CAPITA SYMONDS

Sustainable Development
Commission (SDC)

The potential for high speed rail in the UK and an assessment of its environmental benefits

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CONTENTS

1. INTRODUCTION

1.1 This note has been produced in response to SDC's request to assess the potential for the introduction of high speed rail in UK and examine the environmental benefits.

1.2 The structure of the note is as follows:

- Chapter 2 provides background information on future rail demand
- Chapter 3 provides information on the different types of high speed rail
- Chapter 4 looks at traditional cost benefit assumptions for high speed rail and the approach used in and recommendations from the Eddington transport study
- Chapter 5 looks at the environmental benefits of high speed rail
- Chapter 6 provides a summary of the report's main conclusions.

2. RAIL DEMAND

Passenger Demand

2.1 Overall rail demand is forecast to grow by 70% by 2031[1], an average growth rate of 1.8% per year and it is suggested that significant sections of the north-south strategic rail network will suffer considerable levels of crowding in the future. Research[1], therefore, suggests that an expansion in rail capacity is required.

2.2 In terms of the UK, capacity constraints and therefore analysis is concentrated on:

- West Coast Main Line (WCML)
- Midlands Main line (MML)
- The East Coast Main Line (ECML)

It is suggested that demand for these routes could more than double over the next 30 years.

- On the WCML – the southern most route sections between London and Milton Keynes and the northern section from Preston to Glasgow are forecast to be overcrowded in 2016. By 2031 it is suggested the whole route will be overcrowded

- On the MML mainline by 2031 the London-Loughborough section is forecast to be crowded

- On the ECML the London to York section is likely to be overcrowded by 2031

2.3 The role that high speed rail, might play in meeting this expansion is currently under consideration by the government.

[1] Atkins (2006) High Speed Line Summary Report
http://www.dft.gov.uk/pgr/rail/researchtech/research/highspeedlinestudysummaryreport

3. THE TYPES OF HIGH SPEED RAIL

3.1 High Speed Rail is defined[2] as trains that run at a maximum of at least 250 km/h

High speed rail falls into two categories:

1) **Those based on conventional railway technology**. These systems are segregated or integrated within an existing rail network. For example the TGV in France and the Eurostar. The introduction of these types of high speed rail involves the following:

   Changes to track
   - High speed railway lines have larger radii to enable trains to travel at high speed without increasing the centrifugal force felt by passengers
   - More precise track alignment

   Signalling
   - High speed trains use automated in-cab - the operating speeds are too high for drivers to see and react to traditional lineside signals

   Rolling stock
   - High speed rail carriages are normally articulated to reduce the weight of each train
   - High speed trains are all electrically powered

2) **Those which use of an alternative means of guidance –** the only system currently under development is magnetic levitation (Maglev). Maglev is a system of transportation that suspends, guides and propels vehicles above a 'guideway' using electromagnetic energy. These are totally separate from existing railway networks. For example the airport transit system in Shanghai.

   Table 3.1 illustrates the difference in speeds between current, high speed based on conventional technology, and maglev trains.

[2] European Directive on interoperability

Table 3.1 Train technologies – difference in speeds

	Top Speed	Average Speed
Current Classic UK Train	200	140
Eurostar	300	190
TGV	320	220
Maglev*	430	250

Source: Various

Note: IOS Maglev, airport transit system in Shanghai

3.2 The UK could, in theory, use high speed systems based on conventional technology and alternative means of guidance. However, there are a number of technological and financial risks associated with Maglev technology, and the technology is still in its infancy compared to conventional high speed railways[3]. Therefore, while Maglev offers higher top speeds, UK cost-benefit analysis on high speed rail has concentrated on the more conventional technologies.

[3] SPICe briefing (2006) High speed rail

4. COSTS AND BENEFITS

4.1 Atkins[1] have, for the DfT, undertaken analysis on a number of high speed rail options, including:

A New HSL infrastructure for the route section from North London to the West Midlands and Stafford where it would link in to the WCML. This would allow HSL services to be operated from London to Birmingham, Manchester, Liverpool and Glasgow

B New HSL infrastructure from London to the West Midlands and Manchester on one branch and to the East Midlands, Yorkshire, the north-east and Scotland on an easterly branch.

London to West Midlands is a core route section, given the forecast capacity constraints.

4.2 The cost benefit analysis, which considers:

- Net revenues (HSL revenue minus revenue lost from existing train companies)
- Non financial benefits e.g. journey time savings and accident costs
- Benefits from freed capacity on main line routes
- Capital costs of developing and constructing the HSL including risk
- Costs of operation and maintenance including risk

suggests that the benefits of high speed rail outweigh the costs in a ratio of between 1.9 and 2.8 to 1 (depending on the route option). The capital cost for the introduction of a high speed rail link between London to Scotland is £33 billion.

4.3 This type of cost benefit analysis is traditionally the approach used for the justification of transport infrastructure schemes. However the Eddington study which[4] examined the long term links between transport and the UK's economic productivity, growth and stability, raised a number of further issues with regard to investment in future transport infrastructure, which could impact on proposals for/ consideration of implementation of high speed rail

4.4 The overall conclusion of Eddington was that the UK has existing 'good levels of connectivity' – the right networks are in place to support travel demand. It identified the key economic challenge was to improve the performance of these existing networks, and identified three priority areas:

1) Growing and congested urban areas and their catchments
2) Key inter-urban corridors
3) Key international gateways

[4] The Eddington Transport Study (2006) The case for action: Sir Rod Eddington's advice to Government

4.5 Eddington suggested that the focus should be on understanding which transport policies would contribute to these policy areas and which provided the greatest overall benefits (i.e. the highest returns per £1 of expenditure).

4.6 Below, some of the benefits associated with high speed rail are compared with the Eddington position. These benefits include:

- Reductions in journey time
- Support of national economic growth
- The potential for modal shift
    - environmental benefits associated with this (discussed in Chapter 5)
- Wider environmental impacts (discussed in Chapter 5)

Reductions in journey time

4.7 One benefit of a high speed rail link is a reduction in passenger journey time. Potential travel time savings associated with high speed rail are illustrated in Table 4.1.

Table 4.1 Journey times

Journey	**Current time**	**Potential journey time with HSL**	**Time saving**
London to Birmingham	80	55	25
London to Manchester	125	80	55
London to Liverpool	130	95	35
London to Glasgow	285	180	105
London to Leeds	125	85	40
London to Newcastle	170	120	50
London to Edinburgh	255	155	100
Birmingham to Manchester	105	55	40
Manchester to Leeds	55	25	30

Source: Atkins[1]

4.8 The Eddington study took a top down approach, using new metrics to assess how well networks support actual demands on the system. These metrics avoided a modal approach. It concluded that new high-speed rail networks in the UK would not significantly change the level of economic connectivity between most parts of the UK - most UK cities are already a day-trip away from each other given existing aviation and rail links. Effectively, although there would be journey time savings, because of the UK's existing good connectivity, this would not necessarily result in economic benefit.

Support of national economic growth

4.9 It is suggested the introduction of high speed rail could also bring other economic development including:

- Inward investment
- Additional opportunities for tourism
- Housing and economic development

The economic performance is expected to improve in the regions of Midlands, the North and Scotland rather than the Southwest and the Southeast

4.10 The Eddington study position on connectivity (as detailed above) is also highly relevant here. Eddington also raised further concerns over business use of the high speed network since in France it is low.

4.11 There is the suggestion that the introduction of a high speed line could be beneficial in regeneration terms. However, Eddington highlights, that a "build and they will come" way of thinking is a dangerous approach to transport projects, especially given that transport is a two way process, and therefore local businesses may actually lose out. It suggests that in many potential regeneration areas inadequate transport capacity will not be limiting growth and policies such as skills or fiscal incentives may be more appropriate.

4.12 Eddington recognises there could be substantial benefits if new, high speed, lines removed interurban trains from commuter and freight lines. But suggests these benefits could be achieved by other means, and potentially at much lower cost. Measures include:

- Fares pricing policy
- Signal-based methods of achieving more capacity on the existing network
- Longer trains

Modal shift

4.13 Analysis[1], indicates that the introduction of HSL will result in modal shift from air and road to rail. (Annex A)

For example in 2031 modal shift is

- For the London to Edinburgh air route - 24%
- For the London to Manchester air route - 18%
- For the London to Manchester road journey - 19%
- For the London to Edinburgh road journey – 18%

However, the majority of trips on a HSL will come from classic rail

- 68% in 2016 and 58% in 2031

And generated travel, which otherwise would not have taken place, also makes an important contribution.

- 17% of trips are ‘generated’ in 2016 and 18% in 2031

5. ENVIRONMENTAL IMPACTS

5.1 The environmental benefits of this modal shift are explored in detail in Annex B, and the results are summarised below.

5.2 The carbon savings from the modal shift from air to rail (assuming a multiplier of 4 for non-carbon impacts):

- In 2016 is 0.12 MtC
- In 2031 is 0.42 MtC

5.3 These are based on the modal shift on a number of key routes as provided in the Atkins analysis. Allowing for a doubling of impacts (to fully cover all routes) would result in carbon savings of :

- In 2016 of 0.24 MtC
- In 2031 of 0.84 MtC

5.4 However, it should be noted that the carbon savings would only occur if flights were removed. Lower load factors on the same number of flights would not bring carbon saving benefits.

5.5 For the shift from road to rail:

- In 2016 the carbon saving would be 0.0036 MtC
- In 2031 the carbon saving would be 0.0072 MtC

5.6 These are based on the modal shift on a number of key routes as provided in the Atkins analysis. Allowing for a doubling of impacts (to fully cover all routes) would result in carbon savings of :

- In 2016 the carbon saving would be 0.0072 MtC
- In 2031 the carbon saving would be 0.0144 MtC

5.7 The Eddington study, as an illustrative measure, examined the carbon savings associated with a zero carbon high speed line and the assumption that all existing air travellers between London and Scotland switched to rail. This would save 0.33 MtC per year. While this number is not comparable with the above air modal shift analysis (different routes are examined, different carbon figures for rail and air are used) it provides a useful sensibility check.

5.8 In terms of cost benefit analysis, Eddington suggests that the value of carbon saved (31.4 MtC), over a 60 year period would be around £3.2 billion. Using the sensitivity range of £35/tC to £140/tC would result in carbon savings of £2.1 billion to £5.4 billion.

5.9 Here, using the Stern value of carbon of £238 and factoring up the above numbers, results in carbon savings worth £9.2 billion, over a 60 year period.

5.10 Also, using the 0.84 MtC per annum (the highest figure from the Capita Symonds analysis) and the Stern value of carbon of £238, results in a carbon savings worth of £12 billion over a 60 year period.

5.11 Given the financial cost of £33 billion the carbon savings, even under optimistic assumptions, are unlikely to be significant part of the business case.

Wider environmental impacts

Air quality pollutants

5.12 High speed rail journeys currently have higher emissions of SO_2 per passenger km, than domestic air[5]. These are likely to decrease in the future and SO_2 emissions from both modes will be similar.

5.13 Domestic aircraft have higher emissions of ground level CO, Nox and VOCs, per passenger km, than high speed rail. And future emissions are likely to be even lower for trains due to changes in the electricity generation mix resulting in greater emission reductions.

5.14 Emissions of PM10 per passenger km, are broadly similar for both modes

[5] AEA Technology (2001) A Comparative Study of the Environmental Effects of Rail and Short-haul Air Travel

Noise

5.15 High speed rail, if sound exposure level, is taken into account generally has a higher population noise burden than domestic air, per passenger carried. If screening effects from buildings are taken into account the difference is lower. In the future the noise burden from domestic aircraft is likely to get lower and the noise burden from high speed rail higher

Natural and built environment

5.16 The construction of a new railway line would also have potentially significant effects on the local environment.

6. CONCLUSIONS

6.1 The main conclusions that can be drawn from this report are listed below:

(i) Rail demand, over the next twenty five years, is set to increase substantially;

(ii) The introduction of a High Speed Rail network may contribute to dealing with this demand and is currently being considered by the UK government;

(iii) The Eddington study, with its emphasis on improving existing networks and investment priority for the highest return schemes highlighted that investment in high speed rail requires careful evaluation and justification.

(iv) Alternative measures and/or a, carefully, staggered approach to high speed rail may therefore be more appropriate. One area for further study is the impact of these measures on the forecast rail demand.

(v) Analysis indicates that carbon savings will have a limited impact on the business case for high speed rail. Other environmental benefits are also (relatively) limited.

(vi) The 2007 rail white paper should, hopefully, provide a clear vision for the future of high speed rail

Annex A

Table 1 Source of demand for high speed rail option B

	2016		2031	
	Annual trips (m)	% of total	Annual trips (m)	% of total
Market				
Shift from classic rail	33.0	68%	45.3	58%
Shift from air	1.0	2%	3.0	4%
Shift from car	6.3	13%	15.6	20%
Generated demand	8.0	17%	14.1	18%
Total	48.3	100%	78	100%

Source Atkins (2006) High Speed Line summary report

Table 2 Impact on air markets of high speed rail option B

	2016			2031		
Daily trips	Base Case	With HSL	% change	Base Case	With HSL	% change
London – Glasgow	12909	12352	-4%	17067	14924	-13%
London – Edinburgh	13614	12358	-9%	19482	14735	-24%
London – Manchester	2979	2649	-11%	3673	3004	-18%
Birmingham – Scotland	3447	3148	-9%	4449	3964	-11%

Source Atkins (2006) High Speed Line summary report

Table 3 Impact on highway demand of high speed rail option B

	2016			2031		
Daily Passenger trips	Base case	With HSL	% change	Base case	With HSL	% change
London-Manchester	3340	2986	-11%	3999	3237	-19%
London – Leeds	4049	3749	-8%	4446	3992	-10%
London – Edinburgh	408	384	-6%	499	409	-18%
Manchester – Newcastle	588	525	-11%	643	527	-18%
Birmingham – Leeds	3675	3615	-2%	4326	4214	-3%

Source Atkins (2006) High Speed Line summary report

Annex B

Assumptions for below

Defra CO_2 emissions per passenger km are:

- 150 grams for short haul flight
- 40 grams for rail
- 114 grams for car

Source:
http://www.defra.gov.uk/environment/business/envrp/gas/envrpgas-annexes.pdf
and internal note

Defra carbon emissions per passenger km are therefore

- 0.041 kg per km for short haul
- 0.011 kg per km for rail
- 0.031 kg per km for car

Factoring up daily trips to annual, using above figures (difference of 0.03 between rail and air) and a radiative forcing factor of 4

Table 1 Carbon savings from modal shift from air to rail 2016

	Distance km	Journeys not made (based on daily trips[1] saved x 365)	Distance saved (Journeys not made x distance)	Carbon savings kg (saving of 0.03 per km)	With radiative forcing (factor of 4 used)	MTC
London to Glasgow	640	203305	130115200	3903456	15613824	0.0156
London to Edinburgh	640	458440	293401600	8802048	35208192	0.0352
London to Manchester	320	120450	38544000	1156320	4625280	0.0046
Birmingham – Scotland	480	109135	52384800	1571544	6286176	0.0063
	2080	891330	514445600	15433368	61733472	0.062

1 Annex A Table 2

Assuming a doubling (return journey) then 0.12 MtC

Table 2 Carbon savings from modal shift from air to rail 2016

	Distance km	Journeys not made (based on daily trips* saved x 365 days)	Distance saved (Journeys not made x distance)	Carbon savings kg (saving of 0.03 per km)	With radiative forcing (factor of 4 used)	MTC
London to Glasgow	640	782195	500604800	15018144	60072576	0.06007258
London to Edinburgh	640	1732655	1108899200	33266976	133067904	0.1330679
London to Manchester	320	244185	78139200	2344176	9376704	0.0093767
Birmingham – Scotland	480	177025	84972000	2549160	10196640	0.01019664
	2080	2936060	1772615200	53178456	212713824	0.21

* Annex A Table 2

Assuming a doubling (return journey) then 0.42 MtC

Factoring up daily trips to annual, using above figures (difference of 0.02 kg between rail and air).

Table 3 Carbon savings from modal shift from road to rail

	Distance km	Journeys not made (based on daily trips saved* x 365 days	Distance saved (Journeys not made x distance)	Carbon savings kg (carbon savings 0.02 per km)	MtC
London to Manchester	320	129210	41347200	826944	0.0008
London to Leeds	320	109500	35040000	700800	0.0007
London to Edinburgh	640	8760	5606400	112128	0.0001
Manchester –	251	22995	5771745	115434.9	0.0001

Newcastle					
Birmingham - Leeds	190	21900	4161000	83220	0.0001
	1721	292365	91926345	1838526.9	0.0018

* Annex A table 3

Assuming a doubling (return journey) then 0.0036 MTC

Factoring up daily trips to annual, using above figures (difference of 0.02 kg between rail and air).

Table 4 Carbon savings from modal shift from road to rail 2031

	Distance km	Journeys not made (based on daily trips saved* x 365 days	Distance saved (Journeys not made x distance)	Carbon savings kg (carbon savings 0.02 per km)	MtC
London to Manchester	320	278130	89001600	1780032	0.0018
London to Leeds	320	165710	53027200	1060544	0.0011
London to Edinburgh	640	32850	21024000	420480	0.0004
Manchester – Newcastle	251	42340	10627340	212546.8	0.0002
Birmingham - Leeds	190	40880	7767200	155344	0.0002
Total	1721	559910	181447340	3628946.8	0.0036

* Annex A Table 3

Assuming a doubling (return journey) then 0.0064 MtC