhanced Edinburgh to Glasgow link, along the direct M8 corridor. A WCML approach, as with HS2, will not accord so closely. Figure 9.8.4 shows the 'high speed triangle' based on Edinburgh, Glasgow and Carstairs that might result, in simplistic terms. A 'meet in the middle' solution – perhaps a T-junction in the Livingston area – might be adopted as a compromise, but this would result in greater Anglo-Scottish journey times on the west-sided high speed line.

9.8.4 Improved Journey Times to Aberdeen and Inverness

Existing journey times of around 2h40m from Edinburgh and Glasgow to Aberdeen, and 3h30m to Inverness, are commonly acknowledged to be a major problem for the development of Scotland's railways, and of the economy as a whole. This typifies the north-south economic imbalance in Scotland, similar in many ways to that which prevails in the UK as a whole.

It is therefore vital that any high speed rail solution for Scotland takes into account the needs of (Scottish) northern communities, and extends beyond the Forth-Clyde line. Although the financial case for construction of a full-length dedicated high speed line does not appear exist for a new route to (say) Aberdeen, the most populous northern city, a more modest scheme may deliver major benefits.

The High Speed North vision includes the extension of hourly high speed services (originating in London, and possibly also on the CrossCountry axis) beyond Edinburgh to Aberdeen. See Figure 9.8.2. These would follow the existing northerly route across the Forth Bridge, before taking a new northbound track towards Perth; this would be an effective restoration of the direct Edinburgh to Perth Glenfarg route (closed in 1964), partly on existing trackbeds and partly following the newer M90. Speeds in the region of 160 – 200kph appear to be practicable here.

From Perth, the route would follow the abandoned Strathmore route (closed in 1967) to the north-east. This was a well-aligned railway through level topography; with an almost unobstructed trackbed, restoration appears possible as a full 300kph high speed line. The new line would rejoin the existing Edinburgh-Aberdeen railway north of Montrose, and proceed north-east to Aberdeen. A cut-off line near Stonehaven (to avoid the circuitous Carron Water section) should also be considered.

Overall, it appears possible to reduce Edinburgh to Aberdeen journey times to less than 1h30m, and to bring Aberdeen to within four hours of central London. This will bring major benefits, not least of which is the conversion to rail of Heathrow's 13 daily flights to Aberdeen.

Major benefits will also accrue for Inverness. Although through running from the high speed line is less likely, the direct and accelerated Edinburgh-Perth route should allow a reduction of almost an hour in journey times to Inverness from both Edinburgh and Glasgow, with Glasgow services utilising the high speed line, before swinging to the north across the Forth Bridge.

Figure 9.8.3 illustrates the proposed 'inverted-tee' model. It should be noted that Edinburgh Airport is located in the heart of the triangle at the focus of this system; this will allow services from most Scottish population centres direct access to longer-haul international connections.

Such an inverted-tee model might be developed even if a WCML-aligned high speed line were to be constructed. But the lack of a focal exchange point in the central belt of Scotland would comprise a major difficulty. For High Speed North, this function can be fulfilled at Edinburgh Waverley; for a west-sided HS2, a parkway station near Edinburgh airport would have to suffice. In essence, this is another manifestation of the WCML dysfunctionality, discussed at length elsewhere in this study.

9.8.5 Extension of National Railfreight Network to Scotland

There are two major handicaps for the development of rail as the prime means of trunk haulage of freight within the UK, and to wider European destinations. The first is lack of capacity on the existing rail network – which will of course be greatly relieved by the construction of sensibly-aligned high speed railways. The second and more intractable issue is the inability of the existing rail network to accommodate freight wagons of the size that commonly operate around the European network.

It is a massive frustration for freight operators to witness the (potential) dawning of the age of high speed rail within the UK. These new lines, constructed to generous aerodynamic clearances necessary to allow the passage of double-decker (Eurogauge) rolling stock at 300+kph, would also – if suitably graded – allow the passage of European freight wagons. The problem comes with the incompatibility between operating speeds – 300+kph for passengers, and perhaps 150kph for freight.

A simplistic solution, of four-track construction throughout, does not appear to be sustainable. Instead, an allied strategy is being developed, that could deliver a national Eurogauge freight network in association with High Speed North. The following broad strategy is proposed:

- Four-track construction along the M1 corridor from London to Leicester.
- Development of freight route along parallel corridors – often redundant or semi-redundant 'coal railways' – through East Midlands and Yorkshire to the North-East.

- Rebuilding of existing ECML route from Newcastle to Edinburgh.
- Onward extension to Glasgow (Mossend??) via Edinburgh Suburban Line and (probably) Shotts route.

The rebuilding of any existing route to accommodate larger – and potentially heavier – rolling stock is a massive undertaking. It will require the sluing of tracks for greater separation, the rebuilding of bridges and other overhead structures to achieve greater clearances, and possibly the strengthening and widening of bridges supporting the railway, *inter alia*. It could only be accomplished with a general absence of tunnels (for which reconstruction for wider-bodied rolling stock is likely to prove impracticable), and with the line in question closed for a lengthy period, possibly over a year.

Such a closure could not be contemplated on a busy railway route, carrying intercity passengers and freight. But with the Newcastle to Edinburgh section of High Speed North constructed and operating, the existing ECML route via Berwick would be reduced to the status of a local railway, serving relatively small populations and without a major 'base load' of freight. Replacement coach services could be offered, and any freight diverted via the Tyne Valley and Carlisle, for the duration of the blockade.

Although a year-long loss of rail services would constitute major disruption to the local communities along the ECML, the benefit comes with the longer-term security that the new freight services will bring to the route. The danger, as with all high speed line construction bypassing existing routes, is that the residual local railway will not prove viable in the long term.

A similar strategy is not possible with a WCML-aligned high speed line. This would do nothing to enhance connections between Scotland and Yorkshire or the North-East, and the ECML would remain a vital intercity rail artery along which wholesale reconstruction to Eurogauge would not be practicable. The other Anglo-Scottish routes – either the Settle-Carlisle and Glasgow South Western via Dumfries, or the WCML via Shap and Beattock – are similarly circumscribed. The former comprises the key heavy freight route, vital for importing coal and ore from the Hunterston terminal on the Clyde; the latter (although relieved by the high speed line in its passenger-carrying function) comprises the only route currently capable of carrying W10 container traffic (ie 9'6" containers on standard flatbed wagons).

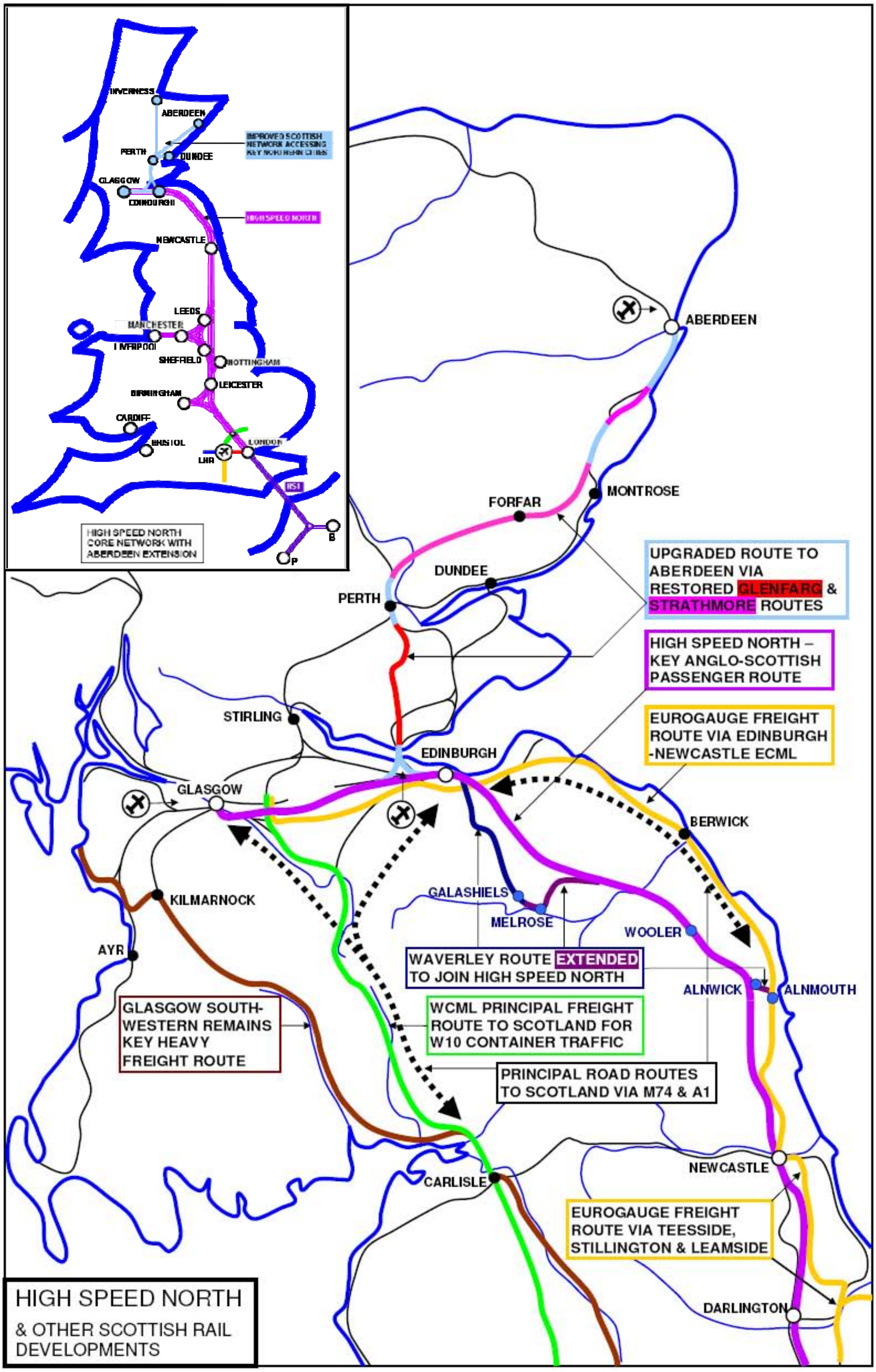

INVERNESS
ABERDEEN
IMPROVED SCOTTISH NETWORK ACCESSING KEY NORTHERN CITIES
PERTH
DUNDEE
GLASGOW
EDINBURGH
HIGH SPEED NORTH
NEWCASTLE
LEEDS
MANCHESTER
LIVERPOOL
SHEFFIELD
NOTTINGHAM
LEICESTER
BIRMINGHAM
CARDIFF
BRISTOL
LHR
LONDON
B
P
HIGH SPEED NORTH CORE NETWORK WITH ABERDEEN EXTENSION
ABERDEEN
MONTROSE
FORFAR
DUNDEE
PERTH
UPGRADED ROUTE TO ABERDEEN VIA RESTORED GLENFARG & STRATHMORE ROUTES
HIGH SPEED NORTH – KEY ANGLO-SCOTTISH PASSENGER ROUTE
EUROGAUGE FREIGHT ROUTE VIA EDINBURGH -NEWCASTLE ECML
STIRLING
EDINBURGH
GLASGOW
BERWICK
KILMARNOCK
GALASHIELS
MELROSE
WOOLER
AYR
WAVERLEY ROUTE EXTENDED TO JOIN HIGH SPEED NORTH
ALNWICK
ALNMOUTH
GLASGOW SOUTH-WESTERN REMAINS KEY HEAVY FREIGHT ROUTE
WCML PRINCIPAL FREIGHT ROUTE TO SCOTLAND FOR W10 CONTAINER TRAFFIC
PRINCIPAL ROAD ROUTES TO SCOTLAND VIA M74 & A1
NEWCASTLE
CARLISLE
EUROGAUGE FREIGHT ROUTE VIA TEESSIDE, STILLINGTON & LEAMSIDE
DARLINGTON
HIGH SPEED NORTH
& OTHER SCOTTISH RAIL DEVELOPMENTS

Figure 9.8.3

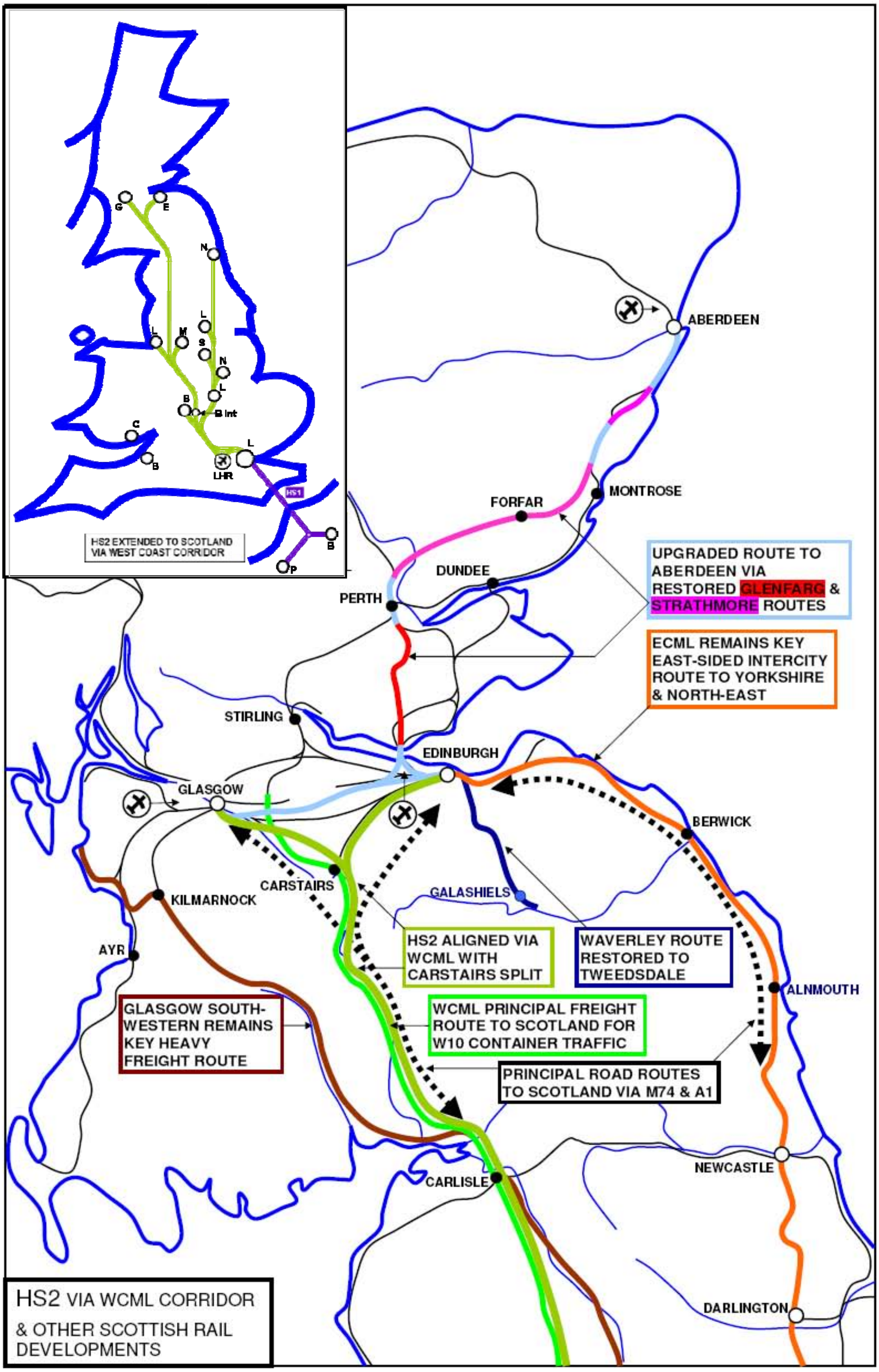

HS2 EXTENDED TO SCOTLAND VIA WEST COAST CORRIDOR
LHR
HS1
ABERDEEN
MONTROSE
FORFAR
DUNDEE
PERTH
STIRLING
EDINBURGH
GLASGOW
CARSTAIRS
KILMARNOCK
AYR
GALASHIELS
BERWICK
ALNMOUTH
NEWCASTLE
CARLISLE
DARLINGTON
UPGRADED ROUTE TO ABERDEEN VIA RESTORED GLENFARG & STRATHMORE ROUTES
ECML REMAINS KEY EAST-SIDED INTERCITY ROUTE TO YORKSHIRE & NORTH-EAST
HS2 ALIGNED VIA WCML WITH CARSTAIRS SPLIT
WAVERLEY ROUTE RESTORED TO TWEEDSDALE
GLASGOW SOUTH-WESTERN REMAINS KEY HEAVY FREIGHT ROUTE
WCML PRINCIPAL FREIGHT ROUTE TO SCOTLAND FOR W10 CONTAINER TRAFFIC
PRINCIPAL ROAD ROUTES TO SCOTLAND VIA M74 & A1
HS2 VIA WCML CORRIDOR
& OTHER SCOTTISH RAIL DEVELOPMENTS

Figure 9.8.4

9.9 High Speed North : Network Development Strategy

One of the most powerful arguments for conventional (ie steel wheel on steel rail) high speed rail technology, as opposed to newer (and possibly technically superior) systems such as maglev, is the capability for incremental development. The first stage of a high speed route to the North, from London to the Midlands will allow major acceleration of services to points further north, as far as Scotland, to be accelerated by at least 20 minutes. Even this relatively small gain will bring the critical London to Edinburgh and Glasgow journey times to below 4 hours, and start to tip the balance against internal aviation.

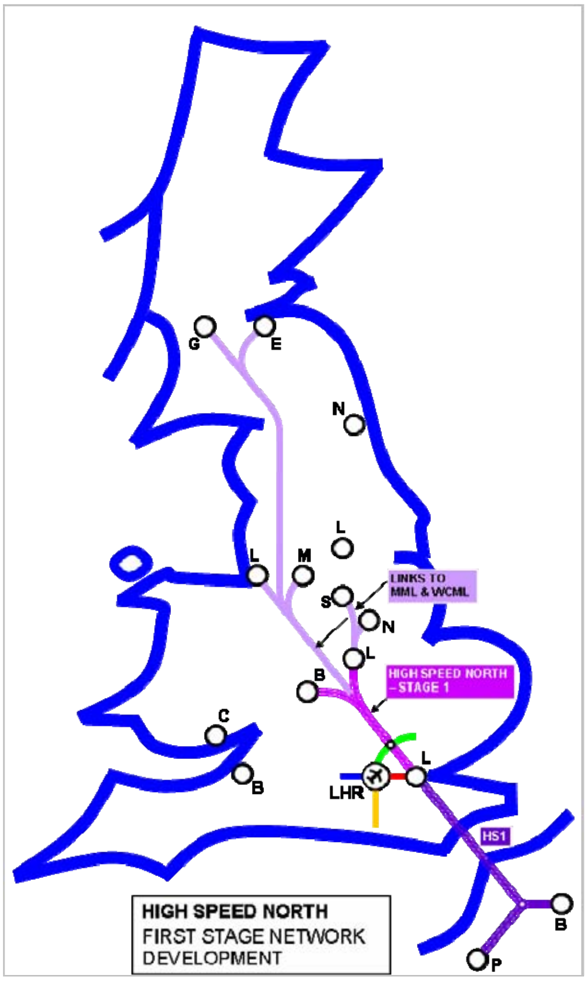


Figure 9.9.1

The development of High Speed North will accord with this incremental strategy. A first M1-aligned phase (see Figure 9.9.1) from London to the West and East Midlands will connect to the WCML near Rugby, delivering the 20 minute acceleration noted above, and to the MML at Leicester. With the MML a heavily speed-restricted route, the high speed connection at Leicester will allow the existing journey time of 75 minutes to be almost halved, to around 40 minutes. The same 35 minute saving will apply for the other principal MML destinations ie Nottingham, Derby and Sheffield.

Of almost equal importance to the journey time savings is the extra capacity that will be achieved on the most congested sections of both West Coast and Midland Main Lines. It will become possible to develop the WCML to realise its true potential as a freight route (it is the only main line to the north with W10-clearance ie capable of carrying standard sea-going 9'6" containers on flat wagons for its full length).

The second phase (see Figure 9.9.2) in envisaged as continuing north through the East Midlands, to reach the ECML to the north of Doncaster, and to reach Manchester via Sheffield and the Woodhead pass across the Pennines. This will achieve journey time savings of around 30 minutes to all principal ECML destinations ie Leeds, Newcastle and Edinburgh, and deliver extra capacity on this corridor too.

Equally significant, a high speed connection between Birmingham and the ECML is created with the second phase; this will allow major accelerations on the CrossCountry route, perhaps a time saving of 45 minutes between Edinburgh/Newcastle and Birmingham/Bristol. This is an axis on which domestic aviation is expanding, and the potential here for environmental savings is clear. It is also worth noting that connections from Leicester to the North-East and Scotland, currently very poor, will be greatly improved.

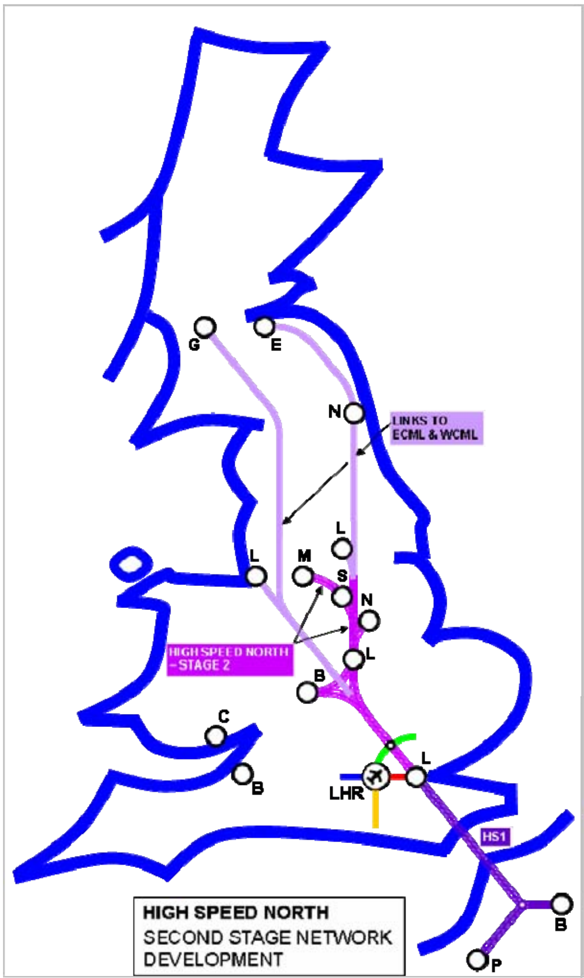


Figure 9.9.2

This approach accords with perceived priorities of maximising capacity enhancement on the most congested railway routes ie the southern sections of the key main lines radiating from London.

But there are powerful arguments to develop high speed rail on two fronts, both from London and from Glasgow. This would allow early establishment of an enhanced Glasgow-Edinburgh link and a journey time of around 20 minutes..

From the viewpoint of converting Anglo-Scottish air flows, it is worth noting that the ECML between Newcastle and Edinburgh comprises the slowest and most circuitous section of the route. Here, a faster and more direct section of high speed line could bring about the greatest potential time saving, down to 40 minutes from around 90.

Taken in combination, the first and second phases of High Speed North, aligned with motorway rather than existing railway corridors, will provide congestion relief to all three northern main lines, and to the Crosscountry axis also. It should additionally be noted that with high speed access to Birmingham achieved with the first phase, and Manchester accessed with the second, the key aims of any west-sided 'HS2' are met for little more route mileage; but with most of the key elements of a new national high speed network already in place.

With further phases of incremental development, a national core network of Eurogauge high speed lines will be created, linking all principal Midlands, Northern and Scottish conurbations.

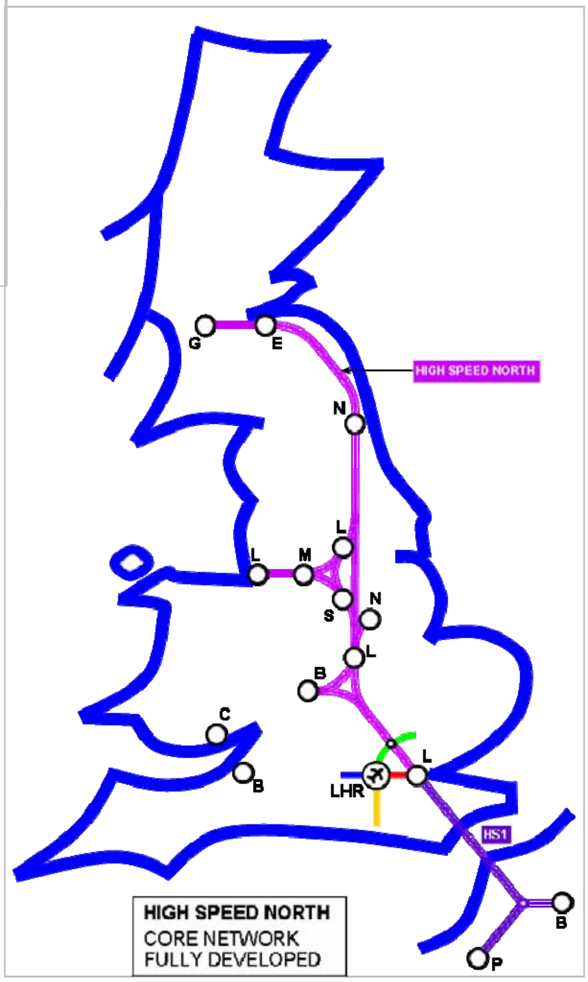


Figure 9.9.3

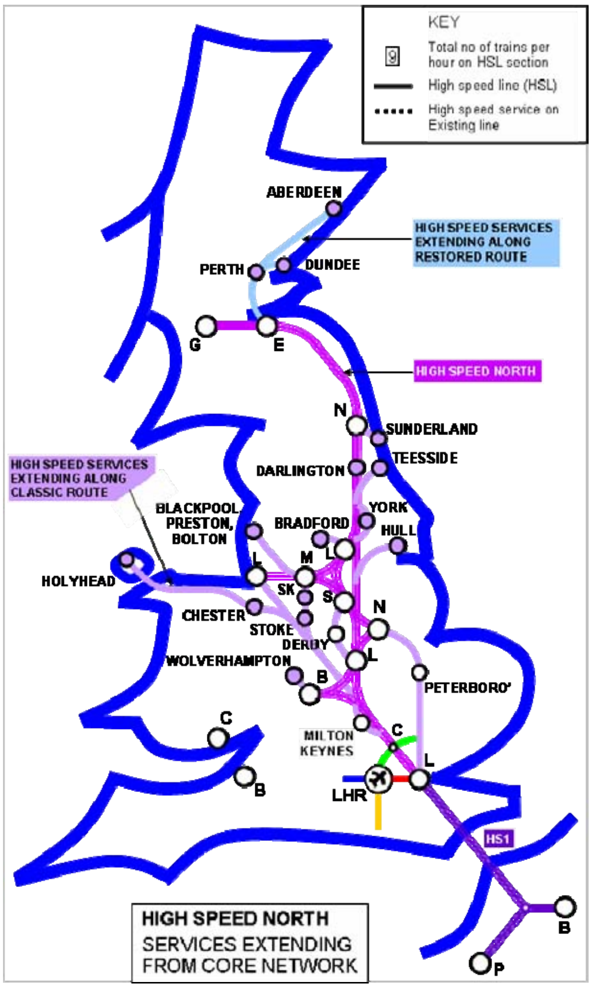


Figure 9.9.4

It is vital, from the point of view of public and political acceptance of the massive investment that will be required to establish high speed rail in the UK, that its benefits are spread as widely as possible. It is clearly impracticable to construct new railways to every potential destination – and so far as direct links to Europe (likely to be dictated by the capability of running Eurogauge rolling stock) it is probable that these will be confined to the key conurbations on the core network.

Instead the strategy must be to run domestic UK high speed services that maximise the timing advantages of the new line before running off-network onto existing lines. This will allow the inclusion of cities such as Aberdeen, Hull and Bradford, and key Lancashire centres such as Bolton, Preston and Blackpool. See Figure 9.9.4.

This will demand trains of similar specification to the existing Eurostars – capable of 300kph+, but sized to be compatible with the existing UK network. It is anticipated that further electrification of the existing network would proceed as necessary to facilitate all-electric operation of the new high speed line.

The High Speed North 'core network' concept has been developed with the aim of optimising the roll-out of high speed rail in the UK, delivering a network to connect key Midlands, Northern and Scottish cities, and maximising the improvements to the existing network (and in doing so, maximising conversion of domestic air flows to rail).

Further development of UK high speed rail may see development of High Speed West (connecting Wales and the West Country to the national and European network) and supplementary northern routes, leading to a more traditional West Coat/East Coast network format. See Figure 9.9.5.

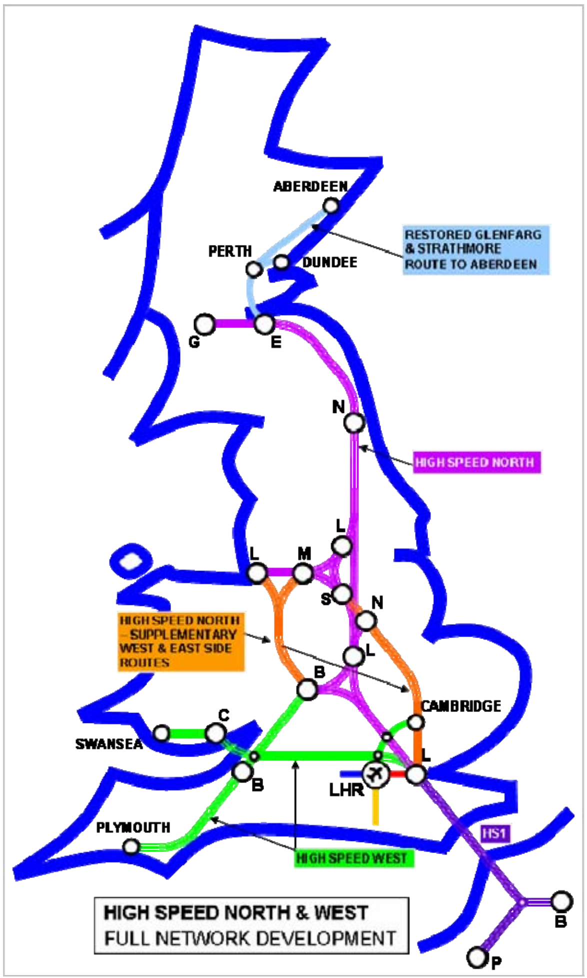


Figure 9.9.5

9.9.1 Proposed Service Pattern

The services that operate on High Speed North will be a mixture of:

- Domestic high speed running from the core network onto existing lines.
- Domestic high speed running exclusively on core network.
- High speed services from UK regions to European high speed network.

The latter two service categories could be worked with Eurogauge 'duplex' double-decker rolling stock, which would maximise capacity, and harmonise with operations elsewhere in Europe. However, the first category will require a fleet of trains capable of operation at the line speed of the core network (provisionally 300kph) but no larger than existing UK trains, to permit off-network running. With the UK on the verge of entering the age of high speed train travel, it must be a matter of concern that the Government is proposing to introduce to the national rail network the new generation of IEP intercity trains that will only be capable of 225kph, barely any faster than the existing 200kph-capable fleet.

Figures 9.9.6 and Table 9.9.7 indicate a possible service pattern for High Speed North. It should be noted that of the 20 identified trains per hour (16 bound for London and Europe, and 4 inter-regional), only 9 would be exclusive to the high speed line, and therefore potentially operated by Eurogauge stock; the other 11 would require UK-gauge trains.

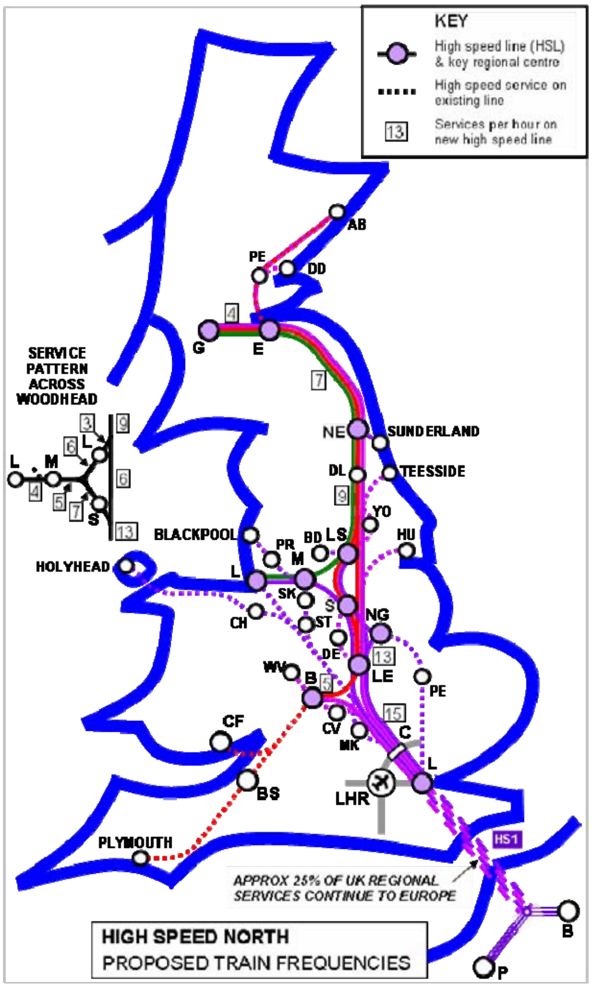


Figure 9.9.6

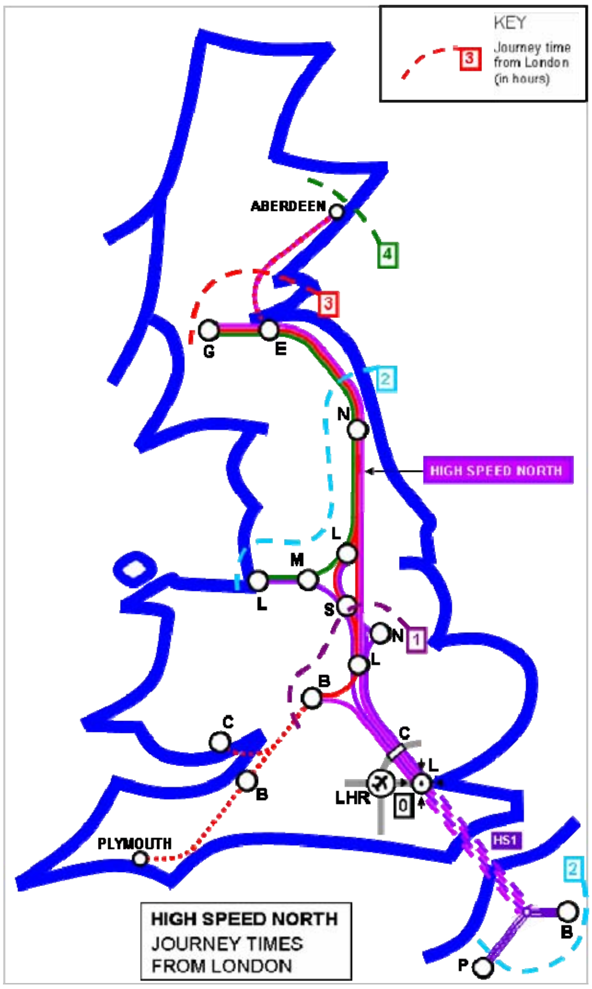
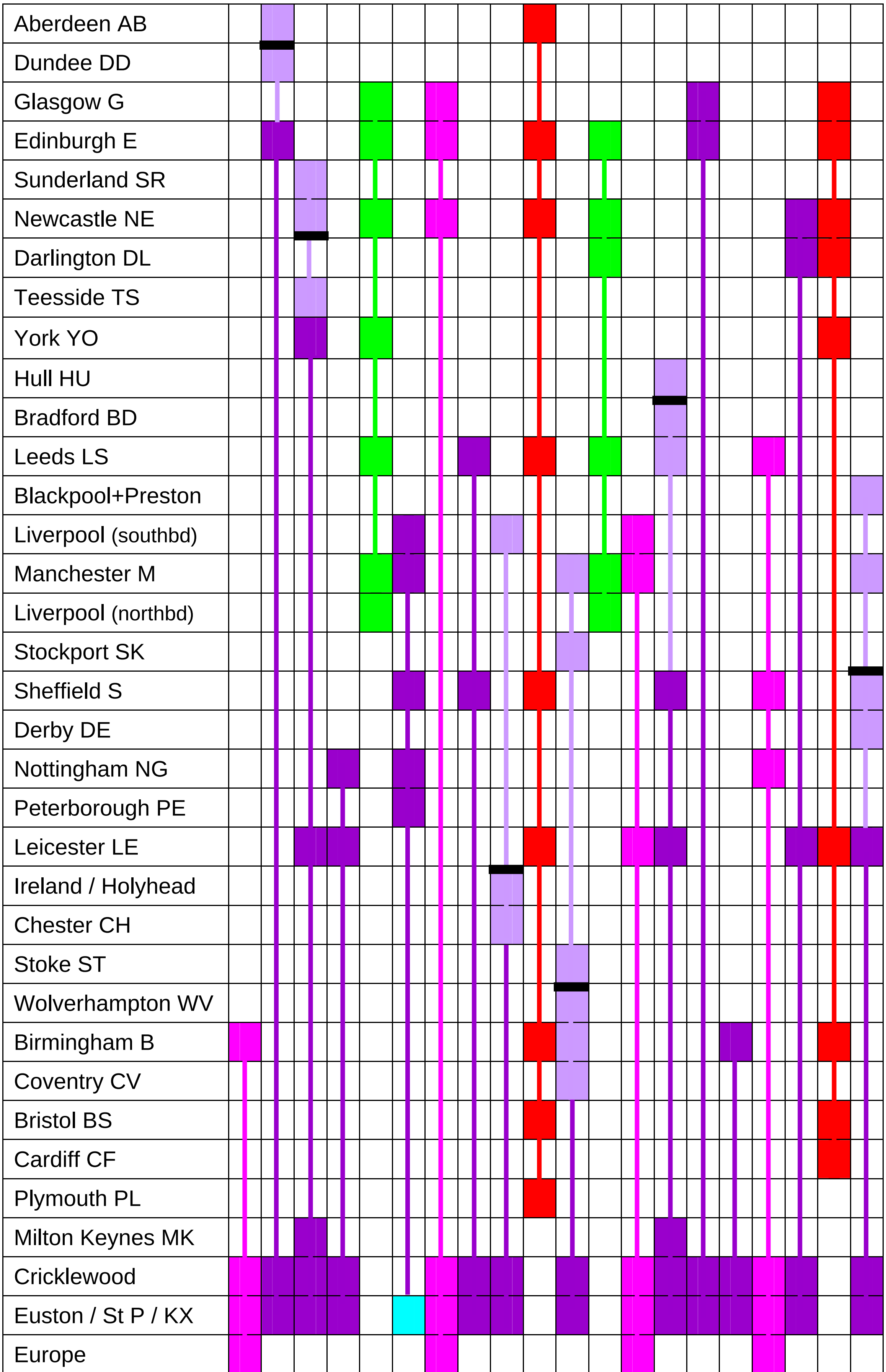


Figure 9.9.7

KEY *to Table 9.9.8 overleaf*			
Domestic high speed to Euston			
European service via St Pancras			
TransPennine			
CrossCountry			
Split train working onto existing network indicated in lilac with bar between portions.			



HIGH SPEED NORTH :
PROPOSED HOURLY SERVICE PATTERN

Table 9.9.8

10. Comparisons between High Speed North & 'HS2' Routes

It is not the purpose of this document to develop detailed benefit-to-cost ratios for the High Speed North proposal (nor is it within the author's expertise to do so). The work in establishing the essential financial case for high speed rail in the UK has already been undertaken, through a variety of studies. These have uniformly indicated favourable BCRs for new high speed intercity railways in the region of 2.0.

Of particular relevance to this study is the BCR of 2.0 calculated by Atkins for a national system of high speed lines in the recent report *Because Transport Matters* (2008)[38]. This was the 'Full Network' option (or Option 8 from the 2004 *High Speed Line Study*[39]), similar in its configuration to the 'East-Sided HS2' option illustrated in Figure 10.2, but without a dedicated Heathrow link.

With the fundamental business case for high speed rail established by previous studies (by Atkins and others), the focus has now shifted towards the development of engineered high speed rail solutions. The aim should be one of optimisation, to maximise the benefits and minimise the costs, and thus achieve greater benefit-to-cost ratios.

This section attempts to make objective comparisons between the candidate schemes, namely High Speed North as an east-sided spine route and various permutations of west-sided Heathrow-oriented 'HS2' proposals.

As previously discussed, there is no single definitive 'HS2' scheme. The systems postulated by Arup (Figure 8.3.2) and the Greengauge21 high speed corridors (Figures 8.2.1 and 8.2.4) offer a guide, from which assumptions can be made:

- A variety of 'HS2' schemes will be considered, with both west- and east-sided approaches to Scotland.
- All schemes will consider the same nine conurbations: London, Birmingham, Leicester, Sheffield, Manchester, Liverpool, Leeds, Newcastle, Edinburgh and Glasgow.
- Nottingham is excluded owing to current lack of definition as to how it might be placed on a through route. It seems that city centre access can only be achieved by means of a spur from the main line.
- City centre stations at Leeds and Sheffield cannot practicably be located on a trunk, time-sensitive route from London to destinations further north (either the North-East or Scotland).
- To maximise network opportunities and minimise aggregate route length, it is assumed that west-sided and east-sided high speed lines will diverge in the Warwickshire area, after a combined route from London via Heathrow. Both west- and east-sided routes will be considered as extending to Scotland.
- A classic west-sided 'HS2' routeing, combined with an east-sided 'HS3' direct to London (with no intervening connections), and both extending to Scotland, is also considered.
- The possible routeings that have been postulated from the remit of the DfT's HS2 Company (see Item 8.4) are also analysed. Given the apparently deliberate omission of the East Midlands and South Yorkshire, it is not proposed to include the cities of Leicester and Sheffield in the analysis. Hence the comparisons that are made are not fully normalised. (However Liverpool, representing Merseyside, will be included).

[38] Bibliography Item 13.
[39] Bibliography Item 3

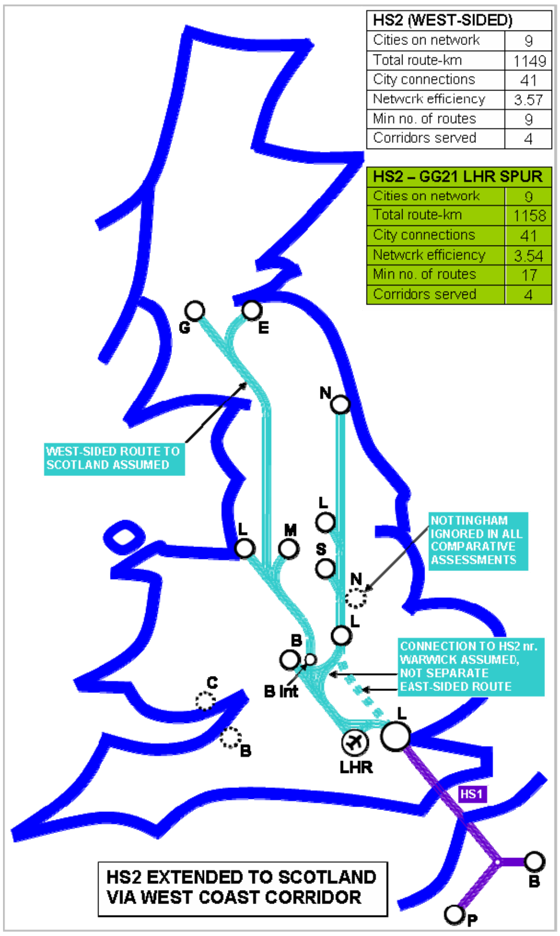


Figure 10.1

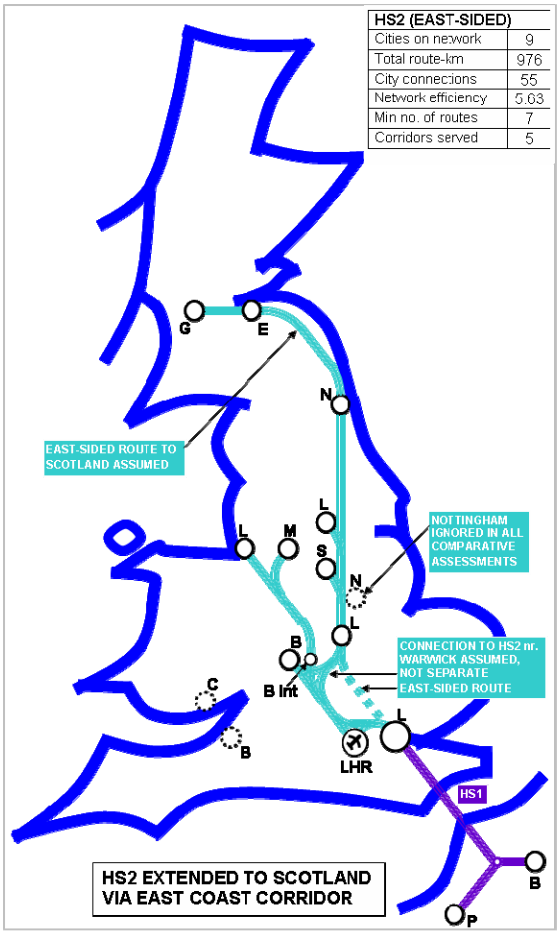


Figure 10.2

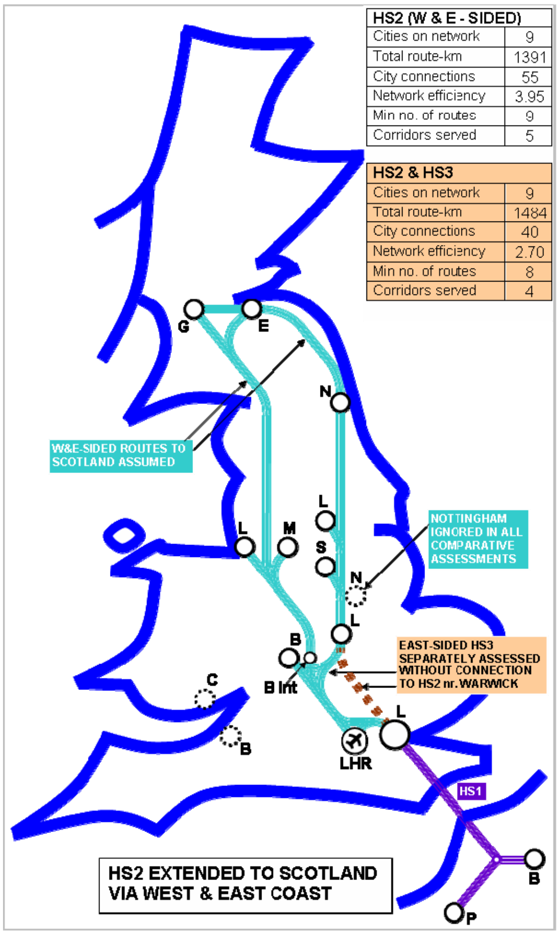


Figure 10.3

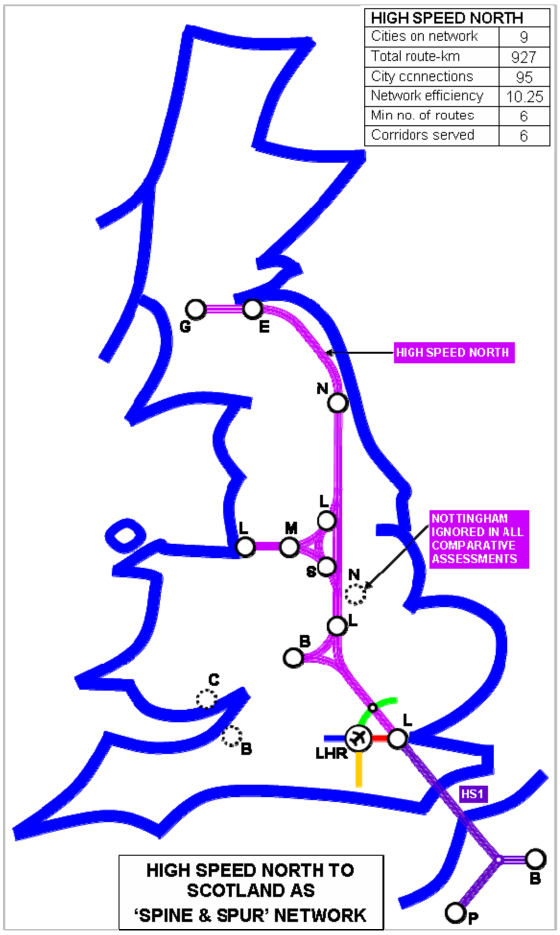


Figure 10.4

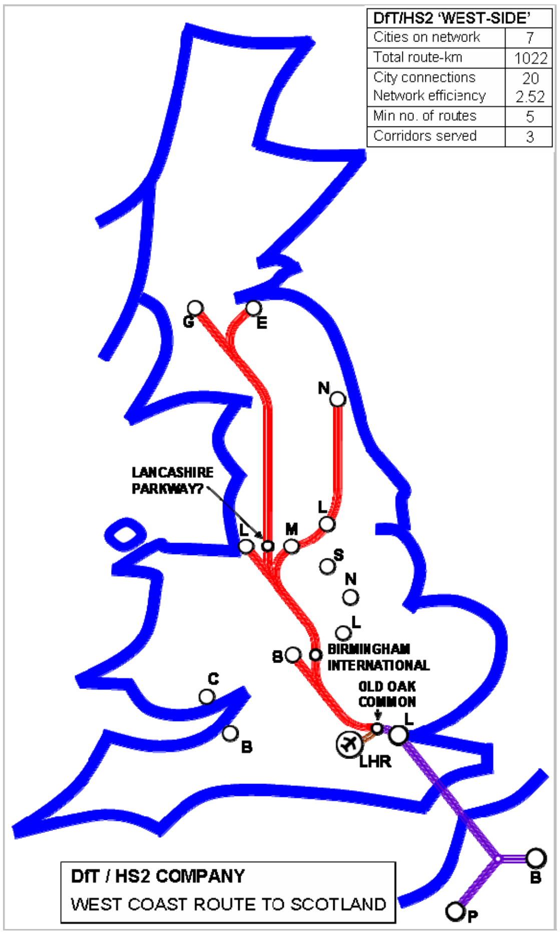


Figure 10.5

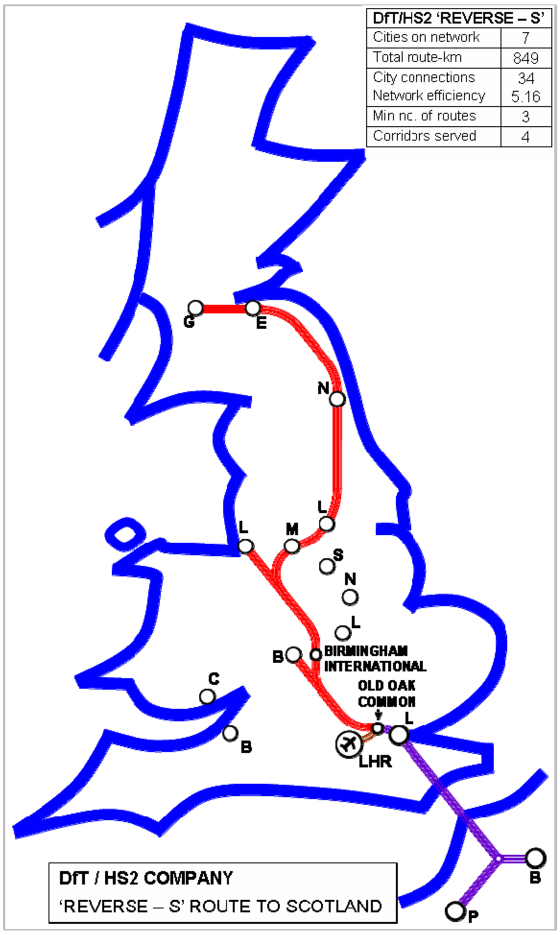


Figure 10.6

10.1 Comparison of 'Full Network' Options

The various routeings are analysed in the spreadsheets in Appendix E, and illustrated in Figures 10.1 – 10.6. The following calculations are made:

1. Aggregate route length, using grid references of key points along the routes. A uniform allowance (of 6%) above straight line distances is made to account for natural sinuousness.
2. Number of city connections made.
3. Network efficiency – no. of city connections divided by aggregate route length.
4. Number of separate routes required to achieve these city connections.
5. Operational efficiency – no. of city connections divided by no. of routes.
6. Cost of the network – based on unit rates per kilometre for high speed rail construction. No allowance is made for DfT 'optimism bias' since rates are based on out-turn costs for the construction of HS1.
7. Feasible journey times between main centres.

From the first two calculations, an assessment of network efficiency is made. This is calculated as the number of city connections divided by the total route length (and multiplied by 100 to normalise the numbers). Operational efficiency is an attempt to capture the potential convergence and combination of flows onto the minimum number of trains, from which load factor can be optimised; benefits for both financial and environmental performance should then follow. See Item B14. All results are summarised in Table 10.7.

	GG21 west	HS2 west	HS2 east	HS2 & HS3	HSN	DfT west	DfT Rev-S
Ref Figure…	*10.1*	*10.1*	*10.2*	*10.3*	*10.4*	*10.5*	*10.6*
Cities on network	9	9	9	9	9	7	7
Total route-km	1157	1149	976	1484	927	1022	849
City connections	41	41	55	40	95	20	34
Network efficiency	3.54	3.57	5.63	2.70	10.25	2.52#	5.15#
Min no. of routes	17	9	7	8	6	5	3
Operational effcy.	2.41	4.56	7.86	5.00	15.83	4.00	11.33
Corridors served	4	4	5	4	6	3	4
Heathrow access?	All routes	All routes	All routes	HS2 only	All routes	All routes	All routes
Indicative cost (*no optimism bias*)	£39.5 bn	£39.5 bn	£34.0 bn	£52.5 bn	£30.5 bn	£38.0 bn	£32.0 bn

Table 10.7 : Comparison of 'Full Network' options

10.1.1 Network Considerations

It is apparent that the spine and spur format of High Speed North has the shortest total route length, the greatest number of city connections and the least requirement for separate train routes to operate – and hence comprises the most efficient network. It also serves the greatest number of existing main line corridors, with the greatest operational efficiency and thus would seem to be capable of optimising mode shift.

From consideration of the various HS2 schemes, it would seem that network inefficiency grows as focus increases on the WCML corridor, with spurs required to all key centres. The assumed combination of east-and west-sided routes in the Warwick area provides some mitigation, but this is largely lost with separate HS2 and HS3 systems (ie west-sided and east-sided and thus exclusively London-centric); these perform even more poorly, with high cost and low network and operational efficiency, amongst other issues.

In the assessment of the projected options inferred from the remit of the DfT HS2 Company, the calculated network efficiency has been normalised to take account of the lesser number of key centres (seven, as opposed to nine considered for the other schemes). Although the 'Reverse – S' scores well for operational efficiency (single uniaxial route covering maximum practicable number conurbations) this potential may not be realised on account of the difficulty of achieving city centre 'through routeing' for Leeds and Manchester (as with Birmingham).

10.1.2 Heathrow Access

There is a presumed desire (if not a business model – see earlier discussion of Greengauge21 and Arup schemes in Items 8.2 and 8.3) for regional access to Heathrow to be as 'interchange-free' as possible. All options have been scored on the basis of achieving the minimum specification of access to all airport terminals with no more than a single (cross-platform) change of trains at a remote hub (be it Cricklewood, Old Oak Common, Arup's Heathrow Hub or Greengauge21's proposed terminus at Terminal 5) with frequent onward services to the airport.

The practicality of Greengauge21's proposed spur into Heathrow needs to be critically examined. The operating speed of the 11km spur, extending from Northolt Junction to Terminal 5, will be restricted to perhaps 200kph at best due to curves at the junction and the necessary tunnelled alignment. It seems unlikely that trains could deviate from the main line, stop at Heathrow and 'bounce back' in less than 20 minutes.

Hence it would seem that the Greengauge21 policy, of placing of Heathrow on a spur off the main line, will of necessity prevent integration between London- and Heathrow-bound services. This accounts for the high number of separate routes listed in Table 10.7, and the low operational efficiency. Aside from any question of load factor, and associated economic and environmental concerns, it must be questioned whether it is viable for the new high speed line to accommodate this range of services, given competing demands for line capacity and the need for flexibility for future expansion.

Although the Greengauge21 and Arup's options score very similarly for cost and network efficiency, it must be borne in mind that the figures relate to railway infrastructure, and the cost of any distributor systems within Heathrow has to be added. These costs are certain to be greater for the much wider geographical scope of the Arup scheme, perhaps by of the order of £1 billion. In the context of a project costing upwards of £30bn, the cost difference is relatively minor and Heathrow Hub models have generally been used for purposes of comparison with other proposals, on account of their greater operational simplicity.

There are also concerns with regard to a divided HS2/HS3 configuration, in which only HS2 would have direct access to Heathrow. This would leave the east side of the country without the advantage of a Heathrow connection other than via central London, and as noted previously, this would raise major regional political issues.

10.1.3 Cost Comparisons

It is important to translate the comparisons between the various route options into cost. While calculation of absolute cost is difficult, and notoriously subject to inflation and 'scope creep', calculation of comparative cost can be much more accurate and reliable. There are two elements to the calculation – the length of route to be constructed and the cost per kilometre of construction, appropriately varied to take account of local factors eg tunnelling or heavy environmental protection.

Estimates of cost for high speed line construction vary hugely. The Channel Tunnel Rail Link (now HS1) was delivered at a cost of around £50M per kilometre, for a heavily engineered route comprising tunnel or viaduct for over a quarter of its length. From this the extremes might be inferred, that tunnel or viaduct construction will cost towards £100M/km, while construction on a level greenfield site, without major environmental constraints, might cost as little as £25M/km.

For the purposes of this calculation, the following costs have been assumed:

- £30M/km for construction in level topography along existing corridors,
- £50M/km for heavily engineered routes involving frequent tunnels and viaducts,
- £80M/km for fully tunnelled routes.

These costs, with some interpolation where appropriate, have been applied consistently across the various proposals under consideration. It should be no surprise that High Speed North, requiring a shorter length of construction in generally more favourable topography, comes out as the cheapest – and best value – proposal. As previously discussed, no attempt is made to calculate a BCR for High Speed North. But given its comprehensive outperformance of the competing proposals, in particular the 'East-Sided HS2' (see Figure 10.2), which roughly equates to the Atkins 'Full Network' Option[40], it is evident that a BCR well in excess of 2.0 would apply to High Speed North.

[40] Bibliography Item 13.

10.1.4 Climate Change Economics

But 'old world' considerations such as benefit-to-cost ratios must be treated with extreme caution. For any publicly-funded project, with whatever BCR (say xx:1), the difficulty is always that the Government has to pay for the '1' now, while the (presumably greater) 'xx' generally represents a 'trickledown' return to the economy, over a probably lengthy period in the future.

In the post-Credit Crunch economy, with Government spending challenged on all fronts, it is difficult to see how investment in high speed rail can be justified under conventional economic logic. Spending on such mega-projects will only be permitted if it can be fully aligned with contemporary priorities, in particular the fight against climate change.

CO_2 – or the reduction thereof – seems certain to become the new money, and high speed rail can access this through facilitation of mode shift. The key to mode shift is capacity relief to the existing rail network, on as many main line axes as practicable. In this context, Transpennine and CrossCountry are as important as the London-centric main line axes.

Again, High Speed North scores best in this category.

10.1.5 Comparative Journey Times from London

A fairly crude comparison of comparative timings has been made, based upon the calculated distances and an assumed speed for each section of route. An average speed of 250kph (representative of 300kph top operating speed) has been applied to most sections, but is reduced to 200kph in specific locations such as the Metropolitan area (within the M25) and the Woodhead Transpennine crossing (for High Speed North and the DfT HS2 Company options). Where the route is assumed to follow existing tracks (particularly on the HS2 south-sided approach to Manchester Piccadilly through Wilmslow, Stockport et al) a much lower average speed of 125kph is applied. On this basis, High Speed North's longer route via Woodhead, all on reserved alignment, achieves equivalent journey times from London.

Only at the very western extremities of the High Speed North system ie Liverpool and Glasgow are timings marginally compromised, by approximately 20 and 15 minutes respectively. Here, the mitigation is the greater journey opportunities and frequencies that become possible through the placing of Liverpool and Manchester, and Glasgow and Edinburgh, on the same spurs off the network. For Liverpool, it should also be noted that as the high speed network matures, a more direct 'Trent Valley' route, possibly via Birmingham, appears to be a strong contender for further development. See Figure 9.9.5.

There are few serious concerns with regard to timing for most of the various HS2 options; all comfortably achieve London-Glasgow journey times of less than three hours, with the single exception of the 'Reverse – S' option inferred from the DfT HS2 Company remit. The sinuous nature of this route would extend its length to such an extent that it would be necessary to raise operating speeds above the assumed 300kph, to perhaps 350kph, to achieve the commercial and political goal of a London-Glasgow timing below three hours. This acceleration will have the inevitable effect of increasing energy use (by approximately one third), with consequent increased CO_2 emissions and damaged environmental credentials.

10.2 Initial Objectives : Birmingham, Manchester and Leeds

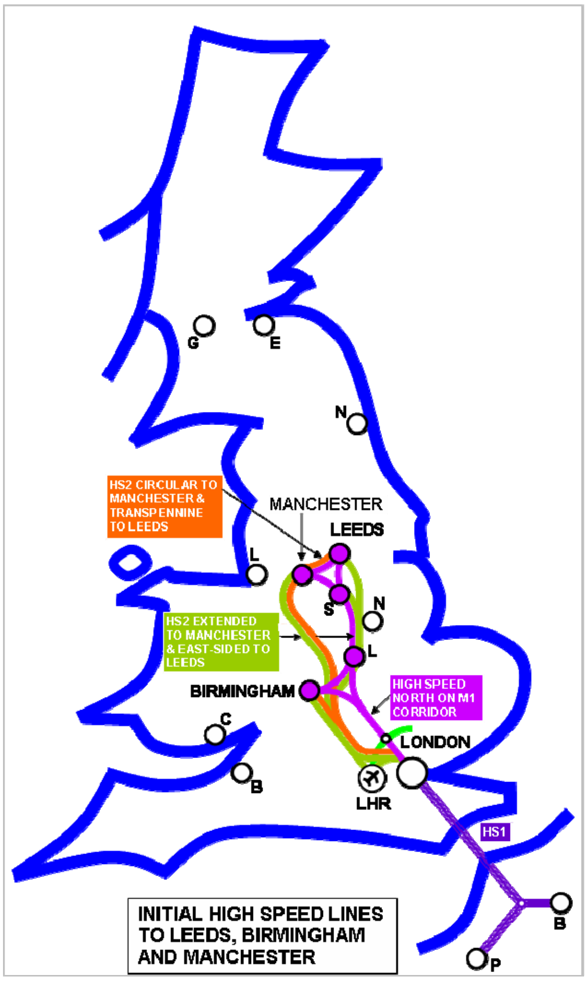


Figure 10.8

In respect of the emerging requirement for an initial UK high speed rail system extending to cover Birmingham, Manchester and Leeds, an assessment has been undertaken of three different potential routeings (as illustrated in Figure 10.8):

- High Speed North: east-sided spine route from London to Yorkshire via Leicester and Sheffield, with west-facing spurs to Birmingham and (over Woodhead) to Manchester.
- HS2 'North-West Corridor' route to Birmingham and Manchester via Heathrow and Chilterns, with east-sided spur to Leeds.
- Circular Heathrow-Birmingham-Manchester-Leeds route, following HS2 as far as Manchester and then across the Pennines to Leeds.

Criterion / HSL option	Route Length (km)	Indicative Cost	Key cities served	City Conne-ctions	Timings to Leeds
High Speed North	401	£14.5bn	6	33	1h17m
HS2 Y-shaped	541	£18.5bn	6	24	1h28m
HS2 circular to Leeds through Birmingham	385	£18.0bn	4	15	Not calc'd
HS2 circular to Leeds bypassing Birmingham	418	£17.5bn	4	11	1h38m

Table 10.9 : Comparison of initial routeings

In terms of simple point-to-point distances, the HS2 circular route is slightly shorter than High Speed North. But calculation of distance, timings and general utility of any routeing is always dependent on the assumptions that are made as to alignments through, or around, intermediate cities. All HS2 schemes so far have preferred to bypass Birmingham and Manchester en route to points further north (the HS2 Y-shaped option above has been scored accordingly) and the same consideration will apply to any time-sensitive HS2-oriented circular route to Leeds.

With the need to bypass Birmingham taken into account, total route mileage would increase, and network efficiency would decrease. (It is probably appropriate to make similar adjustments in respect of a bypassing alignment around Manchester, but no such study has yet been undertaken; in any event, there are major difficulties in realising either route, and the costings have been adjusted appropriately.)

High Speed North thus achieves a better network for fewer route kilometres, at less cost.

On the basis of the above, it is evident that, just as for the 'full network' comparisons, the High Speed North proposal also outperforms its rivals in creating an intermediate system, extending as far as Birmingham, Manchester and Leeds, but with more intermediate communities served. This should also be reflected in lesser construction cost, and greater financial returns, through the greater traffic that will be attracted. All of this should serve to improve the BCR and potential mode shift, and thus enhance the business and environmental case for high speed rail in the UK.

10.3 Excessive HS2 Focus on Heathrow and North-West Corridor??

The rationale behind the Greengauge21 HS2 and Arup Heathrow Hub models, and indeed the remit of the DfT's HS2 Company, appears to stem from two basic perceived needs:

- to include Heathrow Airport as an integral element of the UK high speed rail solution.
- to address congestion problems on the North-West Corridor en route to Birmingham and Manchester.

This study does not take basic issue with either of these needs, only in their association into a single uniaxial high speed route via Heathrow to Birmingham and Manchester, confined to a single main line axis along a difficult and controversial route through the Chilterns. The apparent 'line of least resistance' alongside (or in very close proximity to) the M1, that should be cheaper to build and at the same time potentially serves a far greater range of destinations, appears to have been ignored.

This study has demonstrated that the various 'HS2' proposals comprise neither the only way, nor the best way in which the above 'basic needs' can be satisfied. They do not appear to facilitate onward development into a comprehensive and cost-effective UK high speed network that can facilitate optimum mode shift. The wider needs of the UK transport system, economy and environment would seem to demand more effective and imaginative solutions.

The superiority of High Speed North is reflected in the wider comparisons against the high speed rail specification (see Item 8.1), as set out in Table 10.10. Notwithstanding the lesser definition of the various competing proposals, High Speed North would appear to score better in all categories.

Table 10.10 : Comparisons between WCML-aligned HS2 and High Speed North

HSL option / Criterion	**HS2 / WCML-aligned High Speed Line**	**HIGH SPEED NORTH (HSN) plus LHR COMPASS POINT**
Coverage	No clear vision offered beyond North-West Corridor ie London-Heathrow-Birmingham-Manchester. Eastern communities effectively excluded.	All key Midlands, Northern and Scottish conurbations included in Core Network, all with onward European services. Strategy developed for wider coverage through onward running onto classic network.
City Centre Hubs	Few definitive proposals exist, except for trunk route to North-West to bypass central Birmingham with 'through' station at Birmingham International. Hence Birmingham's high speed connectivity compromised.	Proposals developed for city centre access to all key centres except Sheffield (Meadowhall proposed) and Liverpool (Liverpool South Parkway). Both well connected to existing local rail network, and with comprehensive high speed links.
Dedicated New Railway	Few definitive proposals exist, but upgrading of south-sided approach to Manchester along busy commuter network through Wilmslow/Stockport will be expensive and/or disruptive.	Core network will comprise mostly new railway constructed to Eurogauge, with only limited reengineering required on station approaches.
Network Development	Concentration first on North-West Corridor will compel (for political reasons) subsequent development of east-sided route, as next priority, thus delaying establishment of either inter-regional links (ie XC & TP) or trunk route to Scotland. Early concentration on NW Corridor seems to compromise quality and symmetry of ultimate network.	Strategy for incremental development will deliver early benefits on multiple corridors, and ultimate network is better.
Optimised Network	London-centric systems implicit in HS2/HS3 et al will make inter-regional connectivity only achievable with much greater length of new construction, hence much poorer network efficiency.	Spine & Spur configuration allows more cities to be linked for fewer route kilometres. Greater inter-regional connectivity possible through facilitation of Transpennine and CrossCountry corridors, minimising London-centric effects.
Enhanced Network	HS2's exclusive alignment upon WCML axis precludes significant enhancement of wider UK main line network.	Independence of HSN from existing main line axes and greater network coverage allows major network enhancements eg Liverpool & Manchester to Scotland, and Leicester and Milton Keynes to Yorkshire & North-East.
Inclusivity	HS2 focussed entirely along WCML corridor, offering no benefits to East Midlands, Yorkshire or North-East. Major political difficulties anticipated, especially since WCML already upgraded at huge expense.	Orientation of HS1 along M1 axis allows even-handed development of UK high speed rail, favouring neither west- nor east-sided communities.

Carbon Footprint / Modal Shift	Environmental benefits limited through adherence to existing main line corridor, and through delays in achieving necessary improvements in communications to Scotland to divert short-haul air flows.	Greater mode shift achievable with HSN through coverage of multiple main line corridors (ie WCML, MML, ECML, XC, TP) and creation of extra capacity on all of these. Through quicker roll-out to Scotland and generally to Northern destinations, elimination of short-haul aviation will happen sooner.
Environmental Impact	London-centric system aligned along WCML corridor will require parkway stations, with risk of associated major developments on Green Belt land. Major problems will arise with routeing through Chilterns.	Minimised through following existing transportation corridors, and accessing city centre hubs, rather than parkway stations. Incursion into Peak District NP on Woodhead corridor mitigated by net environmental improvement through associated lorry shuttle proposals.
Capacity Relief	HS2 focussed on WCML corridor, hence will only provide capacity relief on that corridor. Congestion on ECML and MML will remain until separate east-sided spur (or HS3) is constructed – presumed to happen after development of HS2 to Manchester.	Spine and spur configuration of HSN plus M1 routeing north of London allows first WCML, MML, and then ECML, Transpennine and CrossCountry corridors to be relieved, as soon as second phase complete. HSN is also compatible with Scottish aspirations along the Edinburgh to Glasgow corridor and wider network improvements.
London Terminal & routes clear of Metropolitan area	Terminal proposals not defined – but even if Euston selected as per HSN, initial westerly track towards Heathrow will compel considerable tunnelling owing to lack of clear rail corridor.	Euston station represents optimum location for domestic terminal, with sufficient groundplan, and capacity generated through diversion of commuter services to CrossRail. Tube connections achieved through integration with adjacent Kings Cross / St Pancras via underground travelator. Only limited tunnelling required to access M1 corridor.
Heathrow Issues	No practicable location exists for GG21's terminating station, directly accessible to all airport terminals. Sufficient traffic (and capacity) does not appear to exist to justify frequent dedicated trains to individual Midlands/ Northern cities. Heathrow Hub delivers better links to existing network and high speed rail system. But connectivity limited and asymmetric, and Hub still approx 10 min. from terminals. No integration of Heathrow rail access offered, and concerns re viability remain.	Comprehensive rail access to Heathrow achieved through development of Compass Point network, independent of high speed rail. Heathrow approx 20 minutes from Cricklewood Interchange on High Speed North. Outer-suburban network achieved on M25 axis through integration with all existing and projected rail schemes.

Table 10.10 : Comparisons between WCML-aligned HS2 and High Speed North

11. Conclusions

On the basis of both the cost comparisons – see Section 10 – and of the wider evaluations against the various 'specification' items – see Table 10.8 – there would seem to be little justification for the adoption of any of the 'HS2' options considered in this study. The projections of possible DfT HS2 Company routeings also seem to score poorly. The only rationale for the difficult alignment through the Chilterns chosen by all these schemes would seem to be a perceived need to optimise high speed rail access to Heathrow Airport.

However, it is clear, from all the comparisons that have been made in this study, that this is only achieved at an unacceptably high cost, both financial and environmental. It also puts at risk the development of a high speed rail solution that would deliver huge economic and environmental benefit to the wider UK. Within London, high speed rail access to Heathrow will do nothing to address local concerns of congestion, and poor public transport access to the airport.

The current development thrust of high speed rail appears to be placing too high a priority on a requirement to serve Heathrow – at the expense of its optimum function as an integrated intercity railway. It is essential that priorities in high speed rail are identified, and adhered to.

This study has consistently demonstrated the bankruptcy of current schemes for expanded aviation operations at Heathrow Airport. These can only be realised at vast environmental damage, in both the destruction of local communities and the vast increase in emissions that must compromise the fight against climate change; moreover, they do not appear to function well as simple transport schemes.

Instead, it sets out the vision for a better transport future for the UK. It shows how real environmental and economic gains can be realised through the integrated planning and implementation of an optimised surface transport system. CO_2 emissions from the transport sector can at last be set on a downward trend, offering a realistic chance of compliance with the stringent targets of the Climate Change Act. In the current financially-straitened times, this may provide the best justification for high speed rail.

Although definitive benefit-to-cost ratios have not yet been calculated, comparison with HS2 and HS3 schemes (for which figures in the region of 2.0 apply) indicates that it is reasonable to assume figures well in excess of 2.0. But the fundamental rationale of this study is that high speed rail is primarily an engineering and an environmental issue; good BCRs will naturally follow a well-engineered and well-aligned scheme, addressing the transport needs of the UK in a holistic manner. And possibly more importantly, such a scheme will be capable of maximising mode shift and consequent CO_2 reductions, in line with climate change objectives.

This requires not one solution, but two – a radical improvement of rail access to Heathrow, linked with (but independent of) development of a comprehensive high speed rail network benefiting the entire UK.

With an optimised high speed network in the High Speed North proposal, and with the allied Heathrow Compass Point network, intercity travel within the UK will be transformed, a better system achieving more at lesser environmental cost. But equally importantly, it will at last achieve the decongested and better-connected Heathrow agreed by all to be necessary, and thus avert the threat of airport expansion and the associated vast local environmental damage.

Appendix A : Heathrow Departure List

The following flight departure data was drawn from the BAA Heathrow website[41] on 22nd June 2009. Given the practice of multiple listing, whereby several (usually longer-haul) airlines each apply their own flight number to a connecting flight, considerable editing has been undertaken, to ensure as far as possible that each flight listed represents an actual single aircraft taking off from the runways. Although total accuracy cannot be guaranteed, a degree of confidence can be inferred from the fact that the reduced list now comprises a total of 656 flights, approximately one take-off every 90 seconds for the entire 16.5 hour period over which flights are scheduled to depart.

The list has been categorised by the equivalent journey time between city centre termini either already achievable, or potentially achievable given appropriate development of high speed rail. Four-hour, seven-hour and 10-hour horizons are identified, and are colour-coded to give the necessary differentiation.

Heathrow – Total Daily Departures	656	100%
Short-haul ~ 4 hours equivalent by HSR	159	24.2%
Medium ~ 7 hours equivalent by HSR	123	18.8%
Longer Euro ~ 10 hours equivalent by HSR	69	10.5%
Irish destinations	34	5.2%
Other (generally intercontinental)	271	41.3%

Table A1 : Summary of Heathrow Departures

Irish destinations (Belfast, Cork and Dublin) are separately identified. In terms of distance, these should fall well within the easily convertible four-hour horizon. The drawback is of course the Irish Sea, for which an undersea tunnel would be required for direct rail communications. However, given considerations of length of sea crossing, difficult undersea geology and relatively small Irish population, there appears currently to be no immediate prospect of an Irish Sea tunnel. Hence Heathrow's flights to Ireland are not considered to be a high priority for conversion to rail.

[41] www.heathrowairport.com

Heathrow Departures	Total
06h00 – 08h00	69
Short ~ 4 hours HSR	23
Medium ~ 7 hours HSR	22
Longer Euro ~ 10 hours HSR	11
Irish	4
Other	9

06:00	ROME	T2
06:00	ZURICH	T1
06:00	LISBON	T1
06:05	MUNICH	T1
06:05	VIENNA	T1
06:15	ATHENS	T5
06:20	MALAGA	T3
06:20	MADRID	T3
06:25	FRANKFURT	T1
06:30	AMSTERDAM	T4
06:30	MANCHESTER	T5
06:40	PARIS CDG	T2
06:40	COPENHAGEN	T3
06:40	SHANNON	T1
06:45	BUCHAREST	T5
06:45	GENEVA	T5
06:50	MILAN -LINATE	T2
06:50	EDINBURGH	T5
06:50	BELFAST CITY	T1
06:50	BRUSSELS	T1
06:50	WARSAW	T1
06:55	GLASGOW	T1
06:55	MANCHESTER	T1
06:55	STOCKHOLM	T3
06:55	BRUSSELS	T5
06:55	ISTANBUL	T3
07:00	ABERDEEN	T1
07:00	EDINBURGH	T1
07:00	DUBLIN	T1
07:05	ISTANBUL	T5
07:05	MILAN -MALPENSA	T1
07:05	BARCELONA	T3
07:05	AMSTERDAM	T5
07:05	COPENHAGEN	T5
07:10	GLASGOW	T5
07:10	ROME	T5
07:10	ZURICH	T5
07:15	NEWCASTLE	T5
07:15	DUSSELDORF	T5
07:15	BERLIN	T5
07:15	FRANKFURT	T1
07:15	ABERDEEN	T5
07:20	OSLO	T3
07:25	MUNICH	T1
07:25	PARIS CDG	T5
07:25	MADRID	T3
07:30	STOCKHOLM	T5
07:30	HELSINKI	T3
07:30	ROME	T2
07:30	DUBLIN	T1
07:30	FRANKFURT	T5
07:35	WARSAW	T5
07:35	PARIS CDG	T2
07:35	MILAN -LINATE	T5
07:35	PRAGUE	T2
07:35	VIENNA	T3
07:40	LISBON	T3
07:40	MANCHESTER	T5
07:45	MILAN -MALPENSA	T5
07:45	CHICAGO	T1
07:50	NICE	T5
07:50	TOULOUSE	T5
07:50	MUNICH	T5
07:55	CHICAGO	T3
07:55	PRAGUE	T5
07:55	HAMBURG	T5
07:55	HANOVER	T1
07:55	OSLO	T5
07:55	WASHINGTON	T1

Heathrow Departures	Total
08h00 – 10h00	83
Short ~ 4 hours HSR	24
Medium ~ 7 hours HSR	19
Longer Euro ~ 10 hours HSR	9
Irish	6
Other	25

08:00	EDINBURGH	T5
08:05	DUSSELDORF	T1
08:10	AMSTERDAM	T1
08:15	LISBON	T1
08:15	MADRID	T3
08:15	BELGRADE	T5
08:15	STUTTGART	T1
08:20	STUTTGART	T5
08:20	ATHENS	T5
08:20	BRUSSELS	T1
08:20	GENEVA	T5
08:30	TORONTO	T3
08:30	NEW YORK	T3
08:30	BASEL	T5
08:30	SOFIA	T5
08:30	GLASGOW	T5
08:30	AMSTERDAM	T5
08:40	LYON	T5
08:40	GLASGOW	T1
08:40	EDINBURGH	T1
08:40	MANCHESTER	T1
08:40	HOUSTON	T4
08:40	DUBAI	T3
08:40	LYON	T5
08:40	AMSTERDAM	T4
08:40	ZURICH	T1
08:45	BUDAPEST	T5
08:50	EDINBURGH	T5
08:50	LARNACA	T5
08:50	BERLIN	T5
08:50	BELFAST CITY	T1
08:50	MILAN -MALPENSA	T1
08:50	DETROIT	T4
08:55	BRUSSELS	T5
08:55	MANCHESTER	T5
08:55	NEW YORK	T5
08:55	TEL AVIV	T5
08:55	MOSCOW	T5
08:55	DUBLIN	T1
08:55	PALMA MALLORCA	T1
08:55	HAMBURG	T1
09:00	ABERDEEN	T5
09:05	PARIS CDG	T5
09:05	DUBLIN	T1
09:05	FRANKFURT	T1
09:10	ABU DHABI	T3
09:10	MUNICH	T5
09:15	ROME	T5
09:15	CAIRO	T1
09:20	NICE	T5
09:20	TRIPOLI	T5
09:20	BARCELONA	T3
09:20	GOTHENBURG	T3
09:25	VIENNA	T1
09:30	MUMBAI	T3
09:30	MADRID	T3
09:30	CORK	T1
09:30	ST PETERSBURG	T5
09:30	MOSCOW	T1
09:30	NEW YORK	T3
09:30	LARNACA	T1
09:35	MILAN -LINATE	T2
09:35	MUNICH	T1
09:35	COPENHAGEN	T3
09:40	ABU DHABI AND MUSCAT	T5
09:40	MIAMI	T5
09:40	DUBAI AND BANDAR	T3
09:40	DUSSELDORF	T5
09:40	ZURICH	T5
09:40	BERLIN	T1
09:45	MUMBAI AND AHMEDABAD	T3
09:45	KIEV	T5
09:45	ALGIERS	T5
09:50	NEWCASTLE	T5
09:50	VENICE	T5
09:50	DUBLIN	T1
09:50	FRANKFURT	T1
09:55	MIAMI	T3
09:55	LOS ANGELES	T5
09:55	AMSTERDAM	T4
09:55	GLASGOW	T5
09:55	VIENNA	T3
09:55	BELFAST	T1

Heathrow Departures	Total
10h00 – 12h00	82
Short ~ 4 hours HSR	16
Medium ~ 7 hours HSR	11
Longer Euro ~ 10 hours HSR	7
Irish	2
Other	46

10:00	BAHRAIN	T3
10:00	NEWARK	T5
10:05	NEW YORK	T4
10:05	HALIFAX	T3
10:05	ABERDEEN	T1
10:05	WASHINGTON	T1
10:10	COPENHAGEN	T5
10:10	DELHI	T5
10:10	KIEV	T1
10:15	CHICAGO	T3
10:15	PARIS CDG	T2
10:15	LISBON	T3
10:15	GENEVA	T5
10:15	COLOGNE	T1
10:20	HELSINKI	T3
10:20	NAIROBI	T5
10:20	OSLO	T3
10:25	DALLAS/FT WORTH	T3
10:25	NEW YORK	T5
10:25	HOUSTON	T5
10:25	NEWARK	T4
10:30	ISTANBUL	T5
10:30	KUWAIT	T3
10:30	HAMBURG	T5
10:35	STOCKHOLM	T3
10:35	WARSAW	T1
10:35	MIAMI	T3
10:35	LOS ANGELES	T1
10:40	FRANKFURT	T5
10:40	BAHRAIN AND DOHA	T5
10:45	PARIS CDG	T5
10:50	WASHINGTON	T5
10:50	MANCHESTER	T1
10:50	MALTA	T4
10:50	DOHA	T3
10:50	SAN FRANCISCO	T1
10:55	LOS ANGELES	T3
10:55	BERLIN	T5
10:55	BUDAPEST	T5
10:55	MADRID	T3
10:55	BELFAST CITY	T1
11:00	RALEIGH/DURHAM	T3
11:00	BUCHAREST	T5
11:00	CHICAGO	T3
11:05	MANCHESTER	T5
11:05	MUMBAI	T5
11:05	PRAGUE	T5
11:05	GLASGOW	T1
11:05	VENICE	T1
11:05	VANCOUVER	T3
11:10	MUNICH	T1
11:10	EDINBURGH	T1
11:15	MILAN -MALPENSA	T5
11:15	DUBLIN	T1
11:15	TEL AVIV	T1
11:15	LOS ANGELES	T3
11:20	LAGOS	T5
11:20	BARCELONA	T3
11:25	STOCKHOLM	T5
11:25	BOSTON	T5
11:25	ISTANBUL	T3
11:25	LISBON	T1
11:30	RIYADH AND DAMMAM	T1
11:30	SAN FRANCISCO	T3
11:35	BOSTON	T3
11:35	EDINBURGH	T5
11:35	SAN FRANCISCO	T5
11:35	NEWCASTLE	T5
11:40	NICE	T5
11:40	DALLAS/FT WORTH	T5
11:40	GENEVA	T5
11:40	CLEVELAND	T4
11:45	ABERDEEN	T5
11:45	CHICAGO	T5
11:45	AMSTERDAM	T4
11:50	ATHENS	T5
11:50	BRUSSELS	T1
11:50	FRANKFURT	T1
11:50	WASHINGTON	T3
11:55	NEW YORK	T3
11:55	SINGAPORE	T3
11:55	TORONTO	T5

Heathrow Departures	Total
12h00 – 14h00	80
Short ~ 4 hours HSR	14
Medium ~ 7 hours HSR	9
Longer Euro ~ 10 hours HSR	12
Irish	4
Other	41

12:00	LOS ANGELES	T5
12:00	AMSTERDAM	T5
12:00	MILAN -LINATE	T5
12:00	KUALA LUMPUR	T3
12:00	WASHINGTON	T1
12:05	HELSINKI	T3
12:05	STAVANGER	T3
12:05	PHILADELPHIA	T5
12:05	NEWARK	T4
12:05	HOUSTON	T4
12:05	CORK	T1
12:10	ZURICH	T5
12:10	MADRID	T3
12:15	DALLAS/FT WORTH	T3
12:15	GLASGOW	T5
12:15	DUSSELDORF	T1
12:15	ATHENS	T2
12:15	SINGAPORE AND SYDNEY	T4
12:20	ROME	T2
12:20	H. KONG & MELBOURNE	T4
12:20	CHICAGO	T1
12:25	MOSCOW	T1
12:25	MILAN -MALPENSA	T1
12:30	BANGKOK	T3
12:30	BUCHAREST	T2
12:30	JEDDAH	T3
12:35	TORONTO	T3
12:35	HONG KONG	T3
12:35	COPENHAGEN	T5
12:35	BRUSSELS	T5
12:40	DUBAI	T5
12:40	ROME	T5
12:45	OSLO	T5
12:45	MUNICH	T5
12:45	ABERDEEN	T1
12:50	PARIS CDG	T2
12:50	CHICAGO	T3
12:50	EDINBURGH	T1
12:55	BERLIN	T5
12:55	CHENNAI	T5
13:00	MOSCOW	T5
13:00	OTTAWA	T3
13:00	SHANGHAI	T3
13:00	NEWARK	T3
13:00	REYKJAVIK	T1
13:05	OSLO	T3
13:05	VANCOUVER	T5
13:05	MADRID	T3
13:05	GLASGOW	T1
13:05	HANOVER	T1
13:05	DENVER	T1
13:05	PHILADELPHIA	T1
13:10	AMSTERDAM	T5
13:15	MUNICH	T1
13:15	EDINBURGH	T5
13:15	CALGARY	T3
13:15	MALAGA AND FREETOWN	T1
13:15	DUBLIN	T1
13:20	RIO DE JANEIRO	T5
13:20	ATLANTA	T4
13:25	DUSSELDORF	T5
13:25	DUBLIN	T1
13:25	ALMATY AND BISHKEK	T1
13:25	BELFAST CITY	T1
13:30	HOUSTON	T5
13:30	MANCHESTER	T5
13:30	MOSCOW	T2
13:35	ZURICH	T5
13:40	TORONTO	T3
13:40	NEW YORK	T5
13:40	MIAMI	T5
13:40	PARIS CDG	T5
13:40	BELGRADE	T2
13:40	LISBON	T1
13:45	TOKYO	T5
13:50	FRANKFURT	T5
13:50	STOCKHOLM	T3
13:50	SAN FRANCISCO	T5
13:55	MEXICO CITY	T5
13:55	MUNICH	T5

Heathrow Departures	Total
14h00 – 16h00	82
Short ~ 4 hours HSR	19
Medium ~ 7 hours HSR	21
Longer Euro ~ 10 hours HSR	6
Irish	5
Other	31

14:00	GENEVA	T5
14:00	EDINBURGH	T1
14:00	NEW YORK	T3
14:00	CORK	T1
14:00	IZMIR	T3
14:05	COPENHAGEN	T3
14:05	BRUSSELS	T5
14:05	MADRID	T3
14:05	WARSAW	T5
14:05	BUDAPEST	T5
14:05	MILAN -MALPENSA	T1
14:10	BANGALORE	T5
14:10	SAN FRANCISCO	T1
14:15	ROME	T5
14:15	ABERDEEN	T5
14:15	GLASGOW	T5
14:15	TOULOUSE	T5
14:15	DUBLIN	T1
14:15	STUTTGART	T1
14:15	DUBAI	T3
14:20	FRANKFURT	T1
14:25	ACCRA	T5
14:25	COPENHAGEN	T5
14:25	MINNEAPOLIS	T4
14:30	DALLAS/FT WORTH	T3
14:30	HYDERABAD	T5
14:35	PHOENIX	T5
14:35	AMMAN AND ADDIS ABABA	T1
14:40	CHICAGO	T5
14:40	VIENNA	T3
14:40	BASEL	T5
14:40	ABU DHABI	T3
14:40	PRAGUE	T2
14:45	BERLIN	T1
14:45	PARIS CDG	T5
14:50	BARCELONA	T3
14:50	BRUSSELS	T1
14:50	HAMBURG	T1
14:50	BOSTON	T3
14:50	AMSTERDAM	T4
14:55	MILAN -MALPENSA	T5
14:55	PRAGUE	T5
15:00	ATLANTA	T5
15:00	DUSSELDORF	T5
15:00	DUBLIN	T1
15:00	TORONTO	T3
15:00	ABERDEEN	T1
15:00	LUXOR	T3
15:00	CAIRO	T3
15:05	LISBON	T3
15:05	MILAN -LINATE	T5
15:05	DOHA	T3
15:05	BELFAST	T1
15:05	COLOGNE	T1
15:10	EDINBURGH	T5
15:10	HAMBURG	T5
15:10	LOS ANGELES	T3
15:15	EDMONTON	T3
15:15	BOSTON	T3
15:15	SEATTLE	T5
15:15	WASHINGTON	T5
15:15	GENEVA	T5
15:15	GLASGOW	T1
15:15	HELSINKI	T3
15:20	CHICAGO	T1
15:25	MUNICH	T1
15:25	MUNICH	T5
15:25	NICE	T5
15:25	BELFAST CITY	T1
15:30	MANCHESTER	T5
15:30	MONTREAL	T3
15:35	TORONTO	T5
15:35	MADRID	T3
15:35	FRANKFURT	T5
15:35	TEL AVIV	T1
15:40	ROME	T5
15:45	MILAN -MALPENSA	T5
15:45	VIENNA	T1
15:45	NEWCASTLE	T5
15:45	NEWARK	T5
15:45	DENVER	T5
15:50	LYON	T5

Heathrow Departures	Total
16h00 – 18h00	84
Short ~ 4 hours HSR	25
Medium ~ 7 hours HSR	16
Longer Euro ~ 10 hours HSR	6
Irish	2
Other	35

16:00	AMSTERDAM	T5
16:00	COPENHAGEN	T5
16:00	PARIS CDG	T2
16:00	LOS ANGELES	T5
16:00	AMSTERDAM	T1
16:00	MANCHESTER	T1
16:00	BAKU	T1
16:00	NEWARK	T4
16:05	ABERDEEN	T5
16:05	SHANGHAI	T5
16:05	ZURICH	T5
16:05	BEIRUT AND KHARTOUM	T1
16:10	BERLIN	T5
16:10	HELSINKI	T3
16:10	EDINBURGH	T5
16:15	PHILADELPHIA	T5
16:15	BALTIMORE	T5
16:15	EDINBURGH	T1
16:15	LOS ANGELES&AUCKLAND	T1
16:15	CALGARY	T3
16:20	WASHINGTON	T1
16:20	PARIS CDG	T5
16:20	BRUSSELS	T5
16:25	ROME	T2
16:25	GLASGOW	T5
16:25	BOSTON	T5
16:25	MADRID	T3
16:25	BARCELONA	T3
16:25	NEW YORK	T3
16:30	ISTANBUL	T3
16:35	CHICAGO	T3
16:35	TOKYO	T3
16:35	ATHENS	T2
16:40	STOCKHOLM	T5
16:40	PARIS CDG	T2
16:40	BEIJING	T5
16:40	BARCELONA	T3
16:40	BILBAO	T3
16:45	NEW YORK	T3
16:45	FRANKFURT	T5
16:45	DUSSELDORF	T5
16:50	COPENHAGEN	T3
16:50	DUBLIN	T1
17:00	OSLO	T5
17:00	PARIS CDG	T5
17:00	NEW YORK	T5
17:00	BRUSSELS	T1
17:00	MANCHESTER	T1
17:00	DUBAI	T3
17:00	BEIRUT	T3
17:05	NEW YORK	T4
17:05	WASHINGTON	T5
17:05	SOFIA	T2
17:05	AMMAN	T3
17:10	VANCOUVER	T5
17:10	AMSTERDAM	T4
17:10	FRANKFURT	T1
17:10	MUNICH	T1
17:15	NICE	T5
17:15	LA CORUNA	T3
17:15	ZURICH	T1
17:20	MUNICH	T5
17:20	GLASGOW	T1
17:25	ISTANBUL	T5
17:25	EDINBURGH	T5
17:25	CALGARY	T5
17:30	MONTREAL	T5
17:30	GENEVA	T5
17:30	OSLO	T3
17:35	MANCHESTER	T5
17:35	GLASGOW	T5
17:35	DELHI	T5
17:35	MADRID	T3
17:35	HANOVER	T1
17:35	SEVILLE	T3
17:40	MILAN -LINATE	T2
17:40	BELFAST CITY	T1
17:45	ABERDEEN	T1
17:50	CHICAGO	T5
17:50	MILAN -LINATE	T5
17:50	WARSAW	T1
17:50	DUSSELDORF	T1
17:50	MILAN -MALPENSA	T1
17:55	CAIRO	T5

Heathrow Departures	Total
18h00 – 20h00	89
Short ~ 4 hours HSR	24
Medium ~ 7 hours HSR	18
Longer Euro ~ 10 hours HSR	12
Irish	7
Other	28

18:00	STOCKHOLM	T3
18:00	PARIS CDG	T2
18:00	AMSTERDAM	T5
18:00	DAMASCUS AND ALEPPO	T1
18:00	COPENHAGEN	T3
18:00	WASHINGTON	T3
18:05	BOSTON	T3
18:05	HELSINKI	T3
18:05	BUCHAREST	T5
18:05	FRANKFURT	T1
18:10	CASABAND MARRAKECH	T2
18:10	NEWCASTLE	T5
18:10	NEW YORK	T5
18:10	DUBLIN	T1
18:15	ABERDEEN	T5
18:15	ROME	T5
18:15	CORK	T1
18:15	LISBON	T1
18:20	HELSINKI	T3
18:20	HONG KONG	T3
18:20	BARCELONA	T3
18:25	PRAGUE	T5
18:25	EDINBURGH	T5
18:25	BRUSSELS	T1
18:30	NEW YORK	T3
18:30	EDINBURGH	T1
18:30	STUTTGART	T1
18:30	SINGAPORE	T3
18:35	BERLIN	T5
18:35	HONG KONG	T5
18:35	FRANKFURT	T5
18:35	HAMBURG	T5
18:35	AMSTERDAM	T4
18:35	DUBLIN	T1
18:35	ZURICH	T1
18:35	MOSCOW	T1
18:45	GLASGOW	T5
18:45	VIENNA	T3
18:45	GOTHENBURG	T3
18:50	MADRID	T3
18:55	PARIS CDG	T5
19:00	DUSSELDORF	T5
19:00	BELFAST CITY	T1
19:00	AMSTERDAM	T1
19:00	TORONTO	T3
19:00	COPENHAGEN	T5
19:00	JOHANNESBURG	T1
19:05	JOHANNESBURG	T5
19:05	LUSAKA	T5
19:05	ZURICH	T5
19:05	FRANKFURT	T1
19:05	STOCKHOLM	T3
19:10	BARCELONA	T3
19:10	SHANNON	T1
19:15	BASEL	T5
19:15	OSLO	T5
19:15	TOKYO	T3
19:15	NAIROBI	T3
19:20	DAR ES SALAAM	T5
19:20	PORTO	T1
19:25	CAPE TOWN	T5
19:25	VIENNA	T1
19:25	BELFAST	T1
19:25	HAMBURG	T1
19:30	NEWARK	T5
19:30	BOSTON	T5
19:30	GLASGOW	T1
19:30	OSLO	T3
19:35	MILAN -MALPENSA	T5
19:35	COLOGNE	T1
19:35	DUSSELDORF	T1
19:35	TOKYO	T3
19:40	DUBAI	T5
19:40	MADRID	T3
19:40	BELFAST CITY	T1
19:45	GENEVA	T5
19:50	STAVANGER	T3
19:50	LISBON	T3
19:50	FRANKFURT	T5
19:50	BERLIN	T1
19:50	ZURICH	T1
19:55	MUNICH	T5
20:00	ROME	T2
20:00	NEW YORK	T5
20:00	AMSTERDAM	T5
20:00	FRANKFURT	T1
20:00	ABERDEEN	T1
20:00	NAIROBI	T4
20:00	ZAGREB	T1

Heathrow Departures	Total
20h00 – 22h30	87
Short ~ 4 hours HSR	14
Medium ~ 7 hours HSR	7
Longer Euro ~ 10 hours HSR	6
Irish	4
Other	56

20:05	NEW YORK	T3
20:05	MILAN -LINATE	T2
20:05	STOCKHOLM	T5
20:05	STUTTGART	T5
20:05	MUNICH	T1
20:10	DUBLIN	T1
20:10	BUDAPEST	T5
20:10	COPENHAGEN	T3
20:15	GLASGOW	T5
20:15	PARIS CDG	T5
20:15	AMSTERDAM	T1
20:15	MILAN -MALPENSA	T1
20:20	ABERDEEN	T5
20:20	MANCHESTER	T5
20:20	HONG KONG	T3
20:25	AMSTERDAM	T4
20:25	JOHANNESBURG	T1
20:25	NEWARK	T3
20:25	BEIJING	T3
20:30	JOHANNESBURG	T3
20:35	LYON	T5
20:35	BRUSSELS	T5
20:35	BRUSSELS	T1
20:40	NICE	T5
20:40	DUBAI	T3
20:45	DELHI	T3
20:45	RIYADH	T3
20:50	ATHENS	T5
20:50	MUMBAI	T4
21:00	NEWCASTLE	T5
21:00	EDINBURGH	T5
21:00	EDINBURGH	T1
21:00	MANCHESTER	T1
21:00	MALTA	T4
21:00	DUBAI	T3
21:00	CAPE TOWN	T1
21:05	BANGALORE	T4
21:05	HONG KONG & AUCKLAND	T1
21:05	STOCKHOLM	T3
21:10	DUBLIN	T1
21:10	REYKJAVIK	T1
21:15	JOHANNESBURG	T5
21:15	HONG KONG	T5
21:15	PRAGUE	T2
21:15	DUBLIN	T1
21:20	ABU DHABI	T3
21:25	MUMBAI	T3
21:25	SEOUL	T3
21:25	SINGAPORE	T4
21:30	DELHI AND KOLKATA	T3
21:30	BANGKOK	T3
21:30	DOHA	T3
21:35	ADDIS ABABA	T3
21:35	GLASGOW	T1
21:35	SINGAPORE AND SYDNEY	T4
21:35	MALE AND COLOMBO	T4
21:40	DUBAI	T5
21:45	MUMBAI	T5
21:45	SAO PAULO & B. AIRES	T5
21:50	AMMAN	T1
21:55	TEL AVIV	T1
22:00	LAGOS	T2
22:00	BANGKOK AND SYDNEY	T4
22:00	MOSCOW	T5
22:00	LARNACA	T1
22:00	KUALA LUMPUR	T3
22:00	LAGOS	T3
22:05	TEHRAN	T1
22:05	SAO PAULO	T4
22:05	SINGAPORE & MELBOURNE	T4
22:05	SINGAPORE	T3
22:05	LAGOS	T2
22:15	ABUJA	T5
22:15	CORK	T1
22:15	DUBAI	T3
22:15	ATHENS	T2
22:15	BANGKOK AND SYDNEY	T4
22:20	HONG KONG	T5
22:25	KUWAIT	T5
22:30	BAHRAIN	T3
22:30	TEL AVIV	T5
22:30	TEL AVIV	T1
22:30	HONG KONG AND SYDNEY	T3
22:35	MOSCOW	T1
22:35	HONG KONG	T3
22:35	MOSCOW	T2
22:35	MUSCAT	T3

Appendix B : High Speed Line Design Considerations

The following points are intended to explain in greater depth the various considerations raised in the High Speed Line specification, as set out in Item 8.1. Reference should also be made to the *Ten Tests for High Speed Rail* set out in Appendix F.

B1 Priority for Intercity Corridors

It is vital to understand that conversion of short-haul flights is not the prime purpose of developing high speed rail in the UK, either for transportation or environmental reasons. The principal reason is strangely similar to that advanced by the airport expansionists; to deliver economic benefits from improved regional connectivity and the elimination of congestion on existing main line routes. This congestion is largely due to the existing express (200kph) traffic conflicting with slower speed freight and stopping passenger services; with the express traffic diverted onto the high speed line, there are disproportionate capacity gains on the existing network.

With the extra capacity generated, significant mode shift from road to rail becomes possible, for both passenger and freight transport. This in turn allows major environmental and sustainability gains – note that road traffic contributes around 90% of UK transport's CO_2 emissions[42], while domestic and European short-haul aviation contribute around 4-5% (the European element is counted separately as part of 'international aviation').

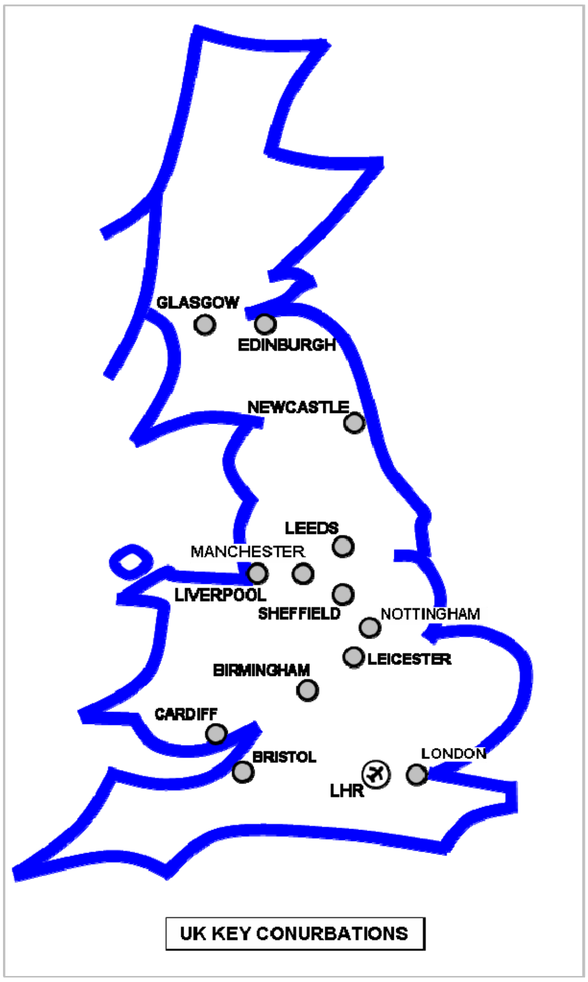


Figure B1

B2 Principal UK Conurbations

The ultimate aim of any HSL system must be to form a comprehensive network covering all principal UK conurbations. There is inevitably debate as to what defines a 'principal conurbation' but the following 12 cities, all of around 400,000 population or greater, are suggested as comprising the hubs of the core network:

London, Birmingham, Bristol, Cardiff, Edinburgh, Glasgow, Leeds, Leicester, Liverpool, Manchester, Newcastle (upon Tyne), Nottingham and Sheffield.

See Figure B1.

B3 Eurogauge Network

For future compatibility with European high speed operations (ie wide-bodied double-decker 'duplex' rolling stock) it is essential that all elements of the core network are constructed to allow these 'Eurogauge' trains comprehensive access to regional city centre hubs.

[42] Bibliography Item 8.

B4 Optimum High Speed Routes between City Centre Terminals

One undisputed feature of high speed rail is that it costs a great deal of money. The 100km of HS1 cost £5 billion, giving a 'unit rate' of around £50M/km. Figures upwards of £30 billion have been advanced for a high speed network extending from London to Scotland. If such a large investment is to be made, it should gain the greatest returns by attracting the largest practicable rail flows. Every study so far carried out on high speed rail development has concluded that economic returns and general benefits are maximised by concentrating on direct city centre to city centre flows.

B5 'Best Value' Routeing – Maximum Number of Cities served and Main Line Corridors covered for Minimum Route Length

The process of optimisation must of course extend beyond the simple notion of attracting the greatest passenger flows. It should also endeavour to drive down the necessary length (and therefore cost) of new construction, and at the same time maximise the number of communities and corridors served. In particular it should examine whether the East Coast/West Coast model so far assumed delivers best value for money, or whether this might be achieved by a shorter net length of 'spine and spur' routes serving several main line axes – and providing congestion relief on all of these.

B6 Selection of Sites for City Terminals

Of all the issues to be resolved in the design of a railway system, high speed or otherwise, location of the city terminals is possibly the most crucial. Terminal location determines the accessibility of the line to its customers, and ultimately its financial viability. This key consideration attains critical proportions in London, the largest, and most developed of all the conurbations. Here, a terminus station will be required that might accommodate up to 16 trains per hour, heading for Midlands, Northern and Scottish destinations.

The selection of the London domestic terminal will be governed by the following criteria:

- ***Groundplan:*** A service of 16 trains per hour will require of the order of 10-12 terminating platforms, all of 400m length to accommodate standard high speed rolling stock. This dictates a groundplan of around 500m by 100m.
- ***Accessibility:*** Local transport systems must be in place to deliver in the region of 15,000-20,000 passengers per hour to or from the terminal. Only a hub location on the existing Tube network, where several lines converge, would seem to have the necessary capacity.
- ***North-facing Location:*** The terminal should be established at a location easily accessible to main line, or other northbound transportation corridors, without the requirement for major tunnelling or destruction of property.
- ***Proximity to HS1 at St Pancras:*** With many passengers' journeys continuing to Europe, it is desirable that the terminal is located close to St Pancras to allow easy transfer to HS1. This will also facilitate a single route entering London from the north, with a relatively short split length where the route diverges either to the domestic terminal or (for direct regional services to Europe) to HS1, with or without a reversing stop at St Pancras.
- ***Connection to Heathrow:*** A connection between the high speed line and Heathrow is an essential element of the total high speed rail solution. This requirement may be achieved by interchange at the terminal, or equally it might be achieved at a suburban hub

- ***Imposing Location:*** The growth of the Eurostar brand since transferring operations to St Pancras can to a significant extent be attributed to the imposing architecture of its new terminal. A similar architectural quality will be essential for the new domestic high speed line terminal.
- ***Integration with Existing Main Line Services:*** If possible, the high speed line service to a particular destination should depart from the same terminal as services on the existing 'classic' main line.
- ***Availability:*** It is almost a certainty that any suitable site for the domestic high speed line will terminal already be occupied. A strategy must be developed to displace whatever existing usages (transport or otherwise) with the minimum of disruption.

Many of the above considerations also apply to the establishment of central stations in provincial UK cities.

B7 Bypassing Strategy??

The alignments necessary for high speed line construction can only be created through urban areas at major expense and disruption. These considerations, plus that of maintaining journey times to further (and more time-critical) destinations, tend to preclude the routeing of the high speed line through city centres. This is particularly the case with major cities such as Birmingham, Manchester and Leeds, for which all schemes so far advanced have opted for bypassing alignments. The consequence of this bypassing strategy is that a parkway station would be provided on the through, bypassing route, but direct city centre access would only be effected by means of a south-facing London-bound spur off the main route. It may only be possible to achieve the structural and track clearances required for the spur to accommodate Eurogauge rolling stock at major cost and disruption.

B8 Parkway Stations??

Greengauge21 figures[43], developed in support of their HS2 proposal, indicate 3.9M passengers per annum from central Birmingham to central London – but only 0.8M from Birmingham International, the likely location of any parkway station on a through route from the North-West to London. This demonstrates the poor performance of out-of-town parkway stations relative to city centre termini. Furthermore, parkway stations often create major environmental concerns arising from the general need for car access and the associated Green Belt development implications.

Parkway stations are usually planned to facilitate the routeing of strategic time-sensitive high speed lines past, rather than through intervening conurbations. This generally achieves reductions in both construction cost and journey times and, given the cost and disruption of city centre routeing, is often the only practicable option. This is particularly true for London-centric systems such as Greengauge21's HS2.

The adoption of a parkway station, rather than a city centre terminal, as the primary means of connecting a city to the high speed line network must be regarded as bad practice, to be avoided wherever possible. This is not to say that parkway stations cannot perform a useful supplementary function, providing access for many more communities to the high speed network. One particular opportunity for High Speed North is a development of the existing Coleshill Parkway station en route to central Birmingham.

[43] Bibliography Item 14.

B9 Undue Influence of Heathrow on High Speed Routeing?

With the publication of recent high speed rail schemes such as Greengauge21's HS2 and Arup's Heathrow Hub, it has come to be accepted, almost as an axiom, that the new line must be routed through, or very close to Heathrow. At first sight, there seems to be an attractive logic in the notion that the UK's first high speed line should serve its key international gateway en route to the UK hinterland. But the figures developed by Greengauge21 in support of HS2 indicate only modest traffic levels of 0.3M per annum (or 1000 per day) from Birmingham to Heathrow. This compares poorly with the 3.9M en route to central London. It is reasonable to suppose a similar split on traffic from other UK cities. This would seem to demonstrate that on a long-distance uniaxial route, Heathrow is not a strong traffic generator.

This would not matter greatly, if Heathrow were located on the natural north-west axis from London to the key Midlands and Northern population centres, and could easily be incorporated into a new line oriented along this axis. But Heathrow's westerly location places it significantly off-line, with the direct route to the West Midlands and North-West now passing through the Chilterns. It becomes necessary to critically examine whether the selection of the most cost-effective high speed route is being prejudiced by an excessive focus upon Heathrow.

This is not to deny the crucial importance of factoring Heathrow into any UK high speed solution. The question is whether the high speed line needs to go to Heathrow – or are there smarter strategies by which Heathrow can effectively be brought to the high speed line?

B10 High Speed Rail to Regional Airports

Many of the parkway stations postulated in various high speed rail schemes as alternatives to a city centre hub are proposed to be located at, or near, the city's airport. Greengauge21 have defined Birmingham International Airport as the location for a station on the bypassing through route to the north; it is believed that similar consideration is being given to Manchester and Newcastle Airports.

As with Heathrow, the seductive logic of high speed rail serving regional airports must be questioned. These airports generate the same 360-degree, rather than uniaxial passenger flows. Moreover, the greater focus of a regional airport on short-haul and leisure routes means that its range of destinations will be even less attractive to high-volume high-speed flows from other regions, than is the case for Heathrow. The priority for these airports is to set up comprehensive regional networks, commensurate with their regional status. This is already the case for Manchester. And, as has already been noted, airport access is no substitute for city centre access; the priority of a very large majority is to get to the city centre, either for the business/employment/leisure opportunities there, or for onward connections at established public transport hubs.

B11 Regional Issues

Although the costs of high speed rail are high, so are the potential benefits. It is calculated that annual economic benefits of around £2 billion per annum[44] would accrue to a typical regional economy with the introduction of a new high speed line, with onward connections to Europe. It is argued that this will help to address the current economic 'tilt' of the UK towards London and the South-East.

[44] Bibliography Item 14.

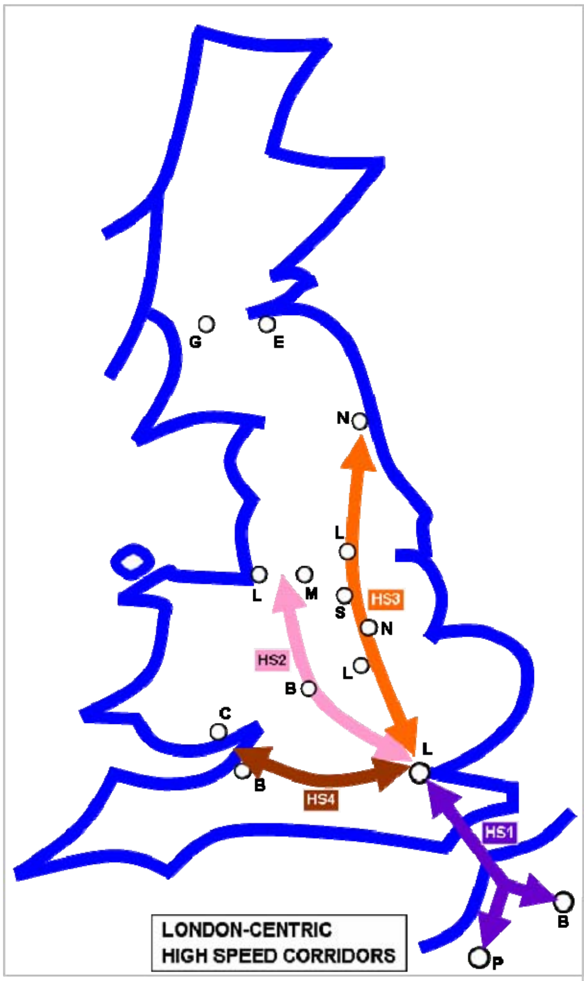


Figure B2

But to an extent, this improved connectivity is a double-edged sword. Communities at either end of a high speed line will gain similar benefits from the improved connectivity. If a simplistic model of high speed rail development is considered, with new lines radiating from London – HS2 to the North-West, HS3 to the North-East and HS4 to the West Country (ie as per the Greengauge21 *Next Steps* model – see Figure B2) then £2 billion might accrue to each regional economy. But London, at the fulcrum of the system, would gain £6 billion.

Hence it seems clear that high speed rail will only deliver true advantage to the UK regions if it can be configured as a genuine network, maximising the possibilities for inter-regional connections, extending beyond the core network to outlying communities, and freeing up existing intercity corridors for more local traffic. Figure B3 gives an indication of the possibilities that arise with High Speed North.

However, the models of future high speed rail development so far advanced have been largely London-centric, generally following existing main line axes. This of necessity restricts the economic benefits, the congestion relief and the environmental gains of any given route to the particular main line corridor along which it is aligned.

There are more subtle disadvantages also. Economics and resource issues will dictate that (for instance) HS2 to the North-West is constructed first, with perhaps a 10-year time lag before HS3 to the North-East follows on. Considering high speed lines as conduits of inward investment, the economic advantages that would be enjoyed by west-sided communities, probably at the expense of east-sided communities in terms of preferential inward investment, are self-evident.

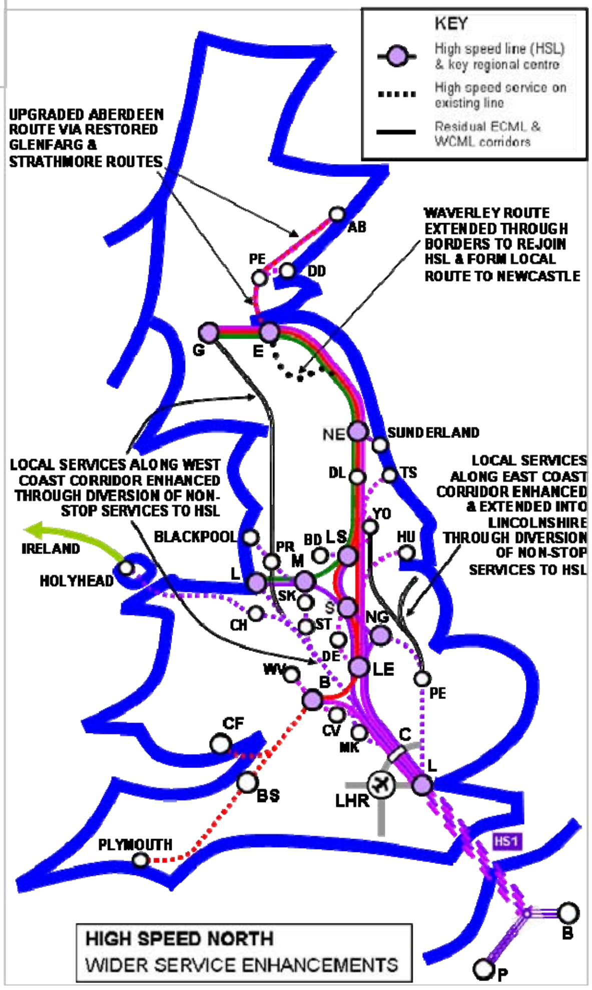


Figure B3

B12 Deficiencies of Existing Main Line Corridors

A further disadvantage of following existing main line routes is that the resulting high speed system tends to replicate the same intrinsic faults. This issue can be best appreciated by considering the existing WCML and Greengauge21's HS2, which is projected to follow the same corridor. The WCML comprises the busiest UK main line, connecting London to the West Midlands, the North-West and Glasgow. The key intermediate cities are Birmingham, Manchester and Liverpool; yet the trunk route that has developed bypasses all three. See Figure B4.

All of these centres have strong services to London, making south-facing connections to the main line. But facing north, services are weak. Birmingham has hourly services to Scotland, but to serve both Edinburgh and Glasgow, only an effective 2-hour frequency is achieved.

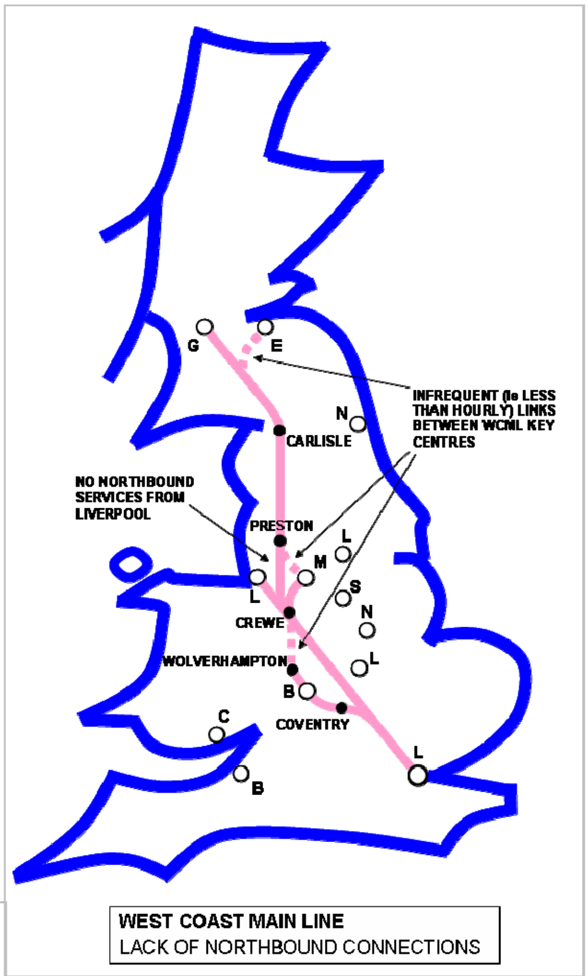


Figure B4

Between the North-West and Scotland, service levels also fail to achieve the quantum of an hourly intercity service between key centres. Liverpool has no direct trains at all feeding northwards onto the WCML. And from Manchester, despite major improvements introduced by Transpennine Express (particularly between Manchester and Edinburgh, where10 daily trains now operate – but only 4 daily between Manchester and Glasgow) service levels still remain low.

This poor level of service, particularly between the North-West and Scotland, stems directly from the fact that the 'gravitational' pull even between cities of populations approaching 1 million, but 300km apart with few intervening population centres, is insufficient to justify frequent intercity rail services.

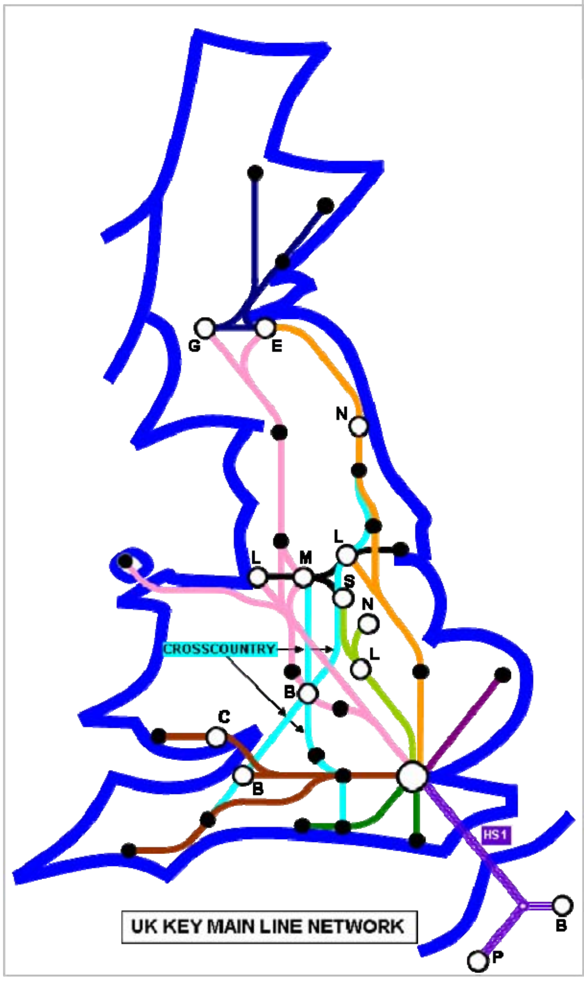


Figure B5

Similar, if not so extreme, issues apply to the East Coast corridor. The conurbations of the East Midlands and Yorkshire are bypassed by the higher speed ECML, routed along the easier topography of the Eastern Counties.

However, the problems of northward connectivity are to a great extent mitigated by the merging of the CrossCountry and East Coast corridors in Yorkshire. The CrossCountry route links the West and East Midlands with Yorkshire, the North-East and Scotland. See Figure B5. This provides the 'glue' to the network that is lacking on the west side of the Pennines.

B13 High Speed Enhancements to Existing Network

High speed rail should offer a once-in-a-century opportunity to redress the deficiencies of the existing rail network, and provide these 'missing links'. But with a WCML-aligned high speed route this can only be achieved by directing the new line through the centres of both Birmingham and Manchester. These will be difficult and highly expensive urban alignments, with major lengths of tunnelling and caverns created for the city centre terminals. Most importantly perhaps, the reduced speeds feasible via city centres may well compromise critical journey times from London to Scotland.

But in the context of a practical high speed route, the likelihood is that considerations of cost and journey time will dictate a high speed alignment very similar to the WCML, bypassing all major intervening communities; and that out-of-town parkway stations will be provided to facilitate northward connections.

B14 Load Factor vs Frequency

A further undesirable consequence of a WCML-aligned high speed route is that all major centres – Birmingham, Manchester, Liverpool, Glasgow and Edinburgh – are placed at the terminus of their own particular branch line. This requires separate trains from London to all these destinations, and with no major intervening population centres, each route is mostly reliant on the city at its end to fill the trains.

With such a restriction on passenger numbers, conflicts arise between the need to offer an attractive high-frequency service, and the need to fill seats. This compromises the economies of scale that are feasible with high speed rail, and impacts on both financial and environmental performance, in particular the crucial 'gram of CO_2 per passenger kilometre' measure.

B15 Sustainability and Environmental Issues

If high speed rail is to be advanced as the 'green' solution, offering maximised decarbonisation of UK transport, it is imperative that its own environmental performance is optimised. This can be achieved by several means:

- Achieving maximum network for minimum route mileage.
- Maximising load factors through concentration on key intercity corridors and avoidance of multi-branched systems.
- Building on technical best practice already developed on other high speed railways.
- Reducing CO_2-producing proportion of UK electricity generation.
- Adopting strategies to minimise CO_2 rating of electricity used by the railway.

The first three of the above measures will reduce the rate of depletion of fossil fuel reserves, and thus also imply enhanced sustainability. The latter two relate more to the growing discipline of 'carbon accountancy'. But these are longer-term concerns. For many UK citizens, the immediate concern will be the impact that the construction, operation and sheer physical presence of a new high speed line(s) will have on their lives.

B16 Local Environmental Impact

There is no doubt that, just as with a new road, a new high speed line will have a significant and probably detrimental effect on the landscape. The 'greening' of UK transport will be of little importance to a local resident whose view across unspoilt countryside is suddenly obstructed by a concrete retaining wall supporting an elevated railway, only metres from his or her front window. A wildlife enthusiast will similarly take a highly unfavourable view of new construction intruding on habitats of flora and fauna.

These concerns – which might crudely be characterised as NIMBY and environmental – are understandable, and entirely legitimate. But considered from the viewpoint of project delivery, they tend to have a hugely negative impact. Inevitably, costs rise and timescales lengthen as focus shifts from implementation of the project (and realisation of its gains) to the resolution (often forced) of a myriad of local issues. The developing controversy will also endanger the necessary political consensus.

By far the most effective and most environmentally-friendly means by which new transportation projects can be implemented is to follow existing routes, either road or rail, wherever possible. Railways can sometimes be suitable, but more often either the concentration of railway-induced urban development around stations or the tortuous low-speed alignment of the original railway construction tend to preclude the necessary clear and straight corridors.

Motorways usually offer the optimum solution. With the ever-present noise nuisance and visual intrusion that are inherent in any busy motorway, the addition of a new railway alongside creates minimal additional environmental damage. These same factors have kept the immediate environs of the motorway free of urban residential development, and so long as the basic alignment permits, an unobstructed and relatively uncontroversial corridor for high speed rail development is available alongside.

Appendix C : Alternative High Speed Technologies

The requirement for enhanced UK surface transport need not necessarily be based upon conventional 'steel wheel on steel rail' technology. There has been considerable interest in the alternative 'maglev' system, whereby trains would 'float' on a frictionless intense magnetic field, and would be powered forwards using track-mounted linear induction motors. The UK Ultraspeed consortium[45] has been prominent in promoting the maglev concept, and have proposed a 'reverse-S' shaped line linking London, Birmingham, Manchester, Leeds, Newcastle, Edinburgh and Glasgow.

.A maximum feasible operating speed of 500kph is claimed for this technology (as opposed to circa 350kph for conventional rail). A trial project is now in successful operation on the new high speed airport link in Shanghai. Although maglev seems outwardly attractive, it embodies several drawbacks which make its use impracticable in the UK high speed rail project:

- It comprises 'stand-alone' technology, with no interoperability with the existing rail network. For any desired route (eg London-Scotland), it would be necessary to build new maglev line for the full length; high speed rail, on the other hand, would allow incremental construction, first to the Midlands, then to Yorkshire, with the train passing from the high speed line to the existing network, before final completion to Scotland.
- Benefits to the UK regions will be severely limited by the impracticability of through running onto HS1 and the wider European high speed network. This will also restrict potential conversion of short-haul air routes from UK regional airports to near-Europe.
- The need for full-length new build will make access to city centre terminals much more difficult and expensive. As envisaged in the UK Ultraspeed proposal, the new line is likely to serve intermediate cities by means of parkway stations. With local public transport access limited through these non-central locations, much of the claimed environmental benefits of high speed surface transport (as opposed to aviation) will be lost.
- Although maglev eliminates the rolling friction implicit in conventional rail technology, it is still subject to frictional air resistance which increases with the square of speed. Hence the frictional losses for 500kph operation will (all other things being equal) be of the order of 2.5 times those for 300kph. Although a maglev train, hugging a dedicated guideway will be aerodynamically 'cleaner' than a train guided and supported on conventional rails, it is difficult to see how the energy savings claimed by UK Ultraspeed can actually be realised.

[45] www.500kmh.com

Appendix D : Route Description

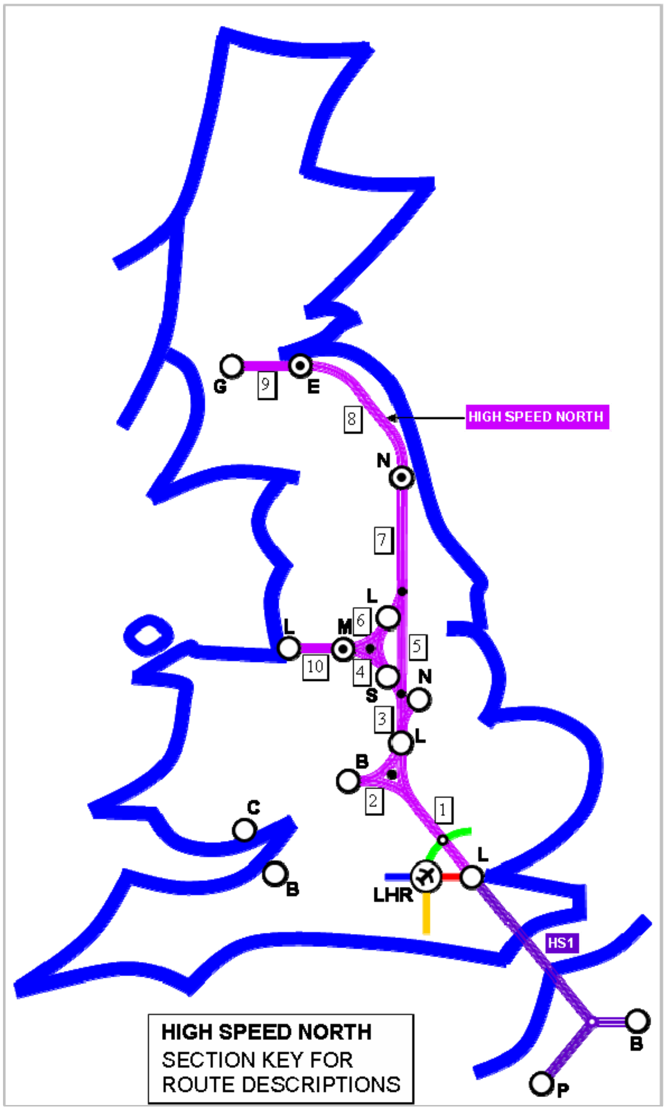


Figure D1

Section 1 : Euston to M1/M6 Interchange

- Euston approaches reengineered to permit passage of Eurogauge trains to eastern portal of Primrose Hill Tunnels (all on existing WCML).
- New tunnel under Hampstead ridge on S-shaped alignment to emerge on south side of MML at West Hampstead on trackbed of semi-redundant freight lines.
- New 'Cricklewood Interchange' on existing wide railway corridor for cross-platform interchange with orbital services from Heathrow network.
- HSN continues along MML/M1 corridor through Hendon and Mill Hill Broadway.
- Adjacent to Scratchwood services, HSN deviates to west from MML, following M1/A41 Watford Bypass to reach M25.
- Beyond M25, full 300kph speed attained. HSN continues alongside M1.
- 3km long tunnel required to avoid suburban development at Luton. Otherwise, no major residential impact for entire section.
- HSN continues alongside M1 through Milton Keynes and past Northampton. No on-line stations proposed, instead loops off main line.
- Triangle junction to Birmingham spur at M1/M6 interchange.

Section 2 : M1/M6 Interchange to Birmingham

- HSN (Birmingham spur) routed alongside M6, passing north of Coventry.
- HSN deviates to north to run alongside Nuneaton – Water Orton – Birmingham rail line.
- Existing Coleshill Parkway expanded as high speed terminal on M42 corridor?
- Birmingham New Street too short and too congested to accommodate 400m long trains (Eurogauge or not!!).
- Instead, Birmingham Moor Street selected as high speed terminal, with new platforms to north of existing. New north-to-west chord required at Bordesley to access Moor Street from Camp Hill Line.
- Underground travelator connection from Moor Street to access main line hub at New Street. Major local benefits.

Section 3 : M1/M6 Interchange to Killamarsh (near Sheffield)

- HSN continues alongside M1 (partly on former Great Central trackbed).
- HSN approaches Leicester along Great Central alignment, accessing existing Leicester (London Road) station on MML via short tunnel.
- Leicester station developed as high speed interchange with existing network.
- HSN continues north from Leicester along MML corridor. Route follows Soar Valley, then north from Trent Junction/Toton Yard along Erewash Valley.
- Various options for Nottingham high speed station include East Midlands Airport Parkway, new parkway station at Toton Yard close to M1/A52 interchange, and/or spur to existing Nottingham Midland station.
- HSN deviates to east of MML corridor near Pye Bridge via tunnel, joining M1 near Junction 28 (A38).
- HSN rejoins MML corridor (Chesterfield – Rotherham 'Old Road') near Killamarsh (SE of Sheffield).

Section 4 : Killamarsh to Manchester Piccadilly via Woodhead

- HSN (Manchester spur) continues along MML corridor, deviating to west through Tinsley Yard.
- Sheffield high speed station located at existing Meadowhall station in Don Valley between Sheffield and Rotherham (existing Sheffield Midland station site too small and constrained by unfavourable topography). Frequent connections to central Sheffield via either local train or tram.
- HSN follows M1 north towards Chapeltown, deviating to west to climb to ridge to east of Upper Don Valley and passing to north of Penistone.
- HSN joins trackbed of currently redundant Woodhead route close to eastern portal at Dunford Bridge (partly on former Great Central trackbed).
- HSN passes through Woodhead tunnel, re-engineered for 200kph operation. All subsequent alignments to Manchester 200kph.
- HSN follows abandoned Woodhead route down Longdendale on smoothed alignment, tunnelling through ridges on south side of valley.
- Independent alignment continues parallel to existing Hadfield-Manchester commuter railway, with tunnel under Hadfield and new viaducts at Dinting and Broadbottom.
- From Hyde to Ardwick, HSN takes up redundant trackbed to north of existing tracks. New flyover required at Guide Bridge for existing Transpennine traffic.
- HSN enters Manchester Piccadilly on new viaduct to north of existing, with new 400m terminating platforms constructed on car park to north of trainshed.

Section 5 : Killamarsh to Colton Junction (near York)

- HSN trunk route deviates east in tunnel from MML corridor, climbing to join M18 corridor near M1/M18 junction.
- HSN follows M18 north-east, then deviates to north to cross Don Valley east of Conisbrough and follow circumferential alignment to west of Doncaster.
- HSN joins ECML near Shaftholme Junction and continues alongside to Colton Junction south of York.

Section 6 : Penistone to Colton Junction

- HSN (Leeds spur) deviates from Manchester spur at triangle junction north of Penistone, passing in tunnel under Hoylandswain. West-to-north side of triangle facilitates Transpennine flows.
- HSN continues to north-east, rejoining M1 corridor near Woolley Edge services and passing to west of Wakefield.
- Near East Ardsley, HSN switches to follow Great Northern/ECML corridor into Leeds.
- Eurogauge trains follow existing route through Leeds West Junction to enter new terminating 400m long platforms constructed in car park to north of Leeds City station.
- UK gauge Transpennine (and CrossCountry) trains follow restored Farnley Viaduct route to south (through) side of Leeds City station, leaving station to east on existing unmodified viaduct.
- Dedicated HSN route resumes, running parallel to existing railway past Neville Hill depot and through Crossgates station.
- HSN deviates to north to follow M1 and bypass Garforth, Micklefield and Church Fenton.
- HSN follows A1(M) and A64 Tadcaster Bypass, with short cross-country section to join ECML and HSN trunk route at Colton Junction.

Section 7 : Colton Junction to Newcastle

- HSN bypasses York to west, following alignment of the A1237 western bypass, and rejoining ECML near Shipton.
- HSN runs parallel to ECML with only minor deviation as far as Darlington.
- High speed station at Darlington adjoining existing station to provide Teesside connection.
- HSN continues on ECML alignment through Darlington, then deviating to east to follow A1(M) and bypass Aycliffe curves before returning to ECML alignment through magnesian limestone ridge at Ferryhill.
- North of Ferryhill, HSN follows A1(M)/Leamside line corridor.
- Still on A1(M) corridor, HSN crosses Wear Valley north of Chester-le-Street and after short tunnel, rejoins ECML corridor near Birtley.
- HSN enters Gateshead along ECML corridor, deviating to east to tunnel under residential development and emerge onto new high bridge over River Tyne, located between King Edward Bridge and Metro Bridge.
- Newcastle high speed station located on new bridge, with connection to existing Newcastle Central station.

Section 8 : Newcastle to Edinburgh

- HSN continues under Newcastle city centre in (bored) tunnel, continuing under Town Moor in cut and cover and following Metro line corridor to east of Gosforth.
- HSN clears suburban development to east of Wideopen, passing under Gosforth Park racecourse in cut and cover.
- HSN continues north along A1 corridor, bypassing Morpeth to the west.
- Former Alnwick branch restored, with new station on south side of Alnwick and joining HSN to south-west of town.
- HSN passes to west of Alnwick through 3km tunnel under Alnwick Moor and emerging into Aln valley before continuing cross-country towards Eglingham and Wooler.
- A new station will be provided at Wooler for local services.
- HSN continues north-west of Wooler along A697 corridor across River Tweed to west of Coldstream, and further north-west into Scotland.
- Near Greenlaw, local route deviates to the east, following former Berwick-Duns-Leaderfoot-Newton St Boswells route, and joining southern end of restored Waverley Line at Melrose/Tweedbank.
- HSN continues along A697 corridor into Lauderdale, passing under ridge of Lammermuir Hills in 3.5km tunnel.
- HSN descends towards Edinburgh along A68 corridor, entering city by following first A1 and then Edinburgh Suburban Line.
- HSN passes in tunnel to south-west of Arthur's Seat, entering Edinburgh Waverley station onto dedicated reconstructed platforms to south of existing trainshed.

Section 9 : Edinburgh to Glasgow

- HSN continues west from Edinburgh Waverley in new tunnel bored to south of existing alignment, emerging west of Haymarket Station.
- HSN follows alignment of existing Edinburgh-Glasgow main line, deviating to south to follow M8 corridor towards Glasgow.
- HSN follows M8/A8 corridor as far as Bargeddie, then deviates to south to follow Whifflet Branch, joining WCML at Rutherglen.
- HSN enters Glasgow Central station on east side of terminus, with new platforms extended out of existing trainshed onto Clyde Bridge.

Section 10 : Manchester to Liverpool

- No feasible surface route exists for a high speed route across Manchester city centre. Hence the HSN Liverpool spur will deviate from the high speed line to the east of the city centre near Ardwick Depot, and drop into tunnel.
- HSN tunnel follows east-west alignment under Fairfield Street, passing adjacent to Piccadilly station. Double-stacked underground station constructed top-down within piled cofferdam.
- HSN tunnel emerges onto (original) Liverpool – Manchester railway near Castlefield, following existing route alongside M602 motorway.
- Clear of suburban development, HSN deviates to follow M62 for most of route length to Liverpool.
- HSN deviates south from M62 at Rainhill (J7) to join corridor of (CLC) Liverpool – Warrington – Manchester railway.
- HSN Liverpool terminal located at Liverpool South Parkway, owing to insufficient feasible platform length at more central Liverpool Lime Street station. Shorter UK-gauge Transpennine high speed trains continue to Lime Street, and other frequent local rail connections to central Liverpool and elsewhere in Merseyside available at Liverpool South Parkway.

Appendix E : Route Analysis

The following spreadsheets provide a comparative analysis of the High Speed North proposal against a variety of west-sided 'HS2' proposals and possible proposals that might emerge from the DfT HS2 Company. These cover all likely permutations of routeing beyond the so-far defined initial destinations of Heathrow, Birmingham and Manchester.

To allow valid comparisons to be made, the systems are developed to cover the same nine Midlands, Northern and Scottish cities ie Birmingham, Leicester, Sheffield, Manchester, Liverpool, Leeds, Newcastle, Edinburgh and Glasgow. Due to current uncertainties as to precise routeings to and station locations for Nottingham, this city is not included in any of the comparisons. The DfT proposals only consider seven cities, with Leicester and Sheffield omitted in accordance with the interpretation of the remit.

Comparisons are made for:

- total route length
- number of intercity connections
- numbers of separate routes required to deliver the intercity connections
- journey times to key cities
- cost

Journey times and cost comparisons are based upon a somewhat arbitrary selection of operating speed and 'cost per kilometre', and cannot be guaranteed in an absolute sense; but the criteria have been applied in an even-handed manner, and it is considered that the spreadsheets represent accurate comparisons.

Comparisons are also drawn for the initial phase of intercity development, which is generally considered to comprise Birmingham, Manchester and Leeds as primary destinations.

Eight spreadsheet calculations are appended, covering:

- Greengauge21 HS2 extended west-sided to Scotland (P136).
- HS2 extended west-sided to Scotland (P137) – assuming Heathrow Hub in lieu of Greengauge21 terminating spur (subsequent spreadsheets similar).
- HS2 extended east-sided to Scotland (P138).
- HS2 extended west- and east-sided to Scotland, with HS2/HS3 sub-option (P139).
- High Speed North (P140).
- Projection[46] of DfT HS2 Company remit, extended west-sided to Scotland, with Transpennine spur to West Yorkshire and the North-East (P141).
- Projection of DfT HS2 Company remit, extended as 'Reverse – S' to Scotland (P142).
- Summary tables (P143).

[46] Projection based on interpretation of remit, as per July 2009 newsletter. Bibliography Item 20.

Appendix F : Ten Tests for High Speed Rail

1. The big-city test

How many major cities (300,000+ population) does the core route serve?

2. The city centre hub test

How many city centre hubs does the core route serve?

3. The short-haul flights test

How many domestic and near-Europe flights could be replaced?

4. The cost test

How much does the core route cost?

5. The value for money test

How many communities are connected for minimised length of new construction?

6. The environmental impact test

How many communities/areas of countryside would be adversely affected by new construction?

7. The Heathrow test

How many regional communities would gain effective and frequent links to Heathrow?

8. The network test

How many existing main line routes would be enhanced through reduced congestion and increased journey opportunities?

9. The regional impact test

How would the route improve links between Northern communities to east and west of the Pennines?

10. The European test

How many communities could be connected to the European high-speed network?

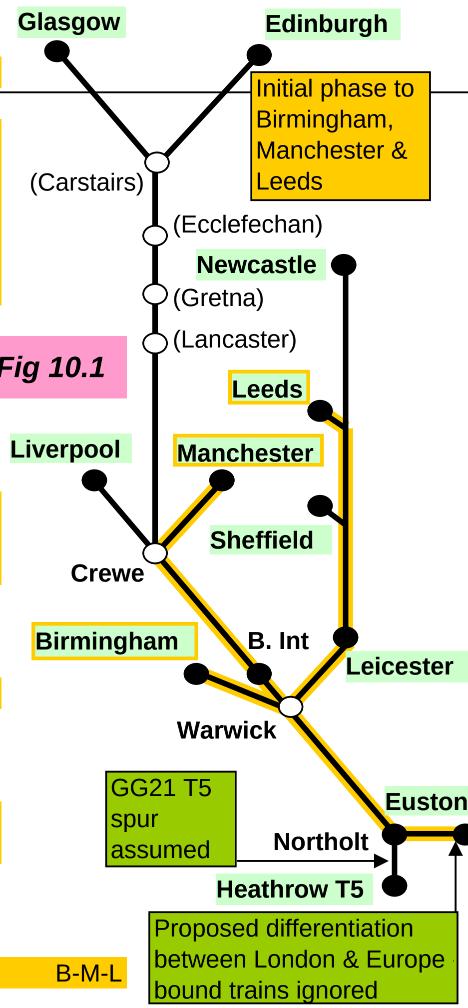
GG21 PROPOSAL - West Coast to Scotland

all distances calculated as straight lines

		E	N	dist	dist	£M/km	£M	£M	ave speed	time hr	Total time hr	hr m
Euston	9	529535	182805									
Northolt		511975	185030	17.7	17.7	40	708	708	200	0.09		
Heathrow T5	9	504970	175970	11.5	11.5	80	916	916				
Princes Risboro		479490	202175	36.7	36.7	65	2388	2388	250	0.16		
Warwick		426465	262485	80.3	80.3	30	2409	2409	250	0.34		
Birmingham Int		419820	283040	21.6	21.6	30	648	648	250	0.09		
Crewe		371125	354670	86.6	86.6	30	2598	2598	250	0.37		
Lancaster		348775	458825	106.5		30	3196		250	0.45		
Gretna		332335	569190	111.6		40	4463		250	0.47		
Ecclefechan		316435	575500	17.1		30	513		250	0.07		
Carstairs		295250	645400	73.0		40	2922		250	0.31		
Glasgow	1	258750	665060	41.5		30	1244		200	0.22	2.58	2 35
Warwick		426465	262485									
Leicester	5	459365	304105	53.1	53.1	30	1592	1592	250	0.22		
Sheffield	3	448115	388645	85.3	85.3	30	2559	2559	250	0.36		
Leeds	3	429850	433195	48.1	48.1	30	1444	1444	250	0.20	1.46	1 28
Newcastle	3	424660	563855	130.8		30	3923		250	0.55	1.94	1 56
									125	0.08		
									10.0			
Warwick		426465	262485									
Birmingham	5	407445	286780	30.9	30.9	30	926	926	200	0.16	0.75	0 45
Crewe		371125	354670									
Liverpool	1	335115	390585	50.9		40	2034		200	0.27	1.32	1 19
Crewe		371125	354670									
Wilmslow		384500	380500	29.1	29.1	30	873	873	250	0.12		
Manchester	1	384825	397820	17.3	17.3	30	520	520	125	0.15	1.32	1 19
Carstairs		295250	645400									
Edinburgh	1	325960	673885	41.9		30	1257		200	0.22	2.58	2 35
							39359	18635	**TOTAL COST** *£ million*			

COST / TIMING

ref Fig 10.1



INTERCITY CONNECTIONS	41	**TOTAL ROUTE LENGTH** (km)	1157	549	B-M-L
		incl sinusoity	41 connections		
NETWORK EFFICIENCY			3.54 connections/100km		

NO OF ROUTES (TO SERVICE CORE NETWORK)	17 No of routes
OPERATIONAL EFFICIENCY	2.41 connections/route

HS2' PROPOSAL - West Coast to Scotland

all distances calculated as straight lines

		E	N	dist	dist	COST £M/km	£M	£M	TIMING ave speed	time hr	Total time hr	hr	m
Euston	9	529535	182805										
Heathrow Hub	9	504750	180070	24.9	24.9	80	1995	1995	200	0.13			
Princes Risboro		479490	202175	33.6	33.6	65	2182	2182	250	0.14			
Warwick		426465	262485	80.3	80.3	30	2409	2409	250	0.34			
Birmingham Int		419820	283040	21.6	21.6	30	648	648	250	0.09			
Crewe		371125	354670	86.6	86.6	30	2598	2598	250	0.37			
Lancaster		348775	458825	106.5		30	3196		250	0.45			
Gretna		332335	569190	111.6		40	4463		250	0.47			
Ecclefechan		316435	575500	17.1		30	513		250	0.07			
Carstairs		295250	645400	73.0		40	2922		250	0.31			
Glasgow	1	258750	665060	41.5		30	1244		200	0.22	2.60	2	36
Warwick		426465	262485										
Leicester	5	459365	304105	53.1	53.1	30	1592	1592	250	0.22			
Sheffield	3	448115	388645	85.3	85.3	30	2559	2559	250	0.36			
Leeds	3	429850	433195	48.1	48.1	30	1444	1444	250	0.20	1.49	1	29
Newcastle	3	424660	563855	130.8		30	3923		250	0.55	1.96	1	58
									125	0.08			
Warwick		426465	262485						10.0				
Birmingham	5	407445	286780	30.9	30.9	30	926	926	200	0.16	0.78	0	47
Crewe		371125	354670										
Liverpool	1	335115	390585	50.9		40	2034		200	0.27	1.34	1	21
Crewe		371125	354670										
Wilmslow		384500	380500	29.1	29.1	30	873	873	250	0.12			
Manchester	1	384825	397820	17.3	17.3	30	520	520	125	0.15	1.34	1	21
Carstairs		295250	645400										
Edinburgh	1	325960	673885	41.9		30	1257		200	0.22	2.60	2	36
INTERCITY CONNECTIONS	41	**TOTAL ROUTE LENGTH** (km)		**1149**	541 B-M-L		39534	18810	**TOTAL COST** *£ million*				

incl sinusoity

41 connections

NETWORK EFFICIENCY 3.57 connections/100km

NO OF ROUTES 9 No of routes

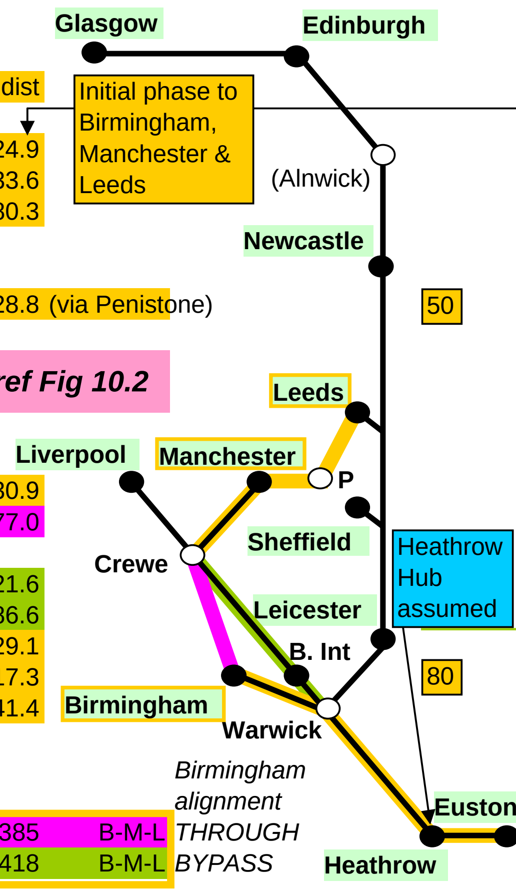
(TO SERVICE CORE NETWORK)

OPERATIONAL EFFICIENCY 4.56 connections/route

HS2' PROPOSAL - East Coast to Scotland

all distances calculated as straight lines

		E	N	dist	dist	£M/km	£M	£M	ave speed	time hr	Total time hr	hr m
Euston	9	529535	182805									
Heathrow Hub	9	504750	180070	24.9	24.9	80	1995	1995	200	0.13		
Princes Risboro		479490	202175	33.6	33.6	65	2182	2182	250	0.14		
Warwick		426465	262485	80.3	80.3	30	2409	2409	250	0.34		
Leicester	7	459365	304105	53.1		30	1592		250	0.22		
Sheffield	3	448115	388645	85.3		30	2559		250	0.36		
Leeds	3	429850	433195	48.1	28.8 (via Penistone)	30	1444	1438	250	0.20	1.49	1 29
Newcastle	5	424660	563855	130.8		30	3923		250	0.55	1.96	1 58
Alnwick		418645	613617	50.1		40	2005		250	0.21		
Edinburgh	5	325960	673885	110.6		40	4422		250	0.47	2.64	2 38
Glasgow	5	258750	665060	67.8		30	2034		200	0.36	3.00	3 0
Warwick		426465	262485						125	0.08		
Birmingham	7	407445	286780	30.9	30.9	30	926	926	200	0.16	0.78	0 47
(Crewe)		371125	354670		77.0	50		3850				
Warwick		426465	262485									
Birmingham Int		419820	283040	21.6	21.6	30	648	648	250	0.09		
Crewe		371125	354670	86.6	86.6	30	2598	2598	250	0.37		
Wilmslow		384500	380500	29.1	29.1	30	873	873	250	0.12		
Manchester	1	384825	397820	17.3	17.3	30	520	1386	125	0.15	1.34	1 21
(Penistone P)		425610	404755		41.4	50		2069				
Crewe		371125	354670									
Liverpool	1	335115	390585	50.9		40	2034		200	0.27	1.34	1 21



INTERCITY CONNECTIONS	55	**TOTAL ROUTE LENGTH (km)** *incl sinusoity*	**976**	385 B-M-L	*THROUGH*	34093 18153 *THROUGH* **TOTAL COST**
				418 B-M-L	*BYPASS*	17514 *BYPASS* **TOTAL COST**

55 connections

NO OF ROUTES **(TO SERVICE CORE NETWORK)** 7 No of routes

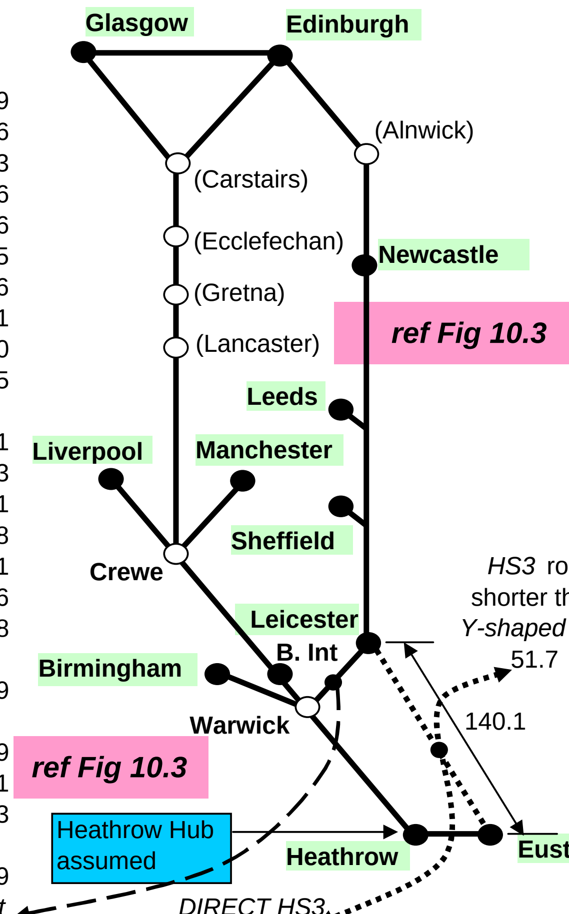
NETWORK EFFICIENCY 5.63 connection/100km

OPERATIONAL EFFICIENCY 7.86 connections/route

HS2/HS3' PROPOSAL West & East Coast to Scotland

all distances calculated as straight lines

Station	Connections	E	N	dist	Routes	COST £M/km	COST £M	TIMING ave speed	time hr	Total time hr	hr m
Euston	9	529535	182805		9						
Heathrow Hub	9	504750	180070	24.9	5	80	1995	200	0.13		
Princes Risboro		479490	202175	33.6		65	2182	250	0.14		
Warwick		426465	262485	80.3		30	2409	250	0.34		
Birmingham Int		419820	283040	21.6		30	648	250	0.09		
Crewe		371125	354670	86.6		30	2598	250	0.37		
Lancaster		348775	458825	106.5		30	3196	250	0.45		
Gretna		332335	569190	111.6		40	4463	250	0.47		
Ecclefechan		316435	575500	17.1		30	513	250	0.07		
Carstairs		295250	645400	73.0		40	2922	250	0.31		
Glasgow	5	258750	665060	41.5	5	40	1658	200	0.22	**2.60**	**2 36**
Warwick		426465	262485					125	0.08		
Leicester	7	459365	304105	53.1	6	30	1592	250	0.22		
Sheffield	3	448115	388645	85.3	2	30	2559	250	0.36		
Leeds	3	429850	433195	48.1	2	30	1444	250	0.20	**1.49**	**1 29**
Newcastle	5	424660	563855	130.8	4	30	3923	250	0.55	**1.96**	**1 58**
Alnwick		418645	613617	50.1		40	2005	250	0.21		
Edinburgh		325960	673885	110.6		40	4422	250	0.47		
Glasgow		258750	665060	67.8		30	2034	200	0.36		
Warwick		426465	262485								
Birmingham	7	407445	286780	30.9	1	30	926	200	0.16	**0.78**	**0 47**
Crewe		371125	354670								
Liverpool	1	335115	390585	50.9	1	40	2034	200	0.27	**1.34**	**1 21**
Wilmslow		384500	380500	29.1		30	873	250	0.12		
Manchester	1	384825	397820	17.3	1	30	520	125	0.15	**1.34**	**1 21**
Carstairs		295250	645400								
Edinburgh	5	325960	673885	41.9	4	30	1257	200	0.22	**2.60**	**2 36**



		HS2 west & east		*DIRECT HS3*		
INTERCITY CONNECTIONS 55	**TOTAL ROUTE LENGTH** (km) *incl sinusoity*	**1391**	9	**1484**	8	*HS2 west & east* / *DIRECT HS3*
		55	connections	40		No of train routes required to service core network
NETWORK EFFICIENCY		3.95	connection/100km	2.70		

48942	**TOTAL COST** *£ million*
52250	**TOTAL COST** *£ million*

HIGH SPEED NORTH

all distances calculated as straight lines

						COST			TIMING			
Heathrow	9	E	N	dist	dist	£M/km	£M	£M	ave speed	time hr	Total time hr	hr m
Euston	9	529535	182805									
M1/M25 interX		513500	202500	25.4	25.4	50	1270	1270	200	0.13		
Rugby (M1/M6)		456100	278850	95.5	95.5	30	2866	2866	250	0.41		
Leicester	9	459365	304105	25.5	25.5	30	764	764	250	0.11		
Sheffield	9	448115	388645	85.3	85.3	30	2559	2559	250	0.36		
York		459600	451710	64.1		30	1923		250	0.27		
Newcastle	9	424660	563855	117.5		30	3524		250	0.50	**1.78**	**1 47**
Alnwick		418645	613617	50.1		40	2005		250	0.21		
Edinburgh	9	325960	673885	110.6		40	4422		250	0.47	**2.46**	**2 28**
Glasgow	9	258750	665060	67.8		30	2034		200	0.36	**2.82**	**2 49**

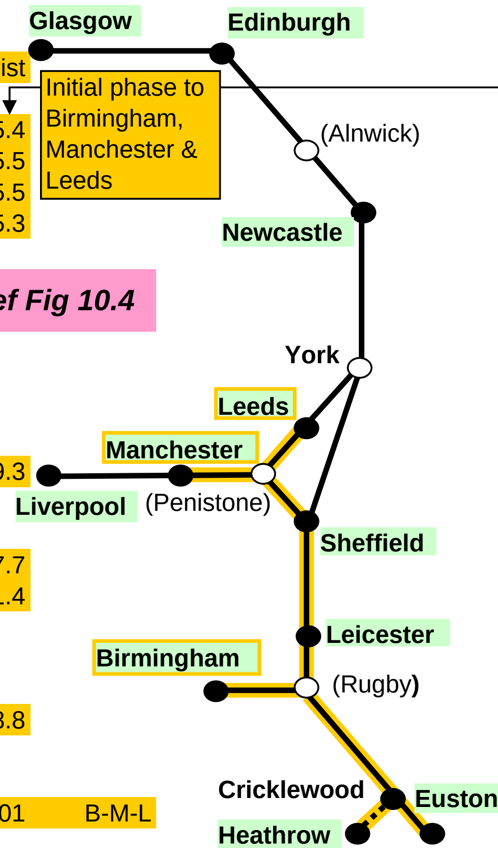
Rugby (M1/M6)		456100	278850									
Birmingham	7	407445	286780	49.3	49.3	30	1479	1479	200	0.26	**0.80**	**0 48**

Sheffield		448115	388645									
Penistone		425610	404755	27.7	27.7	50	1384	1384	250	0.12		
Manchester	8	384825	397820	41.4	41.4	50	2069	2069	200	0.22	**1.35**	**1 21**
Liverpool	8	335115	390585	50.2					250	0.21	**1.56**	**1 34**

Penistone		425610	404755									
Leeds	9	429850	433195	28.8	28.8	50	1438	1438	200	0.15	**1.28**	**1 17**
York		459600	451710	35.0		30	1051					

INTERCITY CONNECTIONS	95	**TOTAL ROUTE LENGTH** (km) *incl sinusoity*	**927**	401	B-M-L	30513	14657 **TOTAL COST** *£ million*

ref Fig 10.4



95 connections

NO OF ROUTES (TO SERVICE CORE NETWORK) — 6 No of routes

NETWORK EFFICIENCY — 10.25 connections/100km

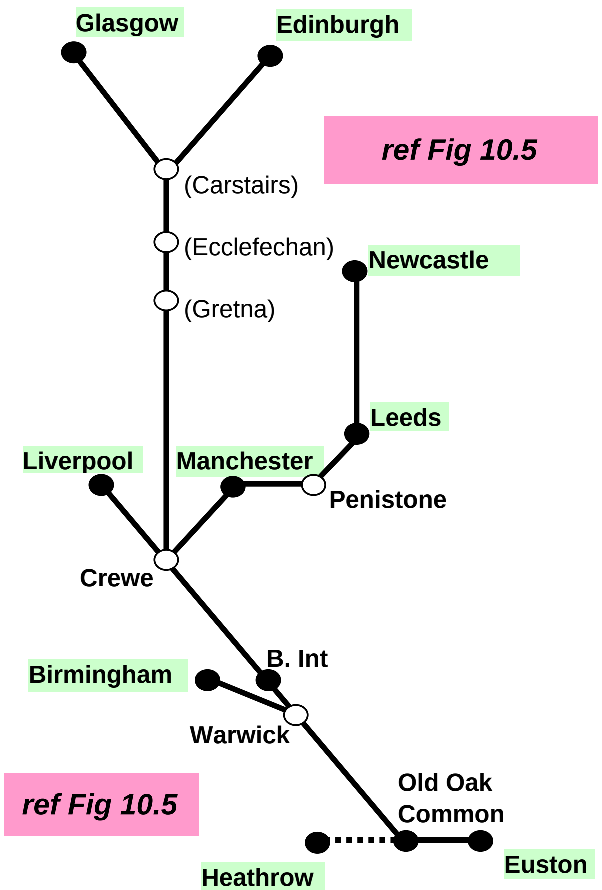
OPERATIONAL EFFICIENCY — 15.83 connections/route

Sinuosity %age	6	%
Sinuosity factor	1.06	
Minutes in hour	60	

DfT Projected - West-sided to Scotland

all distances calculated as straight lines

Station	Conn.	E	N	dist	COST £M/km	COST £M	TIMING ave speed	TIMING time hr	TIMING Total time hr	TIMING Total time hr m
Heathrow	7									
Euston	7	529535	182805							
Old Oak Common		521740	182260	7.8	65	508	200	0.04		
Northolt		511975	185030	10.2	30	305	200	0.05		
Princes Risboro		479490	202175	36.7	65	2388	250	0.16		
Warwick		426465	262485	80.3	30	2409	250	0.34		
Birmingham Int		419820	283040	21.6	30	648	250	0.09		
Crewe		371125	354670	86.6	30	2598	250	0.37		
Lancaster		348775	458825	106.5	30	3196	250	0.45		
Gretna		332335	569190	111.6	40	4463	250	0.47		
Ecclefechan		316435	575500	17.1	30	513	250	0.07		
Carstairs		295250	645400	73.0	40	2922	250	0.31		
Glasgow	1	258750	665060	41.5	40	1658	200	0.22	2.58	2 35
Carstairs		295250	645400							
Edinburgh	1	325960	673885	41.9	30	1257	200	0.22	2.58	2 35
Crewe		371125	354670							
Wilmslow		384500	380500	29.1	30	873	250	0.12		
Manchester	3	384825	397820	17.3	80	1386	200	0.09	1.27	1 16
Penistone		425610	404755	41.4	50	2069	200	0.22		
Leeds	3	429850	433195	28.8	65	1869	200	0.15	1.64	1 38
Newcastle	3	424660	563855	130.8	30	3923	250	0.55	2.19	2 11
Warwick		426465	262485							
Birmingham	1	407445	286780	30.9	30	926	200	0.16	0.75	0 45
Crewe		371125	354670							
Liverpool	1	335115	390585	50.9	40	2034	200	0.27	1.32	1 19



INTERCITY CONNECTIONS 20

TOTAL ROUTE LENGTH (km) *incl sinusoity* **1022**

38100 **TOTAL COST** *£ million*

20 connections

NO OF ROUTES (TO SERVICE CORE NETWORK) 5 No of trains

(Normalised) NETWORK EFFICIENCY 2.52 connection/100km

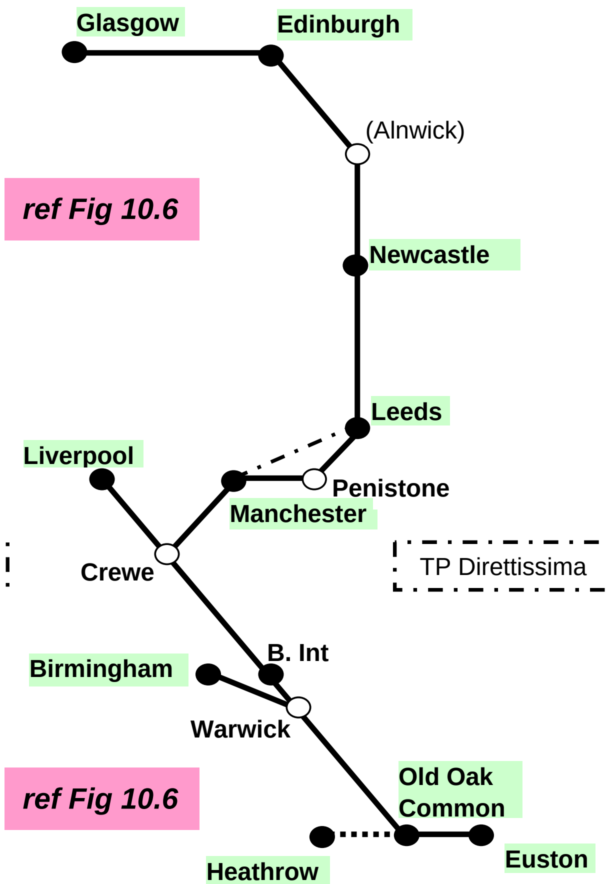
OPERATIONAL EFFICIENCY 4.00 connections/train

DfT Projected - Reverse S

all distances calculated as straight lines

Station		E	N	dist	£M/km	£M	ave speed	time hr	Total time hr	hr m
Heathrow	7									
Euston	7	529535	182805							
Old Oak Common		521740	182260	7.8	65	508	200	0.04		
Northolt		511975	185030	10.2	30	305	200	0.05		
Princes Risboro		479490	202175	36.7	65	2388	250	0.16		
Warwick		426465	262485	80.3	30	2409	250	0.34		
Birmingham Int		419820	283040	21.6	30	648	250	0.09		
Crewe		371125	354670	86.6	30	2598	250	0.37		
Wilmslow		384500	380500	29.1	30	873	250	0.12		
Manchester	5	384825	397820	17.3	80	1386	200	0.09	**1.27**	**1 16**
Penistone		425610	404755	41.4	50	2069	200	0.22		
Leeds	5	429850	433195	28.8	65	1869	200	0.15	**1.64**	**1 38**
Newcastle	5	424660	563855	130.8	30	3923	250	0.55	**2.19**	**2 11**
Alnwick		418645	613617	50.1	40	2005	250	0.21		
Edinburgh	5	325960	673885	110.6	40	4422	250	0.47	**2.87**	**2 52**
Glasgow	5	258750	665060	67.8	30	2034	200	0.36	**3.23**	**3 14**
TP Direttissima Manchester - Leeds				57.3	80	4581	220	0.26	**3.12**	**3 7**
Warwick		426465	262485							
Birmingham	1	407445	286780	30.9	30	926	200	0.16	**0.75**	**0 45**
Crewe		371125	354670							
Liverpool	1	335115	390585	50.9	40	2034	200	0.27	**1.32**	**1 19**

(Cost columns: COST £M/km, £M; Timing columns: TIMING ave speed, time hr, Total time hr, hr m. The TP Direttissima row is labelled "TP Direttissima" on the cost side.)



Communities served 7

Communities served by other schemes 9

INTERCITY CONNECTIONS 34 **TOTAL ROUTE LENGTH** (km) **849**

incl sinusoity 34 connections

(Normalised) NETWORK EFFICIENCY 5.15 connection/100km

32219 **TOTAL COST** *£ million*

NO OF ROUTES 3 No of trains

(TO SERVICE CORE NETWORK)

OPERATIONAL EFFICIENCY 11.33 connections/train

SUMMARY TABLE

		HS2 GG21 west side to Scotland	HS2 Arup west side to Scotland	HS2 Arup east side to Scotland	HS2/HS3 both sides to Scotland	High Speed North	DfT HS2 Co west side to Scotland	DfT HS2 Co Reverse S
Ref Figure		10.1	10.1	10.2	10.3	10.4	10.5	10.6
Total Route Length	(km)	**1157**	**1149**	**976**	**1391**	**927**	**1022**	**849**
No of Connections	(No)	41	41	55	55	95	20	34
Network Effectiveness	(connections/km)	3.54	3.57	5.63	3.95	10.25	2.52	5.15
Routes required to service core network		17	9	7	9	6	5	3
Operational efficency (connections/route)		2.41	4.56	7.86	6.11	15.83	4.00	11.33
Cost	(£ million)	39359	39534	34093	48942	30513	38100	32219
B-M-L route length	(km)	**549**	**541**	**418**	Semi-circ bypassing B'ham	**401**		
No of Connections	(No)	22	22	11		33		
Cost	(£ million)	18635	18810	18153		14657		
Sample Route Length & Timings								
Euston-Manchester	(km)	**306.7**	**311.0**	**311.0**	**311.0**	**318.8**	**307.0**	**307.0**
	(hr)	1.32	1.34	1.34	1.34	1.35	1.27	1.27
Euston-Liverpool	(km)	**311.4**	**315.8**	**315.8**	**315.8**	**372.0**	**311.7**	**311.7**
	(hr)	1.32	1.34	1.34	1.34	1.56	1.32	1.32
Euston-Leeds	(km)	**340.5**	**344.8**	**344.8**	**344.8**	**305.4**	**381.3**	**381.3**
	(hr)	1.46	1.49	1.49	1.49	1.28	1.64	1.64
Euston-Newcastle	(km)	**479.1**	**483.4**	**483.4**	**483.4**	**438.0**	**519.9**	**519.9**
	(hr)	1.94	1.96	1.96	1.96	1.78	2.19	2.19
Euston-Edinburgh	(km)	**628.2**	**633.0**	**653.7**	**633.0**	**608.3**	**629.0**	**690.3**
	(hr)	2.58	2.60	2.64	2.60	2.46	2.58	2.87
Euston-Glasgow	(km)	**628.7**	**632.5**	**725.6**	**632.5**	**680.2**	**628.5**	**762.1**
	(hr)	2.58	2.60	3.00	2.60	2.82	2.58	3.23
Aggregate Route Length	(km)	**2694.7**	**2720.6**	**2834.4**	**2720.6**	**2722.7**	**2777.5**	**2972.4**
Aggregate Timings	(hr)	11.19	11.34	11.78	11.33	11.24	11.57	12.52