Planning and Regulation

Route Planning

New Lines Programme

High Speed Rail Investment; an overview of the literature

High Speed Rail Investment: an overview of the literature

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1. Introduction.

This short review was commissioned as part of the Network Rail New Lines project to try to learn from experience elsewhere. After a brief introduction, we will consider world experience of HSR country by country, looking first at the reasons for its introduction, then at its impact and finally seek to draw lessons from the experience for Britain.

Definitions of high speed rail differ, but a common one is rail systems which are designed for a maximum speed in excess of 200 km.p.h. They may take any of three forms – upgraded existing lines (which would almost inevitably involve the use of tilting trains to attain such speeds), new technologies or purpose built new high speed conventional railways.

The British strategy back in the 1980s was to upgrade existing lines and introduce tilting trains (the Advanced Passenger Train) However, whilst a prototype did reach 245 km ph., the project encountered both technical problems and changing economic conditions, and was abandoned. Whilst other countries (including Sweden and Italy) persevered with tilting technology, and such trains are now in service in many countries including Britain, they do not normally run at speeds above 200 km p h. Their rationale is to upgrade services at relatively low cost in countries which have sufficient capacity to cope with increased divergence of speeds on routes shared with all forms of traffic.

The only form of totally new technology that has come close to being implemented is maglev. However, no country yet uses such a system for inter city transport. It was proposed to introduce such a system between Hamburg and Berlin, but this project has been abandoned; it is still under discussion for the Tokyo-Nagoya route in Japan. The technology is capable of very high speeds, but apart from cost considerations, it has the inflexibility that the trains are not able to make use of a section of new infrastructure and then to transfer to existing tracks to finish their journey. The latter mode of operation is a feature of all new high speed rail systems worldwide, even where – as in Japan and Spain – the New Lines are built to a different track gauge from the existing lines (Spain uses bogies capable of adjustment to the different gauge, whilst Japan has undertaken installation of limited sections of multi gauge track). Maglev technology has its greatest chance where there is sufficient traffic to justify both a new self contained route and the existing one, and the most likely corridor to satisfy that requirement in the near future is the Tokaido corridor in Japan.

Thus the only high speed inter city projects to have been completed to date use conventional rail technology. That is therefore the focus of this review.

2. Motivation for the introduction of high speed rail.

The first country in the world to build a dedicated line for new high speed trains (originally at 210 km p h, so just satisfying the above criterion) was Japan. The background to this was that the original Tokaido line was narrow gauge (3 feet 6 inches) and unsuitable for high speeds. It was also at capacity. It was the twin desire for a big increase in capacity in one of the most densely used corridors in the world, and for a major improvement in journey time to be competitive with air that led to the approval of the construction of a new high speed line at standard gauge. The Tokaido Shinkansen started running between Tokyo and Osaka on October 1, 1964, and was an immediate success, carrying 23m passengers in its first year and leading to demands for its extension countrywide (Matsuda, in Whitelegg et al 1993). Wider economic considerations such as regional development and equality led to the development of Shinkansen investment on progressively less busy and profitable routes. When Japanese railways were reorganised as a set of separate regional commercial organisations in 1987, the high speed infrastructure was placed in a separate holding company (the Shinkansen holding company) and the new operating companies were charged for its use on the basis of ability to pay, thus permitting cross subsidy between profitable and unprofitable routes. (Ishikawaka and Imashiro, 1998). Whilst this decision was later reversed and the Shinkansen sold to the operating companies in order that it should appear on their balance sheets, the principle of basing the charge on ability to pay rather than historic construction cost was maintained.

The success of the Japanese high speed system, particularly in gaining market share from air, was undoubtedly a major factor inspiring European railways to follow the same path. The next in line was France, where intensive economic and technical research led to the proposal to build a new high speed line from Paris to Lyons. Again the background was a shortage of capacity on the route in question plus the growing threat of competition from air (Beltran, in Whitelegg et al 1993). In 1981 the TGV Sud-Est between Paris and Lyon opened with speeds up to 270km/h. The name Sud-Est was itself designed to emphasise the network effects of this line, which as well as serving the Paris-Lyons market carried trains for a large number of destinations beyond Lyons. From this beginning plans were developed for a network of lines, linked by the interconnection line in Paris, with the justification being largely in transport cost-benefit analysis terms although hopes were also raised for wide regional economic impacts (Polino, in Whitelegg et al 1993). The idea that high speed trains should be open to everyone, at reasonable fares (democratisation of speed) was an important part of the philosophy and helped the popularity of TGV with the general public. Subsequent developments have seen extensions to Marseille and Nice, the TGV Atlantique Paris-Bordeaux, Paris-Lille-London/Brussels and most recently Paris-Strasbourg.

The background to the introduction of high speed rail in Germany was somewhat similar; a perceived shortage of capacity in the face of growing demand, accentuated by particular bottlenecks on north-south routes which became more important following partition. Again the growing threat of air and car competition also led to a perceived need for high speed to satisfy the marketing requirement of ‘twice as fast as car; half as fast as plane’. (Aberle, in Whitelegg et al 1993). However, the geography of Germany did not lend itself to development of a single key route, but rather of new sections of track where particular bottlenecks occurred. These were designed for both freight and passenger traffic, although their use by freight has been small. Although construction started in 1973, it was held up by environmental protests. Not until 1985 was a new design of high speed train (the ICE) introduced. Gradually these trains were extended to cover the principal inter city routes throughout Germany, with long stretches of running on conventional track upgraded for 200 km p h. Thus the marketing of the ICE is very different from that of the French TGV; a lot of shorter journeys are made on it, reservations are not compulsory and load factors averaging 50% as opposed to the French 70% are tolerated.

The geography in Spain is more like that of France, with long distances between the major cities and even less intermediate population. Given the relatively low quality of the inherited infrastructure, Spanish Railways were rapidly losing market share to air and car. High speed was seen as a way of enabling rail to compete, as well as promoting regional economic development (Gomez-Mendosa, in Whitelegg et al 1993). Whilst construction of the first line, Madrid-Seville, was hastened to serve the International Exhibition in Seville in 1992, construction of a whole network of lines was encouraged by Keynesian policies of relieving large scale unemployment by a major public works programme. The aim is to link Seville—Madrid—Barcelona to the French TGV system, and for that reason the network is being built to standard gauge even though other main lines on the Iberian peninsula are broad gauge.

Italy had already taken its first steps towards construction of dedicated high speed lines with the Rome-Florence Direttissima, work on which started in 1966 and the first section of which opened in 1976(Giuntini, in Whitelegg et al 1993) but it was not until 1985 that a team was set up explicitly to study high speed rail, leading ultimately to plans for a network of lines.

In 1986, high speed trains accounted for 9.4 billion passenger kilometres, increasing to 42.3 billion in 1997 (Wilken, 2000). However, high speed rail remained dominated by France, where almost two-thirds of all high speed passenger kilometres are found. The concept of a 15,000 km network of high speed routes emerged, linking all the major cities of Europe (CER, 1989). The High Level Group of the Commission of the European Communities (CEC, 1990) proposed an extensive high speed rail network. The 1993 Treaty of Maastricht called for a network of Trans-European lines, linking the existing high speed lines. Of major strategic importance are the new line between Brussels and Cologne, the extension of TGV Sud-Est to the Spanish border, the planned Alpine crossing between Lyon and Turin and links between the French and German networks. Existing and planned routes are outlined by Walrave (1993). Recognition that such lines would benefit not just the countries in which they were built but the European Union more generally led to their designation as part of the Trans European Network, and a large share of the limited European funds made available for transport infrastructure has been directed towards them. Peripheral countries have also received substantial funding for high speed rail from regional and cohesion funds, designed to reduce economic and social inequality within Europe. In the meantime, high speed rail has been extended to more countries in Asia, including Korea, Taiwan and China.

3. Impact of High Speed Rail

This section will briefly consider impacts on rail market share, standard transport benefits, environmental benefits and wider economic impact.

Detailed results are available for the early impact on mode split of the Paris-Lyon and Madrid- Seville lines. TGV Sud-Est between Paris and Lyon was opened in two stages between 1981 and 1983. The train journey time was first reduced by around 30%, after the opening of the Northern section, and the implied journey time elasticity was around –1.6. However, the time elasticity was around –1.1 for a journey time reduction of around 25% on the opening of the Southern section of the route. The cause of this lower elasticity was because the transfer from air had been largely completed in the first phase when rail was fast enough to provide effective competition. The Spanish AVE service introduced in April 1992 reduced rail journey times between Madrid and Seville from around 6½ hours to 2½ hours, making what was a very unattractive service into one which competes effectively with air.

Table 1 indicates the market shares of plane, train and road before and after the introduction of high speed rail on these two routes. The impact on rail market share is very large, particularly in Spain where the improvement in rail journey time was larger. Much more traffic is extracted from air than road. It should be noted that the figures for TGV Sud-Est will have been influenced by a significant amount of newly generated traffic. Wilken (2000) reports that surveys of AVE passengers indicated that 15% of the additional rail traffic was newly generated. For this reason, the market share figures should be interpreted with some caution.

Table 1: Before and After High Speed Market Shares

	TGV Sud-Est		AVE Madrid-Seville	
	Before	After	Before	After
Plane	31%	7%	40%	13%
Train	40%	72%	16%	51%
Car and Bus	29%	21%	44%	36%

Source: COST318 (1996).

More up-to-date figures are quoted by SDG (2006) for the air-rail mode split, showing that where rail journey times are reduced below 4 hours, rail share of the rail-air market increases rapidly with further journey time reductions, and rail tends to have a market share of at least 70% and sometimes effectively drives air out of the market when rail journey times are below three hours. Future trends are found to depend on a wide variety of factors including the introduction of environmental charges on air transport and trends in air and rail costs.

The method of financing high speed rail can also be significant in determining the outcome. UIC (2008) find that the access charges levied on train operators vary substantially, but absorb between 25 and 45% of the revenue of high speed rail operators. As such, they significantly affect the competitive position of rail as opposed to other modes. Adler, Pels and Nash (2008) find that a number of Trans European Network corridors can justify high speed rail in cost benefit terms, with operators able to run profitable services on a marginal cost basis, but that high track access charges will preclude profitable operation.

Kroes (2000) points out that the available evidence concerning modal shift relates to traffic that is not transferring at the airport to another plane. There is very little evidence on the transfer market. However, we can expect that there has been very little actual use of high speed rail amongst transfer passengers since there is currently very little integration between rail and air operators and hence the cost disadvantage of using a high speed rail link to a hub airport rather than a feeder air service will effectively rule out its use.

There are relatively few published cost-benefit analyses of specific high speed rail projects, although a variety of studies have suggested that of the order of 9-15m passengers per annum are needed for high speed rail to be worthwhile economically (e.g. de Rus and Nash, 2007). Thus it is not surprising that one of the few published studies, for Madrid-Seville, which opened with 5m trips p.a., was not found to be justified. However, the breakeven rail volume will depend on factors such as construction costs, which are found to vary widely between countries (SDG, 2004). Also these studies largely consider circumstances where the need for new capacity, network effects and wider economic impacts are considered unimportant.

It is generally accepted that reducing transport costs may lead to benefits or costs that are not reflected in a standard cost-benefit analysis, due to market imperfections such as uncompetitive labour markets or agglomeration externalities, but generally these have been thought to be small. SACTRA (1999) suggested that wider economic benefits of schemes would not generally exceed 10-20% of measured benefits, whilst a specific study of the TENS network suggested that it would not change regional GDP by more than 2% (Brocker, 2004). On the other hand there may be specific cases where effects are much larger. The impact of HSR on Lille (with its uniquely favourable location) is often cited, whilst a study of a proposed high speed route in the Netherlands found wider economic benefits to add 40% to direct benefits. (Oosterhaven and Elhorst, 2003). Vickerman (2006) concludes that whilst high speed rail may have major wider economic benefits, the impact varies greatly from case to case and is difficult to predict.

Finally, the environmental impact of high speed rail is also controversial. Many comparisons make simple assumptions concerning diversion between modes and load factors. The primary fuel used to generate electricity is also important. When we allow for diversion of some traffic from existing rail routes and generated traffic, as well as traffic diverted from road and air, it appears that even at high load factors such as the 70% quoted for the French TGV and for Eurostar, the benefit of high speed rail in reducing carbon emissions is somewhat marginal, but only at much lower load factors will it be positively harmful (de Rus and Nash 2007). Similarly high speed rail infrastructure will impose land take, visual intrusion, severance and noise to set against any benefits from relieving these effects on other modes.

4. Lessons for Britain

The major lessons for Britain from international experience seem to be the following:

- most successful applications of high speed rail seem to arise when there is both a need for more capacity and a commercial need for higher speeds. It seems difficult to justify building a new line solely for purposes of increased speed unless traffic volumes are very large, but when a new line is to be built, the marginal cost of higher speed may be justified; conversely the benefits of higher speed may help to make the case for more capacity.

-it follows from the above that appraisal of HSR will need to include assessment of the released capacity benefits for freight, local and regional passenger services and the changes in service levels on the conventional lines

-relief of airport capacity through transfer of domestic legs from air to rail is potentially important given indivisibilities and costs, including environmental impact, of airport expansion

- it is important to consider network effects; the benefits of a high speed line may be maximised by locating it where it may carry traffic to a wide number of destinations using existing tracks. Obviously this implies technical compatibility.

- high speed rail is more successful at competing with air than car, and there is evidence for the widely quoted 3 hour rail journey time threshold (although this evidence predates the increased security and congestion at airports which is believed to have increased this threshold). Targeting air markets where rail journey times can be brought close to or below 3 hours therefore does make sense.

- environmental benefits are unlikely to be a large part of the case for high speed rail when all relevant factors are considered, but nor are they a strong argument against it provided that high load factors can be achieved and the infrastructure itself can be accommodated without excessive damage.

- the issue of wider economic benefits remains one of the hardest to tackle; such benefits could be significant, but vary significantly from case to case, so an in depth study of each case by experts is required.

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