Scope for reduction in transport CO$_2$ emissions by modal shift

Roger Kemp

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1 Objectives

The UK is committed to achieving an 80% reduction in CO₂ emissions, with reference to a 1990 baseline, by 2050. With the exception of industries covered by the emissions trading regime, there is no national strategy on the proportion of this reduction that will be made by each sector of the economy; however all sectors will find the targets very challenging and all will be expected to make deep cuts in emissions. Strategies have been postulated for cutting CO₂ from the domestic, commercial and industrial sectors but there is no plausible strategy for achieving a substantial reduction in emissions from the transport sector. One of the mechanisms frequently suggested for reducing emissions is modal shift from more polluting modes to less polluting modes – principally from road to rail. However, there has been no analysis of the scale of transfer that might be practicable and thus the reductions that would be made.

This preliminary study examines the UK transport sector and quantifies the scale of reductions that might be possible by modal shift in the period leading to 2050. It also attempts to quantify the order of magnitude of investment and the scale of technical challenge demanded by such a modal shift. It must be stressed that this is not a detailed investigation but an “order of magnitude” study to see what might be possible.

2 The present situation

The proportion of people and goods travelling by different transport modes is analysed in the Government’s annual report Transport Statistics, Great Britain. For this study, data from the version dated November 2008 have been used. The overall split for passenger transport is shown in Figure 1.

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1 http://www.dft.gov.uk/pgr/statistics/datatablespublications/modal/tsgbchapter1passrtrans1860.xls
This graph shows the challenge involved in achieving emissions reduction by modal shift – since the 1950s travel by car (including vans and taxis) has increased until it now represents 84.3% of the total.

A similar situation can be seen in freight transport. Figure 2 shows the proportion of domestic freight split by mode. As with the passenger data, it can be seen that road transport is dominant and represents 66% of the total.

The major growth in car use took place during the 1970s, since 1990 the rate of growth has slowed to about 1% p.a. However road freight increased at around 2% p.a. from 1990 to 2005. (The effect of the recession has not yet fed through into official statistics but anecdotal evidence suggests there has been a downturn since then.)

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3 Which modal shifts should be considered?

There is a perception that travel by car is generally undesirable, in terms of CO₂ emissions, while travel by public transport is generally desirable. Similarly there is a general perception that transporting freight by HGV is undesirable while alternative modes are desirable. These perceptions need not be universally correct and this section presents comparisons between different modes and determines which should be included in the analysis.

3.1 Passenger transport

A study, Traction Energy Metrics T618, carried out in 2006/7 for the Rail Safety and Standards Board, on behalf of the Department for Transport, investigated the relative emissions of different passenger transport modes.³

Figure 3, below (Figure 42 in the RSSB paper) shows indicative CO₂ emissions per passenger, using average load factors calculated from data provided by operators and national travel surveys. Road, air and diesel-powered rail vehicle emissions were increased to take account of refinery losses and electric powered vehicles take into account losses from power generation through to the train. The bar length represents the emissions based on current electricity generation mix. Data from electricity producers shows that, for 2006, the carbon emitted in producing 1 kWh of electricity was 0.1241 kg; this is equivalent to 455 g of CO₂/kWh.

This analysis showed that the least polluting means of transport are electric trains (almost of whatever speed), and Megabus-type intercity buses. The difference between them is small in comparison with the likely errors in load factor. The worst are planes, private cars and diesel-powered trains in that order. In terms of the priority of modal shift, moving travellers from cars, and particularly planes, to electric rail must be the first priority.

It is relevant to the present study that the above figures are based on average load factors (i.e. the proportion of seats occupied) and the carbon intensity of electricity generation in 2006. Repeating

³ http://www.rssb.co.uk/pdf/reports/research/T618_traction-energy-metrics_final.pdf

4 Notes: Data assume the following load factors: urban bus 20%, intercity coach 60%, intercity rail 40%, all other trains 30%, domestic airlines 70%, and cars 30%. Road, air and diesel-powered rail vehicles emissions have been increased to take account of refinery losses and electric powered vehicles take into account losses in the grid. The aviation figures include a factor for radiative forcing.
the calculations for the situation in the 2030s produces a rather different set of figures from the same travel choices.\(^5\)

Many of the assumptions in producing this graph are open to question – for example, intercity rail operators might decide to introduce an “all booked seats” policy with bookings available up to 5 minutes before the train enters a platform, as on the Japanese Shinkansen. This might enable the load factor to be increased to 60% from 40% which would have a beneficial impact on emissions per passenger. They might also decide to reduce the proportion of first class seats, which would increase the number of seats and reduce the emissions/seat. The important thing is that these figures are not cast in stone; there could be significant variations, depending on the assumptions made.

On the basis of the above analysis, there is negligible benefit to CO\(_2\) emissions in moving people from private car to diesel-powered rail or service buses, if current load factors are retained. This study therefore concentrates on modal shift from private cars and domestic aviation to electrically-powered trains.

There have been plans from both main political parties for building a high-speed network in the UK. The RSSB report T618 analysed the CO\(_2\) emissions of intercity trains operating at different speeds in Figure 27, which is reproduced below as Figure 5. It showed energy consumption data for various European trains (Øresundstoget, Regina, Arlandabanan, Class 90, X 2000, Class 91, Class 390, Flytoget, Eurostar, TGV PBKA, TGV- Réseau and ICE-3) plotted against maximum speed:

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\(^5\) Figure 4 is based on the following assumptions: Load factor is 40% on intercity trains, 30% on other trains, 60% on motorway coaches with booked seats, 20% on service buses and 70% on aircraft. Private cars meet the EU target of 120 g CO\(_2\)/km and have the same load factors as today. Electricity generation has been partially decarbonised and emits 200 g/kWh compared with 455 g/kWh in 2006. An altitude factor of 1.3 has been included in the Cardiff – Newcastle plane emissions (assumed to be by modern turbo-prop) and a factor of 2.0 in the Manchester and Edinburgh flights (assumed to be turbofan planes operating at a higher altitude) to allow for radiative forcing. All the train types included on the graph have been built since the late 1990s and are likely to remain in service until the 2030s.
It can be seen that the energy consumption of 300 km/h trains is about twice that of 180 km/h trains. Theoretically one might expect a larger differential as aerodynamic drag varies as speed squared and the work = drag force x distance travelled but higher speed trains are generally longer than lower speed trains (which improves the passengers : drag ratio) and more care is taken in their aerodynamic design. Even with their higher energy consumption, it can be seen that there are environmental benefits in moving people from cars to high-speed trains (more as electricity generation is decarbonised) and this transfer will be included in the modal shifts studied.

Passenger travel can be divided into three broad areas:

◊ commuting, typically up to 60 km each way (this can include the “school run”);
◊ medium distance trips, typically business or social visits up to 600 km\(^6\) each way;
◊ long distance travel or touring, generally exceeding 600 km.

When looking at technologies that can achieve significant CO\(_2\) reductions over the next 40 years, it is likely that much of the commuting need could be met by electrically-powered public transport or, for people living and/or working away from main transport arteries, electric vehicles or plug-in hybrids running on low-carbon electricity. Technologies for electrically-powered trams and hybrid trolley buses capable of serving the main road transport arteries are well established in other European countries but their use in Britain has been restricted by administrative factors – principally the privatisation and deregulation of bus transport. Electric vehicles with a 60 km range have been available for several decades but their market penetration has been limited for economic reasons. A combination of expansion and electrification of commuter rail networks, re-regulating the bus network, new battery technologies and the right economic incentives for the take-up of electric vehicles could provide a low-carbon solution for commuting. In this area, the study will examine possible modal shifts from conventional fossil-fuelled cars to this wide range of low-carbon alternatives.

At the other end of the scale, long-distance travel (over 1200 km round trip) represents only a small part of the travel market. The journeys are diverse – some time-critical business travellers wanting

\(^6\) 600 km is the distance between London and Glasgow or Exeter and Newcastle-on-Tyne, which covers the vast majority of trips in the UK.
“there and back in a day” trips to large cities; leisure travellers often seeing the journey as an end in itself, rather than a means to an end. It is not proposed to study this sector of the market at present as the numbers are small and sections of the leisure market (e.g. caravanners) are not open to modal change.

It is the middle group – journeys more than 60 km each way but less than 600 km – that represents a large slice of travel and where there is no currently available low-carbon technology that could be used on the road network. (The widespread adoption of biofuels will not be considered in this study as environmental sustainability has not been proven and it is not “modal shift”.) This study therefore considers two groups of passenger transport – commuting and travel in the range 60 to 600 km. It investigates the barriers to modal transfer from the car to electric rail in these sectors.

3.2 Freight transport

Whereas passengers are largely the same and are easy to measure (basically by counting people), freight transport is more problematic. There are huge differences between different classes of freight – bulk materials, low density consumer products, parcels, foodstuffs and so on. Rail already has a dominant market share for long-distance haulage of minerals, fuels and bulk products. At the other end of the scale, local deliveries to city-centre shops or home deliveries from internet shopping have to be by road, unless the wholesale rebuilding of historic city centres is considered.

A first limitation on modal transfer is thus the type of goods to be transported and it was decided to analyse three main areas – bulk commodities, food and drink and general merchandise and parcels traffic.

Although one could envisage low-carbon technologies suitable for city-centre parcels and store delivery traffic, these would require significant development, which is not the objective of this study. For this reason, work has concentrated on freight movements of 100 km or more. (This coincides with a category in the UK Transport Statistics, published by the DfT and thus there is a reliable source of data for analysis.)

4 Methodology

This study analyses three scenarios for both freight and passenger traffic:

◊ The existing modal split;
◊ Transferring 10% of the present road traffic to rail;
◊ Transferring 50% of the present road traffic to rail.

For each of these three scenarios, two different sets of assumptions about the carbon intensity of transport were possible:

◊ The present carbon intensity of both road and rail transport – e.g. average CO₂ emissions of 186 g/vehicle-km for passenger cars, 455 g/kWh for electrified railways, and so on;
◊ Extensive rail electrification and decarbonised electricity (200 g CO₂/kWh) being used for rail and significant progress in reducing the emissions of road travel (average emissions meeting the EU target of 120 g/km, speed limits strictly enforced, etc.);

Because of the time period being studied (up to 2050), it was decided to use the latter.

It is frequently argued that the justification for building new rail (high speed) lines is to enhance the economic development of a particular region. This usually implies a substantial growth in passenger flows, with consequential increases in emissions (discussed further in section 6). In this study it has been assumed that flows of passengers and freight will be maintained at the current levels and that only the modal split will be changed. If it is decided to scale all the outputs as a result of an overall increase or decrease in economic activity, that could be a separate exercise. Similarly, it has been assumed that trains continue to offer a similar journey time performance as the best of current UK...
rolling-stock. The effects of a new 300 km/h rail network have not been considered, partly because this has been an exercise in what is feasible, not an investigation into the inducements necessary to make modal transfer happen.

The study has identified the “roadblocks” to modal transfer of the target levels. These include the capacity of city centre terminal stations, limitations of the national electricity supply, the structure of the privatised rail industry and similar issues. Where it has been necessary to make assumptions about investment in major new infrastructure, these have been based on rough estimates of what will be needed and approximately what it might cost. It was not intended that this study will produce figures that could serve as a guide to future investments – merely as an indication of what it might be sensible to analyse in more detail and what options are not worth considering further.

5 Analysis of passenger transport

5.1 Urban transport and commuting

Transport statistics for 2006 (the latest in which these data are available)\(^7\) show that the average person commutes 3285 km per year; applying the 2030 emissions figures from Figure 4 gives a figure for total emissions of 280 kg CO\(_2\).\(^8\) The following pie-charts (Figure 6 and Figure 7) show graphically a comparison of the total commuting distance and CO\(_2\) emissions attributed to private road transport (car, motorcycle, vans, etc.), service buses (including the “other public” category) and rail.

![Figure 6: Commuting distance](image1)

![Figure 7: Commuting CO\(_2\) emissions](image2)

5.1.1 Scope for 10% modal shift

At present 80% of commuting travel is by car and 13% by rail. What would be the challenges of changing this to 70% and 23%?

The data for commuting covers a wide range of different situations. It includes someone living 10 minutes walk from Carshalton Beeches station and commuting to an office in Victoria Street as well as someone living in Betws-y-Coed and commuting to an industrial estate on the outskirts of Wrexham. The former could easily commute the 20 km by rail (and probably chose to live at that address to make it possible). The latter has no real option but to commute the 75 km by road.

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\(^7\) Data from Transport Statistics Great Britain, 2008, table 1.4

\(^8\) These calculations used the following average figures of CO\(_2\) emissions per passenger-km: Car 98g, motorcycle 40g, other private transport (e.g. vans) 100g, local bus 76g, rail 24g, other public 40. They can only give a rough indication of emissions as the load factor in car commuting tends to be low compared with average, thus understating the emissions, while the load factor on public transport during commuting periods tends to be very high, thus the average figure above overstates emissions. The result of these factors is that car emissions in Fig 7 are understated in comparison public transport emissions.
There are two ways in which the proportion of commuters using rail could be increased. The first is to increase the capacity of existing commuter rail networks and the second is to establish new networks, either using existing infrastructure and/or rights of way or to build completely new systems.

One difficulty in addressing these questions is the need to estimate the size of the population for whom rail commuting might be a reasonable option. The first stage in tackling this was to estimate the proportion of people who live in a community served by rail. The calculation used data on the population of cities, towns and districts available from the City Mayors website. This gives a list of 200 communities with a total population of 44 million. The list was then pruned to eliminate those communities that do not have a significant rail network. This was a subjective judgement and, in some cases, where several communities were borderline, an arbitrary decision was taken to include one and exclude the others. The outcome of this pruning was a list of 21 communities with a total population of 14 million.

The outcome of this calculation suggests that around two thirds of the population live in areas where rail commuting is not, at present, an option. Thus, to achieve a modal shift of 10% in total, the modal shift in those areas served by rail would have to be increased by 30%. But rail’s share in the areas it serves (dominated by London) is already around 30% so to increase the average by 10% requires doubling the capacity of existing commuting services and persuading people to use them.

The National Passenger Survey, Autumn 2008, published by Passenger Focus in March 2009 reports that 22% of passengers consider space inadequate. It is known that commuter services are more crowded than at other times, which has resulted in political intervention to purchase more trains; thus it seems unlikely that there is much flexibility in the present timetable and with the present fleets of rolling stock to accommodate significant growth in commuter numbers.

The problem then comes down to whether there is any flexibility to squeeze more passengers and trains onto the existing network or whether new infrastructure would be needed. Most of the major routes into London are already at capacity during the morning peak. The routes into Manchester, Birmingham and Glasgow are also heavily loaded but some of the commuter trains are only 3 or 4 cars long and there would be scope to increase capacity by running longer trains. This would require major rebuilding at several stations, including Birmingham New Street and Manchester Piccadilly (particularly the through platforms) to accommodate longer trains and higher passenger flows.

Taken overall, it seems unlikely that it would be possible to achieve 10% modal transfer in the commuting sector without a significant expansion of electrified railways. The next part of this calculation is to see what increase in infrastructure and services might be needed, if the objective is to bring train travel to groups of commuters for whom it has not previously been available, rather than to expand what already exists.

Table 1.4 of Transport Statistics lists the number of trips of different purposes undertaken by the average person in Great Britain each year. Discounting walkers and cyclists and assuming a population of 59 million and 250 commuting days a year, this represents around 20 million commutes per day. (i.e. roughly one third of the population).
To transfer 10% of this traffic to rail would require providing 2 million additional commuter trips per day. Working on the basis that commuters arrive at their destination in a 4-hour window (e.g. 06:00 to 10:00) that would require a capacity of half a million passengers/hour.

One means of providing this extra capacity would be by constructing light rail systems. Evidence to the House of Commons Transport Select Committee 13 is that a light rail system, such as London Docklands, has a capacity of 20,000 pphd (passengers per hour per direction) and Croydon tramway has a capacity of 5,000 pphd. If a tramway for a small city or large town has two lines crossing in the city centre, it would have a total capacity of 20,000 pass/h (both directions on both lines). To achieve a total capacity of 500,000 pass/h would require 25 such schemes; starting one per year from 2010 to 2035 would be entirely feasible.

The construction costs of light rail and tramway systems are reasonably well-known. Manchester Metrolink phases 1 and 2 cost £145m and £160m respectively;14 the 29 km Sheffield Supertram cost £240m;15 the 14 km Nottingham Express Transit cost £200m,16 and the Croydon Tramlink was also £200m17 (all at historic costs). On this basis, 25 new schemes, at £300m each, would cost a total of £7.5 bn and would represent less than a 5% increase in the DfT capital budget, if financed at one per year for the next 25 years.

In conclusion, a 10% modal shift in commuting by the 2030s is feasible. A proportion could be achieved by increasing services on existing infrastructure, re-opening stations, extending existing lines and similar organic growth – always accompanied by electrification, where lines are not already electrified. However it seems unlikely that this would be enough and new services over new infrastructure would be needed. A proven way of achieving this, in common use on the Continent, would be to construct light rail or tramway systems in conurbations that have few or no rail services at present.

5.1.2 Scope for 50% modal shift

Achieving a modal shift of 10% has been shown to be feasible but difficult. Achieving 50% would be far more challenging and would go beyond engineering into land-use planning, housing and business relocation, social engineering, e-commuting, carbon permits and “persuasive” taxation. It has been shown above that around two thirds of the population lives in communities with negligible rail services and it would be necessary to change this situation to achieve a 50% modal shift, or 63% of commuting mileage by electric trains or trams.

An RAC publication analysing commuting trends18 shows that in 2006 the average commute time was 27 minutes one way (54 minutes per day), but once this average is broken down there are significant commute time differences: one in ten people in the UK has a journey in excess of 60 minutes in each direction and just over three percent (740,000 people) are ‘extreme commuters’ travelling at least an hour and a half to and from work everyday.

A limitation on persuading people to commute by rail is the distance they would have to walk to the nearest station. Data from the National Travel Survey provide information on walking time to a station:

13 http://www.publications.parliament.uk/pa/cm200405/cmselect/cmtran/378/378we06.htm
14 www.lrlta.org/Manchester/funding.html
15 www.railway-technology.com/projects/sheffield-tram
16 http://www.lightrailnow.org/news/n_not001.htm
17 http://www.railway-technology.com/projects/croydon/
If the average commute time is 27 minutes, it is unlikely that many people would consider walking more than 13 minutes to get to a station, particularly if they also have to walk at the other end. This suggests that, with the current infrastructure, there is a limit to the take-up of rail of 12% of the population – much the same as the present situation.

To approach a 50% modal shift from car to electric rail commuting might be possible by the construction of a large number of new urban rail systems (heavy rail, light rail and tramways) to provide the inhabitants of all conurbations and their suburbs with the same level of rail services as is available in the best-served London boroughs. These would have to be heavily subsidised from central taxation as, to achieve the capacity necessary for the commute period, it would be necessary to build systems that would be deemed “uneconomic” by any current criteria; there would be no possibility of recouping the investment from the farebox without driving people back to their cars.

The costs of this large growth in rail systems can only be a rough guess. For half a dozen major conurbations the costs of extending their existing provision into a comprehensive urban rail system might be of the order of 3 or 4 times the cost of the single line of Crossrail (£16 bn at latest estimate). For 60 smaller towns and conurbations the costs of an LRT that reaches into the suburbs could be around £1 bn. Add into this the expansion of existing lines and various feeder services and the capital costs to achieve a 50% modal transfer could be around £500 bn. Over a 25-year period this would represent £20 bn per year or roughly 1% of GDP, three times the Department for Transport capital budget for 2008 or half the total defence budget.

In conclusion, it is difficult to see the actions to achieve a 50% modal transfer being acceptable under current policies. The development of new infrastructure would have to be accompanied by draconian changes in planning policies to resist suburban and rural development and encourage businesses to relocate to areas near rail stations as well as restrictions on car usage. It would reverse the trends and ethos of the last 5 decades where people have moved to leafier (and lower density) suburbs and business premises, as well as hospitals and universities, have migrated to out-of-town locations.

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19 National Travel Survey 2007, Table 5.2

20 For example, the metropolitan areas of the West Midlands, Bristol – Bath, Glasgow, The North West (Stockport – Manchester – Bolton – Wigan – Liverpool), Leeds-Bradford and Cardiff.

5.2 Inter-urban transport

Data on non-commuting inter-urban travel is not readily available but can be estimated from the National Travel Statistics (quoted earlier) and Road Traffic Statistics.\textsuperscript{22}

From the former, it is possible to extract the following data, which exclude commuting and the school run:

<table>
<thead>
<tr>
<th></th>
<th>Road</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other escort</td>
<td>734 km per capita</td>
<td>13 km per capita</td>
</tr>
<tr>
<td>Personal business</td>
<td>675 km per capita</td>
<td>38 km per capita</td>
</tr>
<tr>
<td>Leisure</td>
<td>3754 km per capita</td>
<td>359 km per capita</td>
</tr>
<tr>
<td>Total per capita</td>
<td>5163 km per capita</td>
<td>411 km per capita</td>
</tr>
<tr>
<td>Population\textsuperscript{23}</td>
<td>60975000</td>
<td></td>
</tr>
<tr>
<td>Total non-commuting</td>
<td>315 bn pass km</td>
<td>25 bn pass km</td>
</tr>
</tbody>
</table>

From the latter, it is possible to calculate the total passenger-kilometres on motorways and non-urban major roads:

- Motorways: 73 bn veh-km
- All rural A roads: 112 bn veh-km
- Total non-urban: 185 bn veh-km
- Occupants/car: 1.6
- Car travel on all interurban roads [bn pass-km]: 296

In round numbers these are the same and represent a total of non-commuting, inter-urban travel as 300 bn pass-km by car and 25 bn pass-km by train.

5.2.1 Scope for 10% modal shift

From the above data it is possible to form a view of the scale of movement necessary from road to rail to achieve a 10% modal shift. The increase in inter-urban rail travel needs to be 130%. The following paragraphs will discuss some of the problems in achieving this shift either by increasing passenger usage on existing lines or by establishing new rail passenger flows, either on completely new or upgraded lines.

For the last 12 years, passenger growth on the UK rail network has been impressive.\textsuperscript{24} Projecting this rate forward another 40 years represents a growth of around 130% relative to 2009. But is it possible to maintain such a level of growth over that period?

\textsuperscript{22} http://www.dft.gov.uk/pgr/statistics/databypublications/roadtraffic/traffic/rtsa2005int419

\textsuperscript{23} http://www.statistics.gov.uk/cci/nugget.asp?ID=6

\textsuperscript{24} Ten-year European Rail Growth Trends (A study by the Association of Train Operating Companies) July 2006
There are several problems with continuing this rate of growth. The first is that, on many lines, the growth has taken up slack in the previous timetables. The principle has been to “make the assets sweat”; this has been done and many lines are now running at near their capacity. Where money has been invested, such as on the West Coast Main Line (WCML), it has added to capacity but this is largely used-up in the recent timetable enhancements.

There are technical “fixes” to allow greater throughput of trains. Moving block signalling, introduced with the European Rail Traffic Management System (ERTMS) may allow 30% more trains on plain track, however the throughput of stations could become limiting. The redesign of intermediate stations to allow “acceleration lanes” before stopping trains rejoin the main lines, as on the Tokaido Shinkansen in Japan and the replacement of many flat junctions with grade-separated interchanges would make a significant difference.

For many intercity services, there is a bottleneck at the terminal stations, such as Euston where the number of platforms is limited. This is as much an issue of industrial culture as of physical capacity. In the UK, turning round a train (including cleaning and re-catering) in less than 30 minutes is seen as very short. However, in May 1997 before opening new platforms at Tokyo, JR East managed to turn round trains in half that time. The following table summarises arrivals and departures at Tokyo at around 08.00 hrs:

<table>
<thead>
<tr>
<th>Arrives from</th>
<th>Train</th>
<th>Time</th>
<th>Time</th>
<th>Train</th>
<th>Departs to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasu-Shiobara</td>
<td>N230</td>
<td>7.18</td>
<td>7.30</td>
<td>Y101</td>
<td>Morioka</td>
</tr>
<tr>
<td>Takasaki</td>
<td>T470</td>
<td>7.22</td>
<td>7.36</td>
<td>A301</td>
<td>Niigata</td>
</tr>
<tr>
<td>Nasu-Shiobara</td>
<td>N232</td>
<td>7.33</td>
<td>7.45</td>
<td>N231</td>
<td>Omiya</td>
</tr>
<tr>
<td>Takasaki</td>
<td>T450</td>
<td>7.39</td>
<td>7.51</td>
<td>T451</td>
<td>Takasaki</td>
</tr>
<tr>
<td>Nasu-Shiobara</td>
<td>N234</td>
<td>7.48</td>
<td>8.00</td>
<td>Y1</td>
<td>Akita</td>
</tr>
<tr>
<td>Nasu-Shiobara</td>
<td>N236</td>
<td>7.54</td>
<td>8.06</td>
<td>Y37</td>
<td>Morioka</td>
</tr>
<tr>
<td>Takasaki</td>
<td>MT452</td>
<td>8.04</td>
<td>8.17</td>
<td>MA303</td>
<td>Niigata</td>
</tr>
<tr>
<td>Nasu-Shiobara</td>
<td>N238</td>
<td>8.09</td>
<td>8.21</td>
<td>Y113</td>
<td>Sendai</td>
</tr>
<tr>
<td>Sendai</td>
<td>Y110</td>
<td>8.25</td>
<td>8.33</td>
<td>A305</td>
<td>Niigata</td>
</tr>
</tbody>
</table>
This performance was achieved by strict timekeeping and by well-organised staff, who had 12 minutes to clean and prepare the train. In that time, the passengers disembarked and the cleaners - two per car - were on within a minute. They picked up litter, rotated the seats to face the direction of travel, replaced any soiled or missing antimacassars and checked each fold-down table for cleanliness. The passengers, who had been queuing since before the train arrived, between lines painted on the platform, boarded in 2 minutes to their reserved seats and the train departed.

This demonstrated that it is possible for a main-line terminus to despatch 4 trains/hour from a single platform edge, but it would require a different industrial culture (and passenger behaviour) to that normally seen in the UK.

In conclusion, it is clear that existing lines can support an increased service. Whether an across-the-board 130% is possible, even with moving block signalling and changes to track layouts and stations is open to doubt. Much of the growth would have to come from new, or significantly enhanced, services between destinations not now considered on major rail routes.

5.2.2 Scope for 50% modal shift

The previous section has shown that achieving a 10% modal shift would be challenging. Achieving 50% would require a change in the way in which the country sees rail and the priorities afforded to different routes by Government.

Target markets

Road traffic can be divided between journeys that are fairly straightforward to transfer to rail and those that are difficult or impracticable. The former category includes travel for business and pleasure between reasonably large centres of population by people who are largely unencumbered. The latter category includes trips between places that are far from a centre of population and those involving people who, either by choice or because of their job, need to travel with bulky equipment or other luggage. In the second category can be included families with children visiting relatives who “need” to take high-chairs, buggies, and other bulky luggage, people going on activity holidays with climbing or windsurfing equipment, musicians with cellos or drum kits, business representatives with samples or tradesmen with an estate car full of power tools. It has not been possible to form a view of the relative sizes of these groups but one might hazard a guess that a third of interurban journeys by road would be very difficult to transfer to an alternative mode.

The above paragraph makes the assumption that individual behaviour and lifestyle cannot be changed. However, in the same way that driving a child to an urban primary school in a large 4x4 “because it protects my child” is increasingly unacceptable, it may be that the assumption that a family visiting grandparents is expected to take a high-chair and a buggy also becomes outdated. There is no practical reason why local businesses should not hire out these items so a family can travel by public transport and still benefit from modern equipment on arrival at their destination, but this would require a major shift in social values.

However, the case of family travel raises interesting questions about priorities in transferring people from high consumption modes to those with lower consumption. Work done for the RSSB T618 report (referenced earlier) showed the key role of vehicle occupancy in energy and CO2 calculations. A family of 4 travelling in a small efficient car produces less CO2 per capita than if they travelled in an electric train, with today’s carbon intensity of electricity generation. Policy attempts to introduce modal shift should thus be focused on people travelling alone or with only 2 in a car, rather than larger groups. There are other benefits in encouraging family groups not to transfer to rail: if there were a large transfer of that sort, there would be pressure for train interiors to become more “child friendly” with a greater number of facing seats or even compartments, as in the 1960s. These changes would have the effect of reducing the energy efficiency of trains by reducing seating capacity (in much the same way as health and safety and disabled access provisions have done in the past 2 decades).

Looking at the whole range of possible trips, the guessed figure of one third not being amenable to transfer from road to rail seems reasonable – and certainly not pessimistic. This means that, to
achieve a 50% modal shift overall, of the trips that are transferrable to rail, 5 out 6 have to be transferred.\textsuperscript{25} This is a hugely challenging target!

\textbf{What counts as a prime route?}

From before the 1960s the UK rail network has been divided into various categories of route. One of several reasons for the failure of the APT project was that a tilting train gives greatest benefit on routes where the average speed is reduced by a large number of curves through which speed is restricted to limit lateral forces on passengers. Half way through the APT development it was decided that, rather than concentrate on a self-powered train that would cut journey times on routes like Newcastle to Carlisle or York to Bristol, the train would be designed for the 25kV line from Euston to Glasgow, where trains already ran at 160 km/h or more over much of the route, because the WCML was the prime route: Newcastle to Carlisle had to be satisfied with previous generations of trains “cascaded” through the system.

The logic of this approach was that new train development was expensive and had to be exploited on routes that brought-in the highest revenue. This approach is largely intact today and the new Intercity Express Programme (IEP) is targeted at the prime routes of London to Bristol, Edinburgh, etc.

\textbf{A new paradigm}

Although it is not true to say that rail lines on the prime routes are already dominant in those transport corridors, concentration on expanding the existing large traffic flows, such as London – Birmingham, London – Manchester, London – Leeds, etc. will not achieve a major modal shift – mainly because rail already has a significant slice of the market on those routes which, by themselves, do not constitute the majority of passenger travel in the UK.

The challenge for policy makers is not only to persuade a higher proportion of people travelling between major regional cities and London to use the train but to make rail the default option for the huge number of trips between towns and cities where most travellers do not think of rail as the normal means of travel.

An example of this is the service between Manchester and Leeds. At present there are 4 reasonably fast trains per hour between these cities\textsuperscript{26} with a total capacity of 700 seats/hour/direction. This is small in comparison with the number of car drivers on the M62 making a journey in the same corridor. The timing from city-centre to city-centre for the 70km trip is much the same (about an hour), the cost is much the same (£16 by train and the same at the HMRC allowable rate of 40p/mile) so why is there such an imbalance?

One of the reasons is the accessibility of the stations to many people who wish to travel. If a business woman needs to go from an office block on Salford Quays to an industrial estate in Pudsey (near Leeds) by public transport, she would need to walk to the tram stop – 10 minutes,

\begin{tabular}{|l|l|}
\hline
\textbf{Existing situation} & \\
\hline
Rail & 10 \\
inaccessible road & 30 one third \\
accessible road & 60 two thirds \\
\hline
\textbf{New situation} & \\
\hline
Rail & 60 increase of 50% \\
inaccessible road & 30 \\
Inaccessible road & 10 \\
\hline
\end{tabular}

\textsuperscript{25} The calculation is:

\textsuperscript{26} For much of the day, trains run from Manchester Piccadilly at xx:07, xx:27, xx:42 and xx:57 and take a little under an hour. These consist of modern three-car diesel sets operated by First TransPennine Express and have a capacity of about 180 seats, many of which will be taken by passengers on the services which run on routes such as Liverpool to Scarborough of Manchester Airport to Newcastle. There are other, much slower, trains from Manchester Victoria, but these have been discounted.
take a tram into Piccadilly station – 10 minutes plus waiting time of up to 6 minutes, walk to the mainline station and queue to buy a ticket – 10 minutes, wait for the train – up to 15 minutes, walk 800m from Leeds railway station to the bus station – another 10 minutes, buy a ticket and wait for a bus – 5 minutes, take a bus to Pudsey – 15 minutes and then walk to the industrial estate – 10 minutes. All this more than doubles the journey time and requires local knowledge of where to find bus stops, etc. The alternative of taking a taxi at each end would be quicker but would double the cost. Unsurprisingly, the option of driving is more attractive to most people who have access to a car, particularly if Sat Nav takes away the difficulty of driving in a strange town.

The challenge to policy makers is thus to reduce the time, cost and “hassle” of potential passengers getting from home or their place of work to an intercity rail station. This could include rebuilding bus stations to be integrated with rail stations as a transport hub, increasing penetration of bus and tram services into suburbs and business parks, building new stations on the outskirts of conurbations linked by an excellent network of local transport as well as providing park-and-ride. As these “non-prime” routes at present have a lower market share than the average of the rail system, and bearing in mind the calculation on accessible trips above, all this would have to be coupled with an expansion of around 10 times of the rail network capacity, if an average modal shift of 50% is to be achieved.

As the RSSB report quoted earlier 27 shows, service buses operating on diesel produce almost as much CO₂ as a private car. Any expansion of bus travel will thus have to be accompanied by a switch to low-carbon technologies – either hybrid battery-trolley buses28 or hydrogen fuel cells (with hydrogen produced from low carbon sources) or will have to involve load matching or pricing strategies to ensure buses operate at a higher load factor.

**Is a 50% modal shift possible?**

Achieving 50% on interurban transport would require massive capital investment. The £500 bn investment identified for a similar transfer in the commuting market would have a good effect on the accessibility of main stations but more would be needed to ensure that all potential travellers could access interurban trains quickly and easily.

The example in the previous section showed the importance of achieving fast transport from homes and places of work to transport hubs. Some of this can be achieved by (electric) bus and tram systems but there will be many locations where traffic flows are not adequate to justify a 100-seat tram and where smaller automated personal rapid transit (PRT) systems, such as that by Advanced Transport Systems in the photo, might be suitable. However such systems are best for extensive networks where passenger numbers are low and thus where potential revenues are small; a large subsidy would be required for sufficiently widespread adoption to make a difference to UK energy-use statistics.

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28 A so-called COMBAT bus (combined battery and trolley) was researched by Lucas for South Yorkshire PTE in the early 1980s but its economics, plus battery technology at the time, did not allow it to be developed further.
As well as investment to allow passengers to get to their nearest stations, the capacity of many non-prime intercity routes would have to be increased by anything up to 10 times. Relatively lightly used routes like Manchester to Sheffield would have to be provided with the capacity of the busiest sections of the West Coast Main Line (WCML). This would mean increasing the capacity of, and electrifying, existing routes, reopening some closed routes, perhaps such as Manchester – Sheffield – Wath, constructing new routes, rebuilding many city-centre stations and constructing new stations and hubs in badly-served areas. The recent refurbishment of the WCML cost around £20 bn and one might envisage spending 10 times this on interurban infrastructure improvement and new construction in addition to work to make terminals accessible. Then there would be the costs of large fleets of trains.

Apart from the capital costs – perhaps £1 tn over the next 3 decades – and the increased maintenance and operating costs, there would be many challenges in the social sphere. While taking a train to work is, for many people, entirely normal, planning a business trip (other than one to London) or a holiday weekend by rail is less common, particularly for the car-owning middle classes. A 50% level of modal transfer would require strong price signals (e.g. high rail subsidies and increased road taxation), a change in the zeitgeist of what is socially acceptable and (probably) strong regulation, carbon tax or other government action to force-down car use. Whether this would be politically acceptable or whether it would trigger a backlash, like the fuel tax protest, shown in the photo, would be the subject of a separate study.

In conclusion, a modal shift in interurban transport of 50% is at the limits of what can be imagined. It would require major investment and would cause disruption to many people’s lives. Realistically it is unlikely to be possible to achieve modal shift of this scale without changing people’s assumptions about urban vs. rural living, partners working in different places or holiday destinations. This is far more than engineering!
6 The rebound effect

“It has become an article of faith amongst environmentalists, seeking to reduce greenhouse gas emissions, that improving the efficiency of energy use will lead to a reduction in energy consumption. This proposition has even been adopted by the UK government who is now promoting energy efficiency as the most cost effective solution to global warming. This debate has promoted discussion among US energy analysts and the climate change community over the extent of the 'rebound' or 'take-back' effect. That is how much of the energy saving produced by an efficiency investment is taken back by consumers in the form of higher consumption, both on the micro and macro level.”

In its simplest form the Khazzoom-Brookes (K-B) postulate, put forward by the US economist Harry Saunders in 1992, suggests that, if the insulation in a house is improved, the occupants will share the benefits between an improved standard of domestic comfort and reduced energy bills. This is particularly true in lower-income homes which have traditionally been poorly heated.

An example quoted by Fouquet and Pearson shows how the greater efficiency of lighting technology over the last 3 centuries has resulted in a massive increase in the use of artificial light.30

![Figure 10: Consumption of light 1700 to 2000 AD](image)

There is a corollary in transport which is that a more efficient transport infrastructure results in a growth in traffic. This has been seen in road provision: before the opening of the M60 round Manchester and its associated motorways, living in Wilmslow and working in Rochdale would have been considered an impossible commute: now it is entirely normal. There is a similar effect in improvements in rail transport. Over 40 years, as rail services from London to the north have been improved, the commuter belt has moved northwards from Welwyn and Hatfield to Cambridge, Peterborough and even Kings Lynn.

The rebound effect has serious implication on the implementation of a policy of modal shift in transport. Identifying a busy route for road commuting and commissioning a parallel, but faster, rail line is likely to persuade some motorists to transfer from their cars. However, over time, it is also

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29 Horace Herring, Does Energy Efficiency Save Energy: The Implications of accepting the Khazzoom-Brookes Postulate, Open University 1998

30 Fouquet and Pearson, quoted in The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency. UKERC, October 2007
likely to result in people commuting greater distances, particularly if the last leg of the trip involves a private car left in a station car park. The end result could be an overall increase in transport energy use and CO₂ emissions.

A high speed rail network in Britain is widely held to be “a good thing” environmentally as it would result in transfer of short-haul air passengers to rail, an environmentally more benign mode. However passenger flows on routes such as Heathrow to Glasgow are below 500 passengers/hour while the minimum economic passenger flows for a new high-speed rail line are of the order of 5,000 passengers/hour. Constructing a new high-speed line is thus likely to result in a growth in total traffic and, including the transfer of passengers from existing rail and bus services, would lead to an overall increase in CO₂ emissions, unless the electricity supply is almost completely decarbonised.\(^3\)

This has implications for the way in which modal transfer can be implemented. Until the present financial crisis, the Government’s preferred solution for new infrastructure investment was to encourage the private sector to invest through a PFI arrangement. Such schemes are only likely to be viable if the promoters are allowed to maximise the returns on their investment by promoting long-distance commuting, off-peak fares, bulk purchase or whatever else is necessary to fill the line to capacity. While Britain has high-carbon electricity, this would be environmentally detrimental.

If modal shift is to have the environmental benefits anticipated from the bare figures of CO₂ per passenger-km, there will have to be strict controls to prevent the generation of new traffic. Energy policy researchers considering Khazzoom-Brookes have argued that, to prevent efficiency improvements leading to energy growth, fuel prices should be increased in line with the average efficiency of the ways it is used. This paper is not the place to analyse different financing methods for transport infrastructure but it should be noted that the present models of privately financed investment are likely to be inappropriate if the objective of modal shift is to reduce CO₂ emissions.

\(^3\) The situation is France is relevant. Here 85% of electricity generation is from nuclear power so the TGV network is essentially “low carbon” in comparison with car, bus or airline travel. In the UK, with the present generation mix, the emissions from a high speed line, per passenger-km, are comparable with those from cars meeting the EU emissions target of 100 g/km.
7 Freight transport

Freight transport is more complicated than passenger transport as the materials being carried are much more variable than are people and the time-sensitivity varies more widely.

The density of freight varies between more than 5 tonnes/cubic metre for mineral traffic to less than 0.05 t/cu m for some foodstuffs – a range of 100 to 1. The time sensitivity also varies from perishable foodstuffs being delivered “just in time” to a supermarket, when meeting a half-hour delivery slot is vital, to some bulk materials where the main constraint is the value of freight wagons tied-up in the logistics operation.

This study has looked at three main groups of freight:

◊ Bulk commodities, such as coal, iron ore and aggregates. Most of these are hauled between high-capacity terminals, such as aggregates from a Somerset quarry to a concrete depot in London or coal from a port to the stockpile at a power station.
◊ Food and drink either from manufacturers or a port to a distribution warehouse or between the central warehouse to regional warehouses providing provisions to stores over a 100 km radius.
◊ General merchandise and parcels traffic, such as that carried by the Royal Mail or DHL.

The study has not looked at “the final mile”, or more realistically, the final 20 miles from a regional warehouse to the local Tesco store or from the DHL depot next to a motorway in Wigan to the householder in the Manchester suburbs who has ordered a boxed set of DVDs. Apart from the obvious unsuitability of using 20-tonne rail vehicles for delivering a 2 kg parcel, the use of rail for “the final mile” would require the wholesale rebuilding of most urban areas.

7.1 Modal split of freight traffic

The modal split for freight traffic is shown in the following graph:

![Modal split of freight traffic graph](image)

**Figure 11: Freight lifted by mode 1980 – 2007**

It can be seen that in 2007, in terms of freight lifted (i.e. the weight of goods loaded), road had 80% of the business. This compares with the figures for total tonne-km in Figure 2 which showed a more even distribution between modes.

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32 Source: DfT (road and water), ORR (rail), BERR (pipeline) taken from TSGB 2007
The reason for this is that the bulk of road traffic is over relatively short distances, as shown in the following graph:

![Figure 12: Average trip length by mode](source)

This creates a particular problem for policy makers aiming for modal shift as most freight, other than bulk commodities, has to travel by road to its final destination and arranging for intermodal transfer on a trip less than 100 km in length is unlikely to be cost effective.

The problem associated with modal transfer from road to rail is exacerbated by the relatively low average payload in the road haulage industry.

![Figure 13: Average payload of domestic road freight](source)

The above graph shows how, even though average payloads have increased over the past 20 years, they are still only a tenth of the level needed to economically use a modern bogie rail vehicle (typically 60 to 100 tonnes load weight). Either this implies that only a small part of road freight is accessible for modal shift or there would have to be significant groupage with additional costs.

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33 Data from same source as previous chart
34 Source: DfT
35 Groupage is the consolidation of various goods from different consignors into one full load. Typically pickups will be made by smaller vehicles, 7.5-tonne rigs or vans and then taken to a central hub to be ‘grouped’. Groupage requires substantial warehouse or depot space for consignments, and usually skilled packers as well as transport workers. From [http://www.roadtransport.com/staticpages/groupage.htm](http://www.roadtransport.com/staticpages/groupage.htm)
The following table shows in greater detail the source of road freight. These figures are important in the analysis of the potential for modal shift.

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Lifted million tonnes</th>
<th>Total billion tonne-km</th>
<th>Av. distance km</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food, drink and tobacco</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural products</td>
<td>104</td>
<td>11.8</td>
<td>113</td>
</tr>
<tr>
<td>Beverages</td>
<td>57</td>
<td>6.8</td>
<td>118</td>
</tr>
<tr>
<td>Other foodstuffs</td>
<td>212</td>
<td>26.5</td>
<td>125</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>373</td>
<td><strong>45.1</strong></td>
<td><strong>121</strong></td>
</tr>
<tr>
<td><strong>Bulk products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood, timber and cork</td>
<td>29</td>
<td>3.3</td>
<td>113</td>
</tr>
<tr>
<td>Crude minerals</td>
<td>390</td>
<td>16.0</td>
<td>41</td>
</tr>
<tr>
<td>Ores</td>
<td>22</td>
<td>1.8</td>
<td>83</td>
</tr>
<tr>
<td>Crude materials</td>
<td>23</td>
<td>2.6</td>
<td>115</td>
</tr>
<tr>
<td>Coal and coke</td>
<td>24</td>
<td>1.6</td>
<td>66</td>
</tr>
<tr>
<td>Building materials</td>
<td>175</td>
<td>11.6</td>
<td>66</td>
</tr>
<tr>
<td>Iron and steel products</td>
<td>47</td>
<td>6.4</td>
<td>135</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>711</td>
<td><strong>43.3</strong></td>
<td><strong>61</strong></td>
</tr>
<tr>
<td><strong>Chemicals, petrol &amp; fertiliser</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertiliser</td>
<td>9</td>
<td>0.9</td>
<td>101</td>
</tr>
<tr>
<td>Petrol and petroleum products</td>
<td>71</td>
<td>5.1</td>
<td>72</td>
</tr>
<tr>
<td>Chemicals</td>
<td>48</td>
<td>7.0</td>
<td>146</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>128</td>
<td><strong>13.0</strong></td>
<td><strong>101</strong></td>
</tr>
<tr>
<td><strong>Miscellaneous products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other metal products</td>
<td>20</td>
<td>2.0</td>
<td>102</td>
</tr>
<tr>
<td>Machinery and transport equipment</td>
<td>83</td>
<td>9.5</td>
<td>114</td>
</tr>
<tr>
<td>Miscellaneous manufactures</td>
<td>113</td>
<td>16.4</td>
<td>146</td>
</tr>
<tr>
<td>Miscellaneous articles</td>
<td>440</td>
<td>32.2</td>
<td>73</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>656</td>
<td><strong>60.1</strong></td>
<td><strong>92</strong></td>
</tr>
<tr>
<td><strong>All commodities</strong></td>
<td>1,869</td>
<td><strong>161.5</strong></td>
<td><strong>86</strong></td>
</tr>
</tbody>
</table>

Figure 14: Breakdown of road freight by product

By comparison with the figures for road transport, Figure 15 shows the breakdown of freight by product category. It can be seen that coal and coke (largely feeding coal-fired power stations from the ports) represents around 2 bn tonne-km, compared with 1.6 bn in the road sector. Construction

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36 Source: Continuing Survey of Road Goods Transport, DfT
37 Source: Network Rail
materials represent only 0.7 bn tonne-km compared with more than 11 bn by road. However, as will be discussed in the next section, the average distance for road transport in this product group is only 66 km and it is a difficult group to transfer to rail.

Figure 15: Rail freight by product group

7.2 Bulk commodities

Looking at the above table, it can be seen that largest figures in bulk products for both the total weight lifted and the tonne-km transported are for crude minerals which comprises sand, gravel, clay and similar materials. A study for The Crown Estate 38 analysed the energy use in the dredging of marine aggregate and compared this to the land-based production. It was concluded that there is no equitable method of comparing different modes of production and transport as the various methods are not often in competition. Because of the low value of the product, users purchase materials from the nearest source – if that is a sand pit, then transport tends to be by road and, if a bed of marine gravel, by the dredger offloading as close to the point of use as practicable. Where there are inadequate local supplies, rail is used for longer hauls, such as from the Mendips to London and deliveries from Glensanda, the West Scotland super-quarry, are by 80,000 tonne sea freighters.

It can be seen from Figure 14 that the average road delivery distance for bulk materials is 41 km. Given that the “last mile” will, in many cases have to be by road, it seems highly unlikely that a significant proportion of these trips could economically be transferred to other transport modes.

During the study for The Crown Estate, an interview was held with the managing director of a marine aggregate producer who had a contract for the London Olympics. The contract required delivery to site by rail; however the nearest offloading quay was on the south bank of the Thames near Greenwich. Because of the layout of rail junctions, the rail journey required a train to head east towards Kent until it came to a junction where it could reverse, then to take a complicated route round the west of London before approaching Stratford from the north. The road journey was direct through the Thames tunnel and to Stratford. A comparative calculation showed that there was no CO₂ benefit in using rail transport.

38 Kemp, R. J., Energy Consumption of Marine Aggregate Extraction, Research contract reference: OSR 06 03, pub. 2007
http://www.thecrownestate.co.uk/mrf_aggregates
This demonstrates an important point: rail freight is many times more energy efficient than road for long journeys; for short trips, where the rail route may be much longer than the road and there may be many stops and starts, it cannot be assumed that the same holds.

A similar situation exists for building materials, the second largest category. It can be seen that the average haulage distance is 66 km. By their nature, building materials are used in a wide variety of different places, frequently far from the nearest rail line and they are required to be delivered to that location for a few months or years, by which time the construction has finished. It is thus impracticable to construct a rail terminal, with a life of >30 years, for a short-term need.

Overall, it seems unlikely that more than about 10% of the bulk products on roads could be transferred to rail without a return to the situation of a rail freight depot in every town that existing in the 1940s. However those were not environmentally benign days. Rail freight owes its low CO2 emissions to the ability to haul large flows of freight in efficient train consists. A return to the days of half a dozen wagons a week being shunted from Leicester to Loughborough coal yard and then offloaded into low capacity lorries for the last few miles would not necessarily save energy or emissions in comparison with road transport from a large local hub.

7.3 Food and drink

Food and drink constitute 27% of road freight traffic measured by tonne-km. However, this is probably an under-estimate in terms of vehicle-km or CO2 emissions as many food products are of much lower density than bulk materials.

There are five distinct traffic flows for food transport:

1. From farms to centralised markets, transport hubs or slaughterhouses;
2. From the Continent and Ireland via ports and the Tunnel to distribution warehouses;
3. From factories and slaughterhouses to distribution warehouses;
4. From a central warehouse to a regional warehouse;
5. From a regional warehouse to a local store.

For certain of these traffic flows (1 and 5) there is almost no possibility of modal shift. Transferring livestock or fresh vegetables from farms to a market or deliveries from a regional hub to a city supermarket are logically by road. 70 years ago, local trains may have picked-up the a few churns of milk or sacks of potatoes for delivery to a city but this could not be replicated without reopening thousands of kilometres of rural routes and, in any case, the emissions of such low capacity trains are unlikely to be better than of road vehicles.

The main areas where modal transfer can benefit are in flows 2,3 and 4 – i.e. from ports and the tunnel to main warehouses, from major factories and from a company’s central warehouse to regional warehouses. Unfortunately most present warehouse sites are not connected to the rail network, even though many of them are built on ex-railway land. Discussions with the Strategy Director of a major rail freight company identified the lack of rail connections to warehouse complexes as the largest obstacle to increased penetration of rail freight in this market.

Discussions with managers at Eddie Stobart, the road haulage company that has recently introduced rail services, indicate that only certain traffic flows have been found suitable for moving by rail. Drinks were singled-out as particularly suitable due to their high density, ease of packing and time insensitivity.

Transporting fresh produce by rail is likely to result in many trains that would be considered “uneconomic” in today’s climate. The trend is for freight trains to get longer and heavier – 2000 tonnes is normal. However a supermarket needing to send vegetables from the New Covent Garden market in Lambeth to distribution warehouses in Livingston, Goole, Milton Keynes and Didcot will want to despatch much smaller quantities. This will require shorter trains, possibly based on passenger multiple units, as the 160 km/h Class 325 dual voltage trains used by the Royal Mail
to carry mail from London to Scotland. These have a load capacity of 12 tonnes/car (48 tonnes per 4-car unit) with two roller shutter doors per side.

However this raises a problem of train pathing. The New Covent Garden market, which employs nearly 3000 people, is next (but not connected) to the line to Waterloo station that splits to serve Dorking, Portsmouth, Bournemouth, Ascot and many other places. To access routes to the north, trains would have to travel south-west to Battersea and then through Kensington Olympia to join the WCML at Willesden. These routes are already congested at peak periods and fleets of “vegetable trains” could not be accommodated without major expansion of these routes. Realistically a switch to transport by rail would need reconfiguring the whole distribution system for fresh produce in Britain with a new market in an out-of-town location and using the existing market only for local distribution.

### 7.4 Miscellaneous and parcels traffic

Looking at the traffic on the M6, one is struck by the large number of HGVs operated by small businesses with logos such as “Daily Deliveries between Scotland and England”. It is hardly surprising that the category “miscellaneous” is one of the largest in the data in Fig 14 and 71% of road haulage, by tonne-km, is carried by general carriers, rather than by the transport departments of manufacturing companies. 39

For several years, companies have been outsourcing transport operations as “non-core business” and there has been a growth in small operators, encouraged by Government support for SMEs (small and medium enterprises). This poses a particular challenge for proponents of modal transfer; while large specialist transport firms have the resources to organise transfer to rail and sufficient throughput to justify the leasing of wagons or even complete trains, smaller operators do not.

The trends in parcels traffic have also been counterproductive to modal transfer. While 3 decades ago the Post Office was an effective monopoly in many parts of the country, this is no longer the case and, even in rural areas, one sees vans from half a dozen competing parcels carriers operating from depots in different towns.

Shifting general merchandise and parcels traffic from road to rail is possible but would involve reversing many of the trends in the past few decades. In particular, container traffic from the ports to the Midlands or, for example, from Hull to Liverpool should be a prime candidate for transfer.

### 7.5 Modal transfer

#### 7.5.1 Scope for 10% modal shift

The scope for a 10% modal shift has been approached from two directions – firstly which flows of road traffic could be targeted for transfer and, secondly, what the effects would be on the rail network.

The following table takes categories of goods travel from the DfT Continuing Survey of Road Goods Transport, and makes a guess of the percentage of each that might be possible to transfer, given the appropriate investments in new sidings, gauge widening, grants for rolling stock, etc. to ensure that the switch would be, at worst, cost neutral.

In 2006, the total freight moved by all modes was 251.6 bn tonne-km. 40 The contribution of coastal shipping and pipelines has been ignored, which leaves road and rail accounting for 189 bn tonne-km. A 10% modal shift thus represents transferring around 19 bn tonne-km. On the basis of the

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39 Continuing Survey of Road Goods Transport, DfT
40 Transport statistics for Great Britain 2007: Table 4.1
discussion in the previous sections, a percentage transfer has been guessed for each and then the amount of traffic switched calculated.

<table>
<thead>
<tr>
<th>Product range</th>
<th>Road traffic bn tonne-km</th>
<th>Assumed transfer %</th>
<th>Total switched bn tonne-km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural products</td>
<td>11.8</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>Beverages</td>
<td>6.8</td>
<td>5</td>
<td>0.3</td>
</tr>
<tr>
<td>Other foodstuffs</td>
<td>26.5</td>
<td>15</td>
<td>4.0</td>
</tr>
<tr>
<td>Wood, timber and cork</td>
<td>3.3</td>
<td>10</td>
<td>0.3</td>
</tr>
<tr>
<td>Crude minerals</td>
<td>16.0</td>
<td>20</td>
<td>3.2</td>
</tr>
<tr>
<td>Ores</td>
<td>1.8</td>
<td>20</td>
<td>0.4</td>
</tr>
<tr>
<td>Crude materials</td>
<td>2.6</td>
<td>20</td>
<td>0.5</td>
</tr>
<tr>
<td>Coal and coke</td>
<td>1.6</td>
<td>10</td>
<td>0.2</td>
</tr>
<tr>
<td>Building materials</td>
<td>11.6</td>
<td>10</td>
<td>1.2</td>
</tr>
<tr>
<td>Iron and steel products</td>
<td>6.4</td>
<td>20</td>
<td>1.3</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>0.9</td>
<td>5</td>
<td>0.0</td>
</tr>
<tr>
<td>Petrol and petroleum products</td>
<td>5.1</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>Chemicals</td>
<td>7.0</td>
<td>20</td>
<td>1.4</td>
</tr>
<tr>
<td>Other metal products</td>
<td>2.0</td>
<td>5</td>
<td>0.1</td>
</tr>
<tr>
<td>Machinery and transport equipment</td>
<td>9.5</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>Miscellaneous manufactures</td>
<td>16.4</td>
<td>5</td>
<td>0.8</td>
</tr>
<tr>
<td>Miscellaneous articles</td>
<td>32.2</td>
<td>20</td>
<td>6.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>161.5</strong></td>
<td></td>
<td><strong>21.7</strong></td>
</tr>
</tbody>
</table>

With the earlier provisos, it seems plausible that a 10% of freight traffic could be switched from the roads. The next question is whether the rail system could cope and what changes would be required.

The total rail freight in Britain in Q1 2008/9 was 5.4 billion tonne-km, equivalent to 21 bn tonne-km/year. A 10% modal shift represents approximately doubling of this total. Efficient freight transport is not really interoperable with passenger traffic as it has developed in Britain — freight operators do not want to run at 200 km/h, which is the speed on the fast lines of West Coast, East Coast and Western routes, because of energy use and the limitation this would impose on axle-load. Also freight operators do not want trains to inter-run with stopping services on slow lines due the increased amount of braking and lost time. And passenger operators could not accommodate a large increase in freight inter-running without a loss of service quality.

A doubling in freight traffic would require dedicated freight lines, either alongside the existing railway or on new or reopened alignments. For efficient freight transport, it would be necessary to extend the loading gauge to at least Continental standards, to accommodate standard ocean-going containers on wagons with a floor c. 1.2m above rail level. (The present gauge limits the transport of containers either on wagons which have lowered floors, meaning containers can only be carried in a well between bogies, thus making for inefficient loading and poor aerodynamics, or on wagons...
with small wheels, which increases wheel-rail stresses and either results in a reduction of allowable axle-load or increased maintenance costs on both sides of the infrastructure.)

Although a diesel-hauled freight train is generally more efficient than diesel-powered lorries on the road, the full environmental benefit of modal transfer would only be achieved with electric traction. At present almost all freight haulage in Britain is by diesel traction and a major campaign of electrification would be needed to benefit from modal transfer.

7.5.2 Scope for 50% modal shift

Earlier sections have discussed some of the challenges of switching a substantial proportion of freight from road to rail. Even to achieve a 10% modal shift would require a doubling in rail freight traffic, the construction of many additional sidings to factories, quarries, aggregate depots and warehouse complexes, new freight lines, electrification and a nationwide campaign to extend the loading gauge to European standards.

Achieving a 50% modal shift would require a major reengineering of Britain’s transport network. Distribution warehouses and industrial sites would have to be resited to be near sea freight access and rail sidings, as was the Trafford Park industrial estate, started in 1896, rather than adjacent to motorways. New freight lines would have to be built. Urban rail networks would have to be extended to give a much higher priority to freight and rail depots would have to be reconstructed near the centre of urban areas. Overall, the infrastructure would revert to a form that was familiar some 80 years ago, before the growth of road transport.

Perhaps the biggest change would be in the organisational arrangements. It is inconceivable that changes as far-reaching as a 50% switch to rail would take place as a result of the publishing of a Government vision statement and a change in taxation and grants. Much greater coercion would be needed and would have to include draconian regulation of industry, carbon rationing, permits and other restriction last seen in the early 1950s.

Two years ago, at the height of the belief in liberal economics, such suggestions would have been completely unacceptable. A new economic structure is being planned that is likely to be less wedded to the Washington Accord and consequent assumptions of privatisation, competition and free markets. However a 50% modal switch would stretch politicians to the limit as it would require the tearing up of the European Union principles of a free market in transport of goods and the British belief in competition, free enterprise, support for small businesses and opposition to monopolies.

8 Summary of conclusions

This report has looked at some of the issues involved in making a 10% modal shift or a 50% modal shift in passenger transport. It is worth recalling from the introduction the inexorable growth in people’s travel:
It has been concluded that achieving a 10% modal transfer from road to rail by 2030 would be possible but far from straightforward. It would require substantial investment in the rail infrastructure – new stations, new light-rail systems, additional tracks on existing routes, new freight lines, extensions to existing routes, new and reopened routes, hundreds of new freight sidings, improved signalling systems, better station access, and so on. It is unlikely that such investment will be forthcoming from the privatised industry – particularly since the recent corporate failures. Both Government strategic direction and funding will be necessary.

Attempting to achieve modal shift in people’s travel habits is aiming at a moving target. Every year more people travel further and the total travel distance increases. Work on the Rebound Effect has shown that, as the speed and comfort of commuter services increase, so people move further from their place of work, thus keeping the journey time constant. Similar considerations apply to the inter-urban market.

Achieving high levels of modal shift in freight transport would be equally challenging. Although a large proportion of the population would support the concept of shifting freight to the railways, most would not welcome the implications discussed in earlier sections of this paper.

To achieve a 50% modal transfer in passenger and freight transport would require a revolution in the way the British population considers travel, as well as calling into question many of the social trends of the last 60 years: the move to suburban living, second homes, long-distance commuting, smaller families, mobility of labour, couples with independent careers working in different cities, out-of-town shopping centres, school choice, centralisation of NHS facilities and long weekends away. Although there are technical “fixes” (such as PRT) that would allow modern lifestyles without personal car transport, the costs of widespread adoption are likely to be unrealistic. Without such “fixes” it is difficult to see public acceptability of 50% modal transfer under any plausible scenario. The prerequisites for a 50% switch in freight transport go directly against many of the principles of competition, free enterprise and liberal economics that governments, of whatever political persuasion, have followed for the last 40 years.

Roger Kemp
Lancaster University
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