



REINVENTING THE WHEEL - PLANNING THE RAIL NETWORK TO MEET MOBILITY NEEDS OF THE 21ST CENTURY

**Moshe Givoni and David Banister
Transport Studies Unit
University of Oxford**

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Reinventing the wheel - planning the rail network to meet mobility needs of the 21st century

Moshe Givoni and David Banister*

Transport Studies Unit
University of Oxford
South Parks Road
Oxford, OX1 3QY, UK

1. Introduction

The sustainable mobility agenda (Banister, 2008) places a key role on the railways, as this mode provides an efficient form of transport and it encourages a modal switch. With the overriding policy concern about the environmental agenda, rail is considered to have an advantage over other modes of transport (on long distance, inter-city journeys), and promotion of rail transport has become an important element in achieving a (more) sustainable transport system. Indeed, rail is experiencing a renaissance, not only in terms of its appeal to policy makers and transport planners, but more important, in terms of its appeal to travellers. Demand for rail travel is now at record levels.

The above argument might suggest the way forward, namely further promotion of rail transport through pro-rail policies and investments in the rail network. But there are also major challenges facing rail transport as a mode for passenger transport. The car is still dominant for many shorter trips, and it seems to provide a more attractive option for travellers on most journeys. And over longer distances the growth in low cost air travel means that rail is now having to compete much more effectively with these alternatives. Yet, as can be seen in Table 1, the demand for rail is still increasing despite the growth in the popularity of the alternatives, and this reflects the general growth in travel distances.

If the success of the railways and development of the rail network, especially the HST network, simply leads to increased mobility, to increase in trip distances (especially commuting trips) and further sprawl of cities, then promoting rail transport can be counterproductive for sustainable transport. Technological innovation and social change have also had a major impact on travel demand, social activities and the ways in which people view the world. These new possibilities also present the railways with opportunities and challenges, and transport policy makers with a real dilemma - how should the railway take a larger share of the current demand for transport without inducing new demand.

This chapter aims to discuss some of the different aspects of the challenges and opportunities facing rail transport as well as the implications these have for transport

* Corresponding author. Email: moshe.givoni@ouce.ox.ac.uk

policy in the pursuit of sustainability. The basic argument here is that if the railways are to really play a major role in meeting the mobility needs in the 21st century and if it is to really contribute to sustainability, it is not enough to simply expand the rail network and facilitate demand for more travel. Rather, a different type of rail system is required, namely one that accommodates more of the existing levels of demand - the wheel needs to be reinvented.

This chapter briefly reviews trends over the last 35 years of passenger rail travel in the EU, and it then raises a series of issues for discussion. The heavy investment in HST has helped the rail renaissance, but it has also encouraged longer and faster journeys that in turn may not lead to a more sustainable transport system. The sustainability of rail travel is also questioned, particularly if most investment is in speed. From an environmental perspective, it is argued that the railways are not green, but probably greener than other modes. Comments are made on the difficult issue of travel time and travel time savings, as well as the notion that travel time is wasted time. Arguments are put forward for better integration between rail and other services so that the total journey is considered, not just the main part of it. This explores the potential for rail stations playing a much more prominent role as places (or nodes) on the network and the need for better access to stations. Finally, the benefits of rail travel are contrasted with the income levels of the users of rail services, and whether investment in rail reduces or increases the equity of the transport system. A synthesis of the above issues, at the end of the chapter, provides some guidelines for a sustainable development of the rail network.

2. Passenger rail use over time

Passenger travel by rail, at least in Europe, is on the rise. Some refer to recent years as the second railway age (Banister and Hall, 1993). In the UK the number of rail passenger-km is at its peak, over 48 billion passenger-km in 2007, the highest ever for the UK (Figure 1). In Europe, demand for rail transport has increased in recent years, although it is not yet close to its past peak (Table 1).

Table 1: European Rail 1970-2006 (1000 mio pkm)

	1970	1980	1990	1995	2000	2001	2002	2003	2004	2005	2006
EU27	326.4	366.0	400.7	347.7	368.3	369.4	362.2	358.4	363.5	373.8	384.0
EU15	220.2	246.9	268.9	273.3	306.9	310.7	308.4	306.5	312.8	324.5	334.2
EU12	106.2	119.1	131.8	74.4	61.4	58.7	53.8	51.9	50.7	49.3	49.9

EU15: Countries joining the EU up to 1995. EU12: Countries joining the EU between 1995 and 2007;

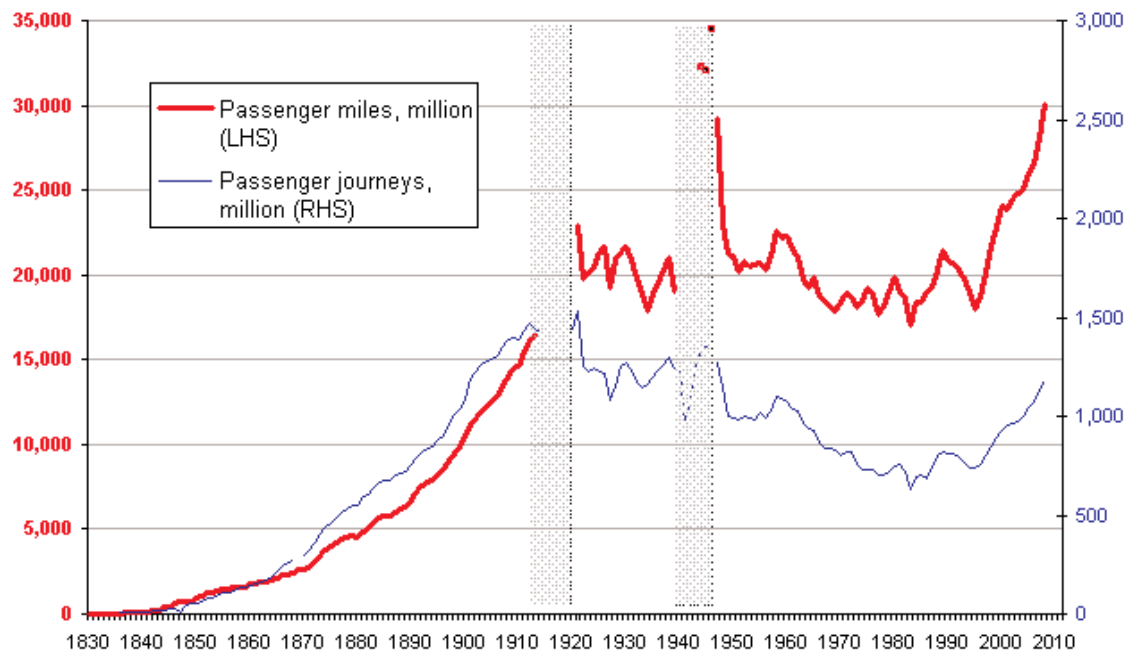
EU 27: current members of the EU

Source: DGTREN (2008).

The key message from Table 1 is the very different patterns of growth in the EU countries joining up to 1995 (EU15), as compared with the substantial decline in the new EU countries (EU12). Over the last 36 years, there has been a uniform growth across all EU15 countries (apart from Greece), reflecting low levels of rail use in the 1970s, and the probability of an increase in travel distances since that time (there is evidence for this in the UK in last 10 or so years, represented in the growing gap between the two curves in Figure 1). The greatest growth in passenger rail use has been in Ireland (+217%) from a low base level, but many of the major EU15 countries

have shown dramatic increases in passenger kms travelled, including France (+92%), the Netherlands (+84%) and Sweden (+109%). There is also a group of countries where the increase has been over 50% (Denmark, Finland, Spain and the UK).

Figure 1: Development of Passenger Rail in the UK (1830-2007)



Source: ATOC (2008).

A completely different picture is given with the new EU12 countries, where the decline in rail use has been of a similar magnitude. Estonia (-75%), Latvia (-73%) and Lithuania (-81%) have recorded the highest falls in passenger rail use, but most of the other countries have seen levels reduced by more than 50% over the 36 year period – Slovak Republic -66%, Romania -55%, Poland -51% and Bulgaria -61%. The Czech Republic has had a 48% reduction over a shorter period (1990-2006), and even Hungary and Slovenia have reported a 41% and a 43% reduction respectively.

The explanation for these two very different, yet internally consistent patterns, is difficult. It might relate to investment in rail services, the quality and frequency of services offered, the growth in car ownership, levels of expendable income, and the location of rail services with respect to the population (i.e. rail proximity). One possible explanation can be interpreted from the graph of rail passenger journeys in the UK (Figure 1). Here it can be seen that there has been a steady decline in rail passenger journeys and passenger-km made over the period 1945-1980 (about 35 years). The low point just after 1980 is about 50% of the peak figure in 1945 for the number of journeys. But since that time, most of the loss in passenger journeys has been regained in the period 1980-2006 (26 years), and all the loss in passenger-km has been more than regained. The EU15 countries could all be located on this second part of the curve, whilst the EU12 countries are still in the earlier phase of declining use of rail by passengers. There is a clear policy message here for the EU12 countries, and an opportunity to revive rail use, and this chapter now discusses these possibilities in more detail.

The relative weight given to the railways in transport policy, especially European (CEC, 2001) and in countries like the UK (DfT, 2007b) and the constant increase in rail use in recent decades might give the impression that this is the main passenger mode of transport, but this is not the case. The railways, still, play a relatively small role in meeting overall demand for transport, although they do play a key role on some specific markets and corridors. This is evident in Table 2, where the rail share in the overall transport of people has remained relatively stable between 1995 and 2006, at just above 6% of passenger-km, smaller than the role bus and coach play in European passenger transport.

Furthermore, despite the growth in rail use, especially since the 90's, their share of passenger transport is in decline. While rail transport is not a substitute for many of the journeys by car and bus, and certainly not an alternative to journeys by sea, it is clear from Table 2 that some of the reduction in rail's share can be attributed to the increased use of air transport. For many journeys these two modes are substitutes. In comparison to the US, the European railways are doing well. In the US, rail transport carried only 0.5% of the passenger km in 2004 (the figure also includes light and commuter rail), the same as in 1990 (DGTREN, 2008). The differences from Europe are attributed mainly to the dominance of freight transport on the US rail network compared to that of passenger transport in Europe.

Table 2: The Position of Rail in Overall Travel in the EU27

	Passenger Cars	Powered Two-wheelers	Bus & Coach	Railway	Tram & Metro	Air	Sea	Total
	1000 mio passenger-km							
2006	4,602	154	523	384	84	547	40	6,333
2000	4,283	136	514	368	77	456	42	5,876
1995	3,855	123	501	348	71	335	44	5,277
	Modal split %							
2006	72.7	2.4	8.3	6.1	1.3	8.6	0.6	100
2000	72.9	2.3	8.8	6.3	1.3	7.8	0.7	100
1995	73.0	2.3	9.5	6.6	1.3	6.3	0.8	100

Source: DGTREN (2008).

The main factors contributing to the observed increase in rail use in Europe can be associated with the development of the HST, road congestion and (rail) regulatory reforms, which result in introducing competition for the provision of rail services and changes to the way the industry is operated and managed. The above factors are likely to continue to influence demand for rail transport, and together with continued economic growth (which is likely to lead to further growth in demand for transport) rail use can be expected to increase. It is not clear, however, whether rail transport, in Europe and elsewhere, can at the same time increase its share across all modes of transport. From a sustainable transport perspective this is the real important question and what transport policy should aim to increase – railways' share rather than railways' use.

3. The High-Speed Train (HST)

The 'comeback' of the railways is very often attributed to the development of the HST. Although rapidly growing, the HST still does not account for the majority of rail travel across the EU, only 23% of the EU27 passenger-km in 2006¹. However in some countries, much of the growth in rail travel has taken place in HST. In France, HST services in 2006 accounted for 57.1% of all rail passenger-km. The figures for Spain, Germany and Sweden are 38.3%, 27.4% and 25.9% respectively. In Italy the figure is slightly lower at 19.2% and in Belgium it is now 10.4% (DGTREN, 2008).

The main reason for the development of the HST was the need to increase capacity through higher speeds, and not to reduce travel (Givoni, 2006). Nevertheless, the reduction in travel time the HST offers is certainly a major contributor to the increase in rail use. This increase can be attributed to shift of demand from other modes, as rail becomes more competitive, or simply an increase in demand for transport – whether it is the former or the latter has important implications for sustainable transport.

In many respects HST can be considered as an ideal mode of transport for long-distance land journeys of up to 1000km. It is fast and (relatively) environmental friendly and thus can offer improved accessibility at lower environmental cost. In addition, the development of the HST can lead to further effects such as economic development around railway stations, although the evidence on this are not conclusive and mainly point for the need for other conditions to be met for the HST to contribute to (local) economic growth (Banister and Berechman, 2000).

The two main benefits HST services can provide, reduction in journey time and (as a result) higher accessibility (which might lead to economic development), can result in undesirable effects – longer journeys and lower accessibility, as explained below.

There is growing evidence that average daily travel time budget is constant across the population (Metz, 2008). The implication of this is that as the speed of services increases, and travel time cut, travellers do not necessarily use the saved time for activities other than travel, but instead choose to carry out their activities further away. Thus, the introduction of HST services can lead to more travel. There are suggestions, for example, that the use of tele-working might reduce the number of commuting trips, but those which are still taken are much longer, resulting in overall increase in travel (Mokhtarian et al., 2004). Thus, HST can encourage infrequent commuting from places further away from the workplace and in general longer commute. Furthermore, there is evidence that the introduction of HST services, and better and faster service, results in the generation of new demand (Givoni, 2006). The introduction of HST services might be counterproductive to sustainable transport, even when it promotes rail use.

An important element in achieving a substantial reduction in travel time by HST services is the spreading of stops at hundreds of km intervals, since a HST service running with frequent stops would not achieve a high average speed (and shorter travel time). This results in many cities and regions being bypassed by the HST. For these areas, the HST is not different from an aircraft, and the inauguration of HST services will not change the level of accessibility. More to the contrary, since the HST

¹ 89.9m passenger-km in 2006, up from 58.8 (16% of rail passenger-km) in 2000 and only 15.2m passenger-km in 1990 (DGTREN, 2008).

often replaces or supplements an existing conventional railway service, these bypassed cities along the HST line will see substantial reduction in rail services because they will lose the through traffic to the HST and local demand would not support the same level of service. In turn, this reduction in rail accessibility can contribute to economic decline.

Another reason the HST is promoted by policy makers is its ability to compete with, and thus substitute, the aircraft (CEC, 2001). Such a modal shift is expected to reduce environmental impact from transport operation. Comparison of HST and aircraft operation impact on the environment confirms that substituting an aircraft seat with a HST seat will result in environmental gains (Givoni, 2007). However, this advantage of the HST does not necessarily translate to environmental gains in practice. Givoni and Banister (2006) found that the introduction of HST services between London and Paris did not result in a substantial reduction of the number of flights on the route. Since a route like London-Paris is essential for carriers like British Airways and Air-France for their Hub and Spoke operation, and in their competition against each other, they continue to offer a very high frequency service on this route (in the order of 60 daily flights one-way between the cities) even when the HST operator captured over 70% of the market, and when evidence suggest that such a route is not profitable for the airlines.

Cooperation between air and HST can take place if the airport is situated on the rail and HST networks² allowing airlines to retain connecting traffic from short haul routes to their more profitable long-haul services, thus giving up flights without compromising their Hub and Spoke operation. This is the case in airports like Frankfurt, CDG and Schiphol where the above conditions exist.

For the HST to reduce air transport impact on the environment two conditions must be met. First, the HST service must be integrated with other aircraft services provided by the airline and thus it must complement it rather than compete with it. Second, the airline (or airport) should not use the freed runway slots for other flights. With the development of the HST network and successful integration of air and rail services (for example at CDG) the first condition is now being met at a number of airports. However, given current levels of demand for air transport services and the lack of runway capacity to meet it, it is unlikely that the second condition is met. This would require some form of demand management policies to be introduced at airports.

The HST have been very successful in competing with the 'traditional' airlines, especially on routes between major cities like the London-Paris and Paris-Brussels, leading to the removal of flights on the latter. However, the growth in low-cost carriers (LCC) operation in Europe has brought new forms of competition that has proved more problematical for HST to compete or cooperate with. The different characteristics of HST and LCC services, including the price advantage of the latter, reduce the level of mode substitution. The lower fares offered by LCCs might be more than compensated for by the cost of accessing the airports from which the LCCs operate (usually small airports far from the centre of the main cities, where the HST

² Equally important is that the airport railway station be easily accessed from the aircraft gates and the transfer between the modes will be facilitated by, for example, hand-free transfer of baggage, through ticketing, coordinated time-table, etc. (see Givoni and Banister, 2007).

stations are located), but it is not clear to what degree passengers account for these costs when choosing their mode of transport.

In the UK, the development of a HST network (along the main four rail corridors) is again on the agenda (Greengauge21, <http://www.greengauge21.net>) although there are no concrete plans for its construction (DfT, 2007b). The debate on the future of HST in the UK highlights all the advantages of the HST mentioned above - namely faster travel time, increased accessibility, economic development, mode substitution and environmental benefits – while the shortcomings mentioned above are ignored. In the context of sustainable transport, which is central to UK Government transport policy, the risk that a HST network would lead to more travel is apparent. There is a risk that such network would bring London and Manchester within commuting distance of each other. The risk of lower accessibility to cities and regions not on the network is apparent. Furthermore, current plans do not put Heathrow airport as a central point on the HST network. This limits the possibility for mode substitution and the potential benefits from HST. To some extent the above argument also applies to further development of the European HST network and the introduction of HST in other parts of the world, most notably China and Korea.

The implications of the above are that the development the HST must be carefully considered to ensure the benefits are fully realised, and the possibility for adverse effects are limited. Integration between the HST network and the conventional rail network seems crucial, as only this will ensure the accessibility benefits from HST services are spread across the entire rail network. For this, the location of the HST stations must consider the entire rail network and not only local demand from cities. In addition, the HST stations must be designed to a relatively seamless transfer between HST services and other rail (or air) services.

4. Are railways green or just greener?

Rail transport is generally considered as being green, and this is its main appeal for policy makers. However, it is hard to see how rail transport can be regarded as ‘green’ if its energy is sourced from diesel fuel or electricity which is generated mainly by coal, oil and natural gas. It can be regarded as ‘green’ if it uses electricity generated by renewable sources or nuclear power, but with a few exceptions (notably France) this is not the case. Yet, there is evidence that rail transport is more energy efficient than other modes of transport used for long-distance travel and thus can at least be regarded as ‘greener’. Whether green or just greener, different types of trains and different types of rail services will have substantially different environmental impact and these differences must be recognised to minimise rail transport impact on the environment and maximise the environmental benefits from mode substitution, namely road and air transport.

Rail transport impact on climate change is mainly affected by the sources of energy used to power the train. Two main categories can be identified, diesel and electric traction. The contribution of the latter to CO₂ emissions and climate change depends on the mix of sources used to generate the electricity. In the UK, electricity is currently (2006) mainly generated using natural gas (39%), coal (34%), nuclear power (20%), renewable sources (e.g. wind, 5%) and others (2%), and this mix results in

CO₂ intensity of the electricity of 554 g/kWh (DTI, 2007). In 2020, with the implementation of policies described in the UK Energy White Paper (DTI, 2007) it is expected that CO₂ intensity of the electricity will fall to 415 g/kWh, a 25% reduction. This reduction is associated mainly with a 10% reduction in the share of coal in the electricity generation mix, a 4% increase in the use of natural gas and a 4% increase in the share of renewable energy to generate electricity.

Considering current electricity generation mix in the UK, electric train operation results in 54 gCO₂/passenger-km compared with 69 gCO₂/passenger-km for diesel trains, a difference of more than 20%. The differences are not associated with differences in the load factor for each type of train as these were similar (Givoni et al., 2009). However, when accounting for the cost of completing the electrification of the UK rail network (estimated at between £550K and £650K per single track km - The Railway Forum, 2008) it does not appear to be cost-effective considering the CO₂ reduction this can bring (at more than £3,000 per tonne of CO₂ saved and including future years). Other options might prove to be cost-effective, including running fewer diesel trains under existing electrified sections, small scale electrification to allow connection of existing electrified routes, and selective electrification of additional routes.

Another important difference between the impact of diesel and electric train operation on the environment is their contribution to local air pollution (LAP). Electric trains have virtually zero impact on LAP at point of use (i.e. alongside the rail network) unlike the operation of diesel trains which results in emission of sulphur dioxide, particulate matter, nitrogen oxides and ozone. This difference is especially important in highly populated urban areas. LAP also occurs at point of electricity generation, but this is usually away from densely populated areas resulting in a relatively low impact. Thus electric trains can be said to have an advantage on diesel trains in terms of both climate change and LAP impacts.

Trains are usually high-capacity vehicles with about 100 to 400 seats. HST will have even higher capacity, as the Eurostar trains operating between the UK and Europe have a capacity of over 750 seats, and some Japanese HSTs can accommodate 1000 seats. The energy efficiency and environmental impact of trains depends very much on the load factor or occupancy rate. In the UK it is assumed that the average occupancy rate is 40% for intercity trains and 30% for other services. Thus, there is a potential for improving the environmental performance of rail, when considered in passenger-km terms and especially when compared to other modes, by increasing the average load factor. Most airlines would achieve an average load factor of 70% while some LCC can achieve 80%, to a large extent filling seats through the creative use of the pricing mechanism. Rail can follow such practices and it is important to balance demand between peak and off-peak travel, as well as aiming to balance demand between the two directions of travel on a specific routes (Rietveld, 2002). This imbalance in the demand for rail transport can result in a marginal environmental burden during the peak that is much higher than is usually thought, whereas it is almost zero at the off-peak period, due to need to add services when demand increase at the peak, while it can be accommodated on existing capacity during off-peak (Rietveld, 2002).

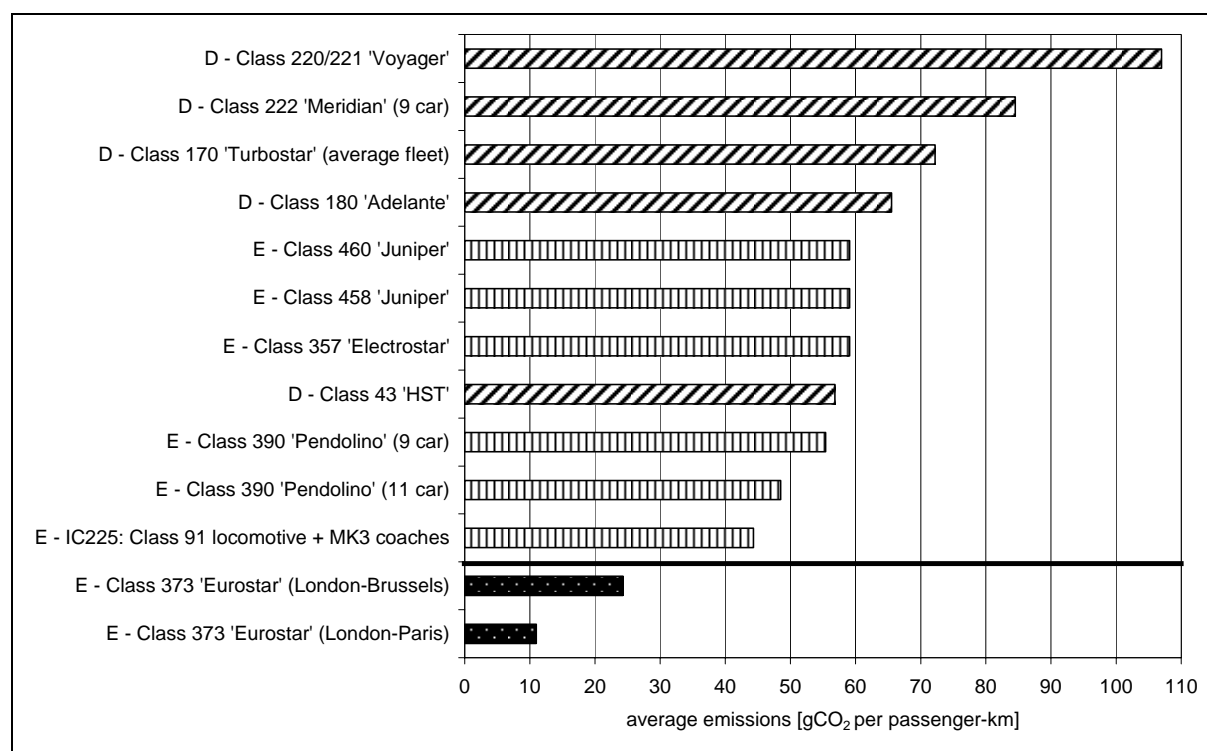
Operational characteristics of the rail service are also important in determining the environmental impact of rail transport. It is expected that energy consumption and therefore environmental impact will increase with speed, yet this is partly offset in the case of HST by aerodynamic design. More important, is the number of stops along the route, whether at stations or at junctions, as the acceleration requires more energy which is not compensated for when slowing down. The spacing of intermediate stops along the route is probably the one factor affecting energy consumption that operators have most control over. Here a trade off between exploiting commercial opportunities, picking up more passengers by stopping at more stations, and fuel and energy savings must be struck. However, increasing the number of stops also has commercial penalties as more stops increase travel time for passengers, making the railways a less attractive option (Givoni et al., 2009).

Figure 2 illustrates the above by showing how different the CO₂ emission levels per passenger-km can be for different types of trains operating on the UK rail network. In determining emission levels, it appears that route characteristics, and especially the number of stops on the route and the distance between them, are more important than the speed at which trains are running at. Figure 2 suggests that the faster trains are responsible for lower CO₂ emission levels per passenger-km³. Thus, although the faster Eurostar trains use more electricity per seat-km (in the region of 0.05 kWh/seat-km), the combination of higher load factors, aerodynamic design and lower CO₂ content of the electricity supplied on non-UK route segments (France, Belgium) yields significantly lower average emissions per passenger-km than other trains. Surprisingly, the most polluting (diesel) train in Figure 2 is probably the newest train, entered service after 2000. Its high level of emissions is hard to explain.

Naturally, the environmental aspects must be considered together with other considerations when developing and promoting rail transport. Yet, careful examination of the environmental impact of rail transport is important to provide a service that not only meets demand but also considers the most effective way to doing so from commercial and environmental perspectives. For example, countries in which large parts of the network are not electrified are advised to take measures to reduce emissions from diesel trains, electrify where the carbon content of electricity is low (e.g. France, Norway), and invest the money in carbon abatement options in other transport sectors and the wider economy (Givoni et al., 2009).

³ For example, maximum speeds of the Class 357 Electrostar, Class 390 Pendolino and Class 373 Eurostar trains are 161, 225 and 300 kph respectively. Class 43 HST (diesel) has a maximum speed of 201 kph.

Figure 2: Average Emissions of CO₂ for a Number of Typical UK Trains (in gCO₂/Passenger-Km)



Notes:

1. 'D' stands for diesel traction, also indicated by diagonal pattern; 'E' for electric traction, indicated by vertical pattern. 'Eurostar' figures indicated by black pattern with white dots.
2. The analysis assumes passenger load factors of 0.4 for UK intercity trains ('Adelante', 'HST', 'Pendolino', 'IC225') and 0.3 for other UK trains ('Voyager', 'Meridian', 'Turbostar', 'Electrostar', 'Juniper').
3. Class 373 'Eurostar' emissions values taken directly from Eurostar (2008).

Source: From Givoni et al. (2009) based on RSSB (2007), DfT (2007b), and Eurostar (2008).

5. Rail time – is it all wasted time?

The notion underlying transport planning is that travel time is wasted time and therefore any changes to the transport network which can reduce travel time are beneficial – to passengers and to the economy. Indeed, reduction of travel time is considered to be the main rationale for expanding the HST network and services, even if originally the HST was 'invented' to increase capacity rather than shorten travel time. However, this notion has been recently questioned. First, Mokhtarian and Salomon (2001) found evidence that, in some circumstances, travellers might not suffer any 'loss' from the need to travel. One of these circumstances is when travel time can be used effectively, or at least partly, to engage in other activities when travelling (e.g. read, rest). Rail travel offers such opportunities. Second, the evidence that the average daily travel time is constant over time (Metz, 2008) suggests that when travel time is cut on one journey, for example by a faster train service, travellers (in the long run) use this time to travel longer distances or make more journeys.

In Britain, the average trip time for rail (and including trips on the London Underground) is 71 minutes (Lyons et al., 2007) and this provides ample opportunities for passengers to 'use' travel time to do 'something worthwhile'. Table

3 (from Lyons et al., 2007: 110) clearly demonstrates this. There are many issues arising from the information presented on how rail passengers use travel time, but what is important here is that rail time is not necessarily a (complete) waste of time.

The possibility to use travel time effectively is very much enhanced in the ‘information age’ where developments in ICT release many activities from their ties to a specific location. The mobile phone and laptop computer are probably the most notable examples. Although most rail passengers (Table 3) do not engage in activities requiring the use of ICT, the possibility to use it is still important, and might influence mode choice (many of the passengers surveyed noted that they have brought ‘work’ with them for the trip but did not use it, the same with mobile phones - Lyons et al., 2007).

Table 3: Comparison, by Journey Purpose and Direction of Travel, of the Percent of Travellers Undertaking Activities for Some Time during the Train Journey and (shown in brackets) for Most of the Time

Activity	Journey purpose							
	All		Commute		Business		Leisure	
	Out	Return	Out	Return	Out	Return	Out	Return
Reading for leisure	53(33)	56(35)	62(42)	62(42)	43(22)	53(29)	46(27)	51(31)
Window gazing/people watching	56(18)	58(18)	49(12)	48(11)	51(12)	58(14)	66(27)	68(27)
Working/studying	26(13)	25(12)	27(13)	29(13)	55(35)	48(27)	13(6)	12(5)
Talking to other passengers	16(6)	14(5)	11(4)	10(3)	14(5)	11(4)	23(9)	21(8)
Sleeping/snoozing	13(3)	19(4)	16(5)	23(5)	11(2)	17(3)	9(1)	14(3)
Listening to music/radio	9(3)	9(3)	12(4)	13(5)	4(1)	5(1)	7(3)	6(2)
Not answered	1(11)	1(10)	1(9)	1(9)	1(10)	1(10)	1(12)	1(11)

Source: Lyons et al. (2007; 110).

If travel time can be used in some way, speed might not be so important anymore. In addition, there is increasing evidence that passengers put a lot of weight in valuing a service on travel time reliability. Passengers want to arrive on time! This time is the service advertised time, the time passengers planned to arrive at to the destination station. Many studies found that passengers will trade travel reduction with travel time certainty and that passengers place a value on the service reliability (Bates et al., 2001). However, the adverse effects of an unreliable service can nowadays be more easily mitigated by the use of ICT (e.g. mobile phones) allowing people to rearrange their schedule while on the move. Furthermore, Urry (2007) claims that development in ICT technologies, and specifically the development and widespread use of mobile phone (and text messaging) change our perception of time and made scheduling of activities more flexible. In this case, it might be that both speed and reliability are less important than they perceived to be.

Lyons and Urry (2005) suggests the following (p. 263):

“The boundaries between travel time and activity time are increasingly blurred. Specifically, many people are using travel time itself to undertake activities. The ‘cost’ to the individual of travel time is reduced as travel time is converted into activity time. In turn, less of the individual’s travel time budget is used, enabling more travel or encouraging greater use of modes that may enable en-route activities to be undertaken”

This has implications for the attractiveness of rail, as this time can be used for work, leisure and other networking activities. The key conclusions here are that travel time is not uniform in terms of its costs or of its potential value to the traveller, and provided that a sufficient level of comfort is provided and there is the necessary support available, then many activities can be undertaken. So travel is no longer only about speed – it is about comfort as well and providing the opportunity to use time (more) effectively. These positive attributes of rail travel need to be countered by the sustainable mobility dimensions that might indicate that there is an incentive to travel more and live even further away from work places and other activities.

Rail has potentially two advantages over other modes, as it can provide shorter travel time and as it provides an opportunity to use this time more effectively. Yet, these advantages might only lead to longer journey distances. In the context of increased congestion on the road network and slower car journeys, rail transport becomes relatively faster even without the expensive investments in increasing the train speed. It would be then logical to conclude that rail operators ought to make their services more comfortable, to reduce the disutility of travel time and improve the conditions that allow to use this time, rather than an overriding concern with higher speeds. This in turn would also probably make rail services more reliable, thus meeting all the passenger requirements, faster (than other modes), reliable and comfortable journey.

6. Railways in integrated transport - the dual role of stations

The increase in rail use, the development of the HST and the promotion of rail by policy makers marks a comeback for the railway station, which is recapturing its central position in the urban landscape. From a wider policy context of promoting rail transport, there are mainly two issues at play, which might prove difficult to reconcile. One of the roles of the station is as a node on the transport network and the other role is as a ‘place’ in the urban socio-economic landscape.

A railway journey is almost always part of a journey ‘chain’ that includes a journey to, and later from, the railway station by different modes of transport. The integration of these components is essential to achieve a continuous travel, door-to-door when using the rail, and in order to make the railway a viable and attractive alternative to the car. The accessibility of the railway station is crucial. Research show that improving access to railway stations can be one way to increase rail use⁴, and this

⁴ Based on the Dutch Railway customer satisfaction survey Brons and Rietveld (2009) show that the total quality score for a railway journey by a railway passenger in the Netherlands is determined 41% by the rail trip itself, 21% by the access and egress and 25% by the station experience.

option is relatively cheap and easy to implement in comparison with improvements to the actual rail journey (e.g. higher speed or frequency). Good access to railway stations requires the station to be designed for a relatively quick and seamless transfer between several different access modes and the train (Givoni and Rietveld, 2007; Brons et al., 2009).

Car parks at railway stations can be seen as one way to divert at least part of the journey from car use to rail use. But these could also encourage car use at the expense of other modes to get to the station, and car parks are expensive to build and hard to accommodate at city centre stations. Public transport accessibility to the stations is therefore crucial, but also these facilities needs to compete for the land in and the around the station, land that might be more profitable for other uses (see below). At large stations, even the need to accommodate parking facilities for bicycle is a challenge, as the Dutch experience reveals. Some Dutch railway stations have cycle parking facilities with a capacity of several thousand places.

Table 4 reflects current patterns of access to the UK rail network, giving high levels of access by walk (cycling is only a small part of that group). This suggests that for many journeys, the proximity of the rail station to the home or activity place is a key determinant of whether that service will be used, perhaps also indicating the importance of network density and rail catchment areas. In the Netherlands, cycling and walking are the main modes (together with public transport) used to access railway stations. At the home end station, access to and egress from the station is 38% by bicycle, 27% by public transport and 20% by walking. At the activity end station, almost half of the journeys (47%) to/from the station are by walking followed by public transport (35%). Bicycle is only used on 10% of the journeys to/from the station at the activity end (Givoni and Rietveld, 2007).

The data from the Netherlands highlight the role non-motorised modes can play in the accessibility of the rail network. The high share of walking at the activity end might is probably related to the success of the Dutch in concentrating commercial development and employment centres close to and around railway stations. Public transport can supplement non-motorised modes to reach the station from further apart, where the distances are too large for cycling. However, in promoting public transport use to railway stations to reduce car use, an adverse effect can be a decline in bicycle use, as happened in the Netherlands when free public transport was given to students (Givoni and Rietveld, 2007).

Table 4: Main mode used in the UK to travel to station of origin

	Percentage
Walk/cycle	55
Bus/coach	10
Car	20
Underground/light rail/metros/trams	15
Total	100

Notes: From the 2007 UK National Rail Travel Survey. The NRTS has about 436,000 records and the data have been expanded to represent approximately 2.7 million rail trips on an average weekday.

Source: DfT (2007a.).

The central place of railway stations in the urban landscape, very much due to their good accessibility (by rail and other modes) at the city, regional and often national and international levels (if HST services are provided), also makes them attractive for activities other than travelling. Most notably, the high accessibility of major railway stations makes them an attractive location for firms and businesses, and a very attractive employment centre. This attraction results in high demand for land and property close to rail stations, and this turn may lead to economic development (Pels and Rietveld, 2007). It marks an important opportunity for rail operation since the rail industry can capitalise on these, where it owns part of the land around the station and has building rights above it, and thus improve its financial viability. In the same way that major airports are profitable due their commercial activities, which are cross subsidizing their aviation activities and used as a resource to finance infrastructure expansion, railway stations can improve their financial viability and the service they provide. Yet, the increase in land values around stations can lead to a conflict (as in the case with airports) between the transport and non-transport role of railway stations. If land around the station is developed as a work place and most workers arrive by train to it, the incentive to provide good access (by public transport) to the station from different parts of the city is reduced, especially when access to the station is seen as outside the control and responsibility of the railways, and is provided by other operators.

While more stations might be desirable in one way, as they increase the accessibility to the rail network especially by reducing the distance to the station, making non-motorized modes more attractive, they are expensive to provide (especially in urban areas). Additional stations also increases travel time for some passengers, and this reduces the overall attractiveness of rail. Given the cost of rail infrastructure (including stations) and the time lead it requires, the key to improving the accessibility of the rail network and making rail travel more attractive is very much in providing better access to railway stations, and by a range of modes (including the private car). This can enhance both the role of the station as a node on the transport network and as a place. However, in this process conflicts between these two roles will have to be resolved.

7. Who is benefiting from a better rail transport?

Making rail travel more attractive can potentially have environmental and economic benefits, as illustrated above. The concept of sustainability, however, also includes a third dimension – the social aspect. This dimension, with respect to transport, focuses on accessibility, the possibility for everyone (without distinction of age, sex, race and income) to have reasonable access to a range of activities. Equity considerations are not an issue for rail operators, where rail services are run on a commercial basis, which is standard practice. For policy makers, rail operation presents a challenge in this respect. Equity issues with respect to rail operation arise mainly in relation to who uses rail transport, or more precisely who can afford rail transport, and where rail services should be provided.

Most rail travellers come from high income groups (Table 5), and the growth in the quality and speed of rail services has helped those travellers move further and faster. This presents decision makers with an interesting dilemma. Investment in high speed

rail may disproportionately benefit the higher income travellers, as they are the main users of rail services. Investment in local rail services and bus services may correspondingly help low income travellers. There are also important issues here relating to whether there is a subsidy for the service or whether the traveller pays the full costs of travel. Again there are distributional outcomes.

Table 5: Rail travel in the UK by household income

	Percentage
Below £7,000	7
£7,000 - £12,500	8
£12,501 - £17,500	9
£17,501 - £35,000	30
£35,501 - £50,000	23
£50,501 - £75,000	15
More than £75,700	9
Total	100

Notes: From the 2007 UK National Rail Travel Survey. The NRTS has about 436,000 records and the data have been expanded to represent approximately 2.7 million rail trips on an average weekday. The UK household median income is about £26,000 (2006).

Source: DfT (2007a).

On a spatial level, intuition might suggest to carry out investments in the rail network in areas where currently the level of rail service is relatively low and the access to it relatively poor – in the periphery. However, Brons et al., (2009) showed for the Netherlands that when the aim is to increase rail use investments should actually be directed towards areas where the level of service (in terms of the rail service and the access to it) is already relatively high and to the most populated areas – the urban centres⁵. The policy implication of this conclusion is that investment should not be directed towards improving the rail service at the periphery of the network but (further) improving it at its centre. In other words, investments in rail infrastructure must be very selective and targeted at the main urban agglomerations.

Conversely, those areas which are reached by the rail network, but where the level of rail service is relatively low (generally the peripheral parts of the network), it is more effective to improve the access to the station rather than the rail service itself. The Dutch rail network already covers most of the country, so improving the current level of service might be more important than further expanding the rail network. This would imply that in the peripheral areas of the Netherlands, transport services may be supplied by other modes than the rail and to increase accessibility from these areas to the rest of the country these modes would be used to provide better access to the existing railway stations on the network. The conflict between efficiency and equity is apparent here.

8. Synthesis – the role of the railway in sustainable transport

This chapter presents the main dilemmas with regard to developing passenger rail transport in a way that will contribute to sustainable transport. There are many opportunities for further increases in the use of rail transport, and more important, an

⁵ These two qualities, large population and high level of rail service, are of course highly correlated

opportunity for a real change in modal shift – where rail will carry a larger proportion of passenger travel. The chapter also provides a health warning and indicates the danger that some of the advantages of rail transport, and especially shorter travel times through faster service, could simply lead to increase demand for travel and to increase in the distance travelled. Thus promotion of rail transport might jeopardise the efforts to move towards a sustainable transport system. Another dimension of the dilemma faced by those promoting sustainable transport through better rail services, is that on environmental grounds all forms of rail travel may be better than long distance travel by car or by air (at least this is currently the situation in Britain), but rail travel is not good for the environment. Furthermore, rail (and especially long-distance high-speed services), are used mainly by very specific segments of the population (those on relatively high income). This conclusion also raises questions concerning the appropriateness of rail transport as a champion of sustainable transport. This is not to write off the railways role in sustainable transport, on the contrary, but to emphasize that for this role to meaningful promotion of and investment in rail transport must be carefully considered.

Returning to the questions raised at the beginning of this chapter, there is one key unresolved issue if rail is to contribute to the new sustainable mobility paradigm. The renaissance of rail seems to be well advanced, at least in the EU15 countries and similar trends will probably occur in the new EU12 countries over the next 10-20 years, but the growth rates are still lower than for all other modes (apart from bus and coach). The railways' modal share is gradually shrinking or at best being maintained while the travel market is continuing to expand. This expansion is unsustainable, particularly as that expansion is taking place in the most energy consumptive forms of transport. Rail is not making a contribution to taking a larger modal share, it is only making a modest contribution to taking on some of the growth in travel. For rail to make a real contribution to the sustainable transport system, it must capture a larger share of the journeys, and this means that people must switch to rail from other modes. This does not seem to be happening, except in the HST market, where there is some evidence of switching from air and car.

The main message emerging from this chapter is that unless the overall levels of travel are reduced and rail takes a much greater share of that market, there seems little opportunity for rail (in particular the HST) to contribute to sustainable mobility. Another important message relates to *Integration*. This can be seen as having two dimensions. First, since HST lines are only viable (from a socio-economic and environmental respects) on a relatively few routes, integration between the HST network and the conventional rail network must be achieved. This can take place by adopting a HST technology where the trains can also run on the conventional network (the TGV model) and by designing the HST stations to allow fast and seamless transfer between HST services and other (national and regional) services. The concept of short and long haul air travel networks which are integrated at the hub can be adopted for integrating HST services with other rail services. In air transport, the distinction between these two networks is conceptual without any noticeable differences at the airport. Second, the rail network (HST and conventional) needs to be fully integrated with the rest of the transport network. The air transport network on one side and the urban/local transport network on the other should work together. The main barrier for such integration is likely to be with respect to institutional barriers, and the very much uni-modal focus within the institutions governing transport

network development and operation. Since investment in rail infrastructure and changes to the physical structure of the rail network is expensive and requires a long lead time, investments might be better directed to the other elements of the rail journey, including those outside the train, but this depends on removing the institutional barriers mentioned above.

There is a segment of the population for which travel by rail is the first option (those passengers will often choose their work and living place next to a railway station) and there is also, a presumably large, segment of the population for which the car is the first option while the rail is not an option at all. For those two segments of the population, improvements in rail transport might not change much their travel behaviour and mode choice. A third, probably large, segment of the population use rail transport infrequently, and increasing the use of rail transport for this segment of the population is probably the main challenge to increasing the railways share in passenger transport.

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