HIGH SPEED RAIL
WHERE ARE THE ENGINEERS?

PWI York Section member Colin Elliff is a Chartered Civil Engineer with almost thirty years experience in the railway industry. In this contribution to the PWI Journal he tackles some of the issues associated with the potential for high speed rail in the UK and highlights where engineers can help define some of the options.

High Speed Rail - A New Dawn?

For years we have been talking about high speed rail. Its benefits are hardly in dispute; faster journeys, improved connectivity bringing regeneration benefits, enhanced capacity on the existing network and the chance for a sustainable and environmentally friendly railway. Already, our continental neighbours in France, Germany and Spain, are reaping its benefits. But high speed rail comes with a hefty price tag and so far UK Governments of whatever political hue have baulked at taking the plunge.

But with the ever increasing price of oil, and with the triumphant entry of High Speed One into St Pancras, it seems that the moment has at last come for a high speed rail network to spread northwards into the UK. When this happens, it should be the most significant development in UK transport since the advent of the motorways, and the first major development of the national railway network since the nineteenth century. None of this can happen without engineering works on an immense scale – or without a new generation of engineers prepared to emulate their Victorian forbears and to drive the design and the construction forwards.

So it seems singularly odd, that in the various groupings which are currently pushing the case for high speed rail and promoting new routes, transport planners seem to be dominant while engineers are conspicuous by their absence. Sour grapes perhaps; but more worrying is the apparent absence of a specification. This is the fundamental discipline that should underpin any project, large or small. We know that we want high speed rail – but we have yet to work out what we want it to do.

The problem is that nobody, at least in the UK, has ever designed a brand new system of railways. It is not a subject taught at universities, and nobody has yet written the requisite British Standard or Eurocode. This may not have worried the railway pioneers of the nineteenth century but in the regulated world of the twenty-first century, engineers are now a more timid breed. We tend to shrink from issues which we do not fully understand or cannot quantify. And in the case of high speed rail, with all its apparent mystique, engineers have been very backward at coming forward.

Certainly none of this should be read as belittling the excellent works that have gone into the construction of High Speed

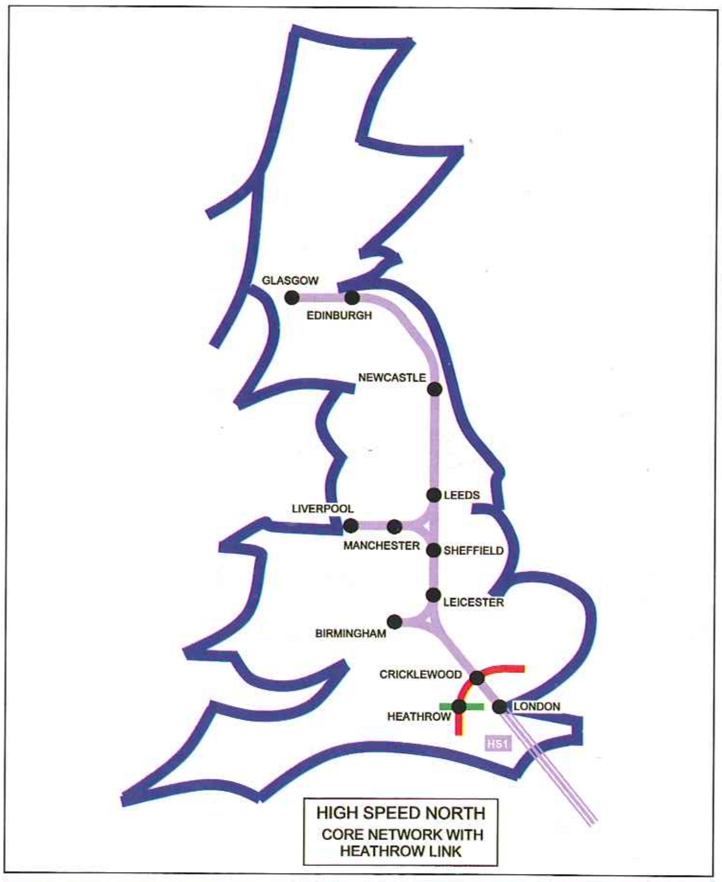

Figure 1 - High Speed North

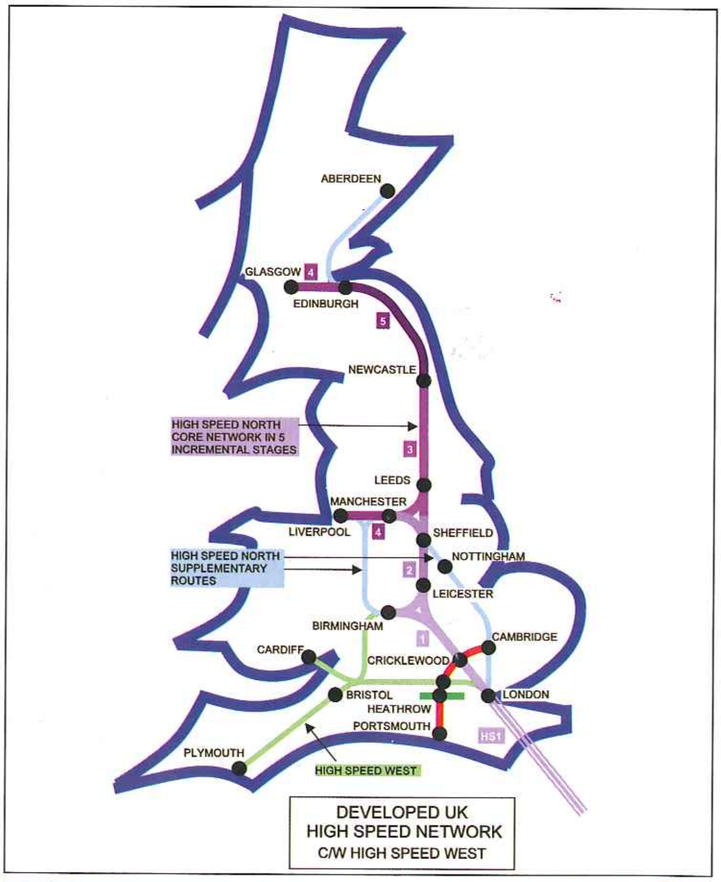

Figure 2 - Developed UK High Speed Network

One, or demeaning the achievements of those who overcame the many technical challenges. But High Speed One was just that – a technical challenge. There was never any doubt of the fundamental requirement for a new high speed railway linking the Channel Tunnel to a north facing London terminus.

High Speed Rail in the UK
Different Challenges

However, for the onward development of high speed rail into the UK, the issues are different. Unlike HS1, which is either in tunnel or on viaduct for a large percentage of its length, topography should be a much lesser issue. Instead, the challenges, at least initially, are more strategic. Where will the new lines go, and what will the basic shape of the resulting system be? How can the design be optimised, to achieve maximum benefit for minimised cost and environmental impact?

These are all basic engineering issues, questions that have to be correctly resolved if we are to avoid the major cost and programme overruns, not to mention scope creep, which have bedevilled major projects in the past. And the bigger the project, the greater the potential for these overruns will be. So it is essential that engineers are fully involved at the earliest stages – and that a disciplined, engineering-led methodology is adopted. And at the core of this methodology must be a high level specification, an agreed summary of the fundamental requirements for a UK high speed rail system.

A Specification for High Speed Rail

To date, no-one has attempted to write such a document. But a start has to be made, and the following core requirements are suggested:

1 - Network - The proposed high speed line(s) must form a logical incremental step in the formation of a genuine (ie not just London-centric) network linking city centres, improving connectivity between all principal UK conurbations and thus maximising economic and regeneration benefits.
2 - Inclusive Routeing - The network must be delivered in an even handed manner, without favouring communities west or east of the Pennines, and thus ensure the broad regional support essential for political acceptance.
3 - Economic Routeing - The maximum network benefits must be gained for the minimum length of new construction. Early gains must be assured by an incremental strategy of staged construction.
4 - Carbon Footprint / Sustainability - A major project such as a high speed rail network must be developed to modern carbon-critical design principles. Overall CO_2 emissions from the transport sector, and the rate of depletion of global fossil fuel reserves must be cut. For high speed rail, with potential increased energy use over conventional rail, this is only achievable by the elimination of most UK internal aviation, and not simply on routes to and from London.
5 - Environmental Impact - The network must be delivered with minimised environmental impact and demolition of property, by following existing transportation corridors where possible. This is essential for keeping the environmental lobby onside, and also minimising NIMBY objections and consequent costs.
6 - Enhancement to Existing UK Rail Network - The HSL system must offer capacity relief to the existing network on a maximum number of main line axes. (This is a key aspiration of the Network Rail's New Lines Programme, and it will also maximise environmental gains through increased capacity for freight and local passengers, allowing modal shift from roads).
7 - London Terminal Strategy - A practical London terminal site must be identified, with a strategy for dispersal of incoming passengers onto the wider underground and suburban rail networks, and for future-proofing against anticipated increases in passenger numbers. (This is a key recommendation of the 2003 SRA High Speed Line Study).
8 - Compatibility with Heathrow Developments - The HSL system must harmonise with necessary improvements to Heathrow rail access from the wider UK. This should eliminate any requirement for internal connecting flights, reduce local congestion and also achieve a wider spread of economic benefits arising from proximity to Heathrow. (This requirement for improved surface access aligns with both the Eddington Study and the SRA High Speed Line Study).

Hopefully, most items in the foregoing list comprise 'self-evident truths', needing little or no further explanation. It seems almost facile to state that a comprehensive network is the desirable outcome of a programme of high speed line construction, and that the maximum number of cities should be connected for the minimum route length. But none of the existing schemes score highly against these criteria. The Greengauge21 HS2 Proposition for a first stage route from London to Birmingham and the West Coast Main Line, with a branch to Heathrow, is particularly worth studying. (Reference 1).

Two significant themes can be drawn from current proposals:

1 - There appear to be major difficulties in achieving 'direct' high speed line access to Heathrow, with no apparent location for a station that can serve all terminals, without requiring construction of new secondary distributor networks within the airport. Moreover, the proposals will not resolve more local surface access issues. Major environmental difficulties will arise in the onward routeing through the Chilterns to the West Midlands, an excessively west-sided alignment that seems unsuitable for further extensions to the east side of the Pennines.

2 - Routeings are largely based around following either existing East or West Coast Main Line corridors. This leads inevitably to a London-centric system comprising two separate routes with poor inter-urban connections. That one or the other of these routes has to be built first would cause controversy in determining which is favoured with the initial phase of construction. A recent Atkins study demonstrated that an east-sided route scored higher benefit-cost ratios, but any betting must be on the west side to prevail, given the dominant influence of Greengauge21 in promoting their HS2 scheme. (Reference 2)

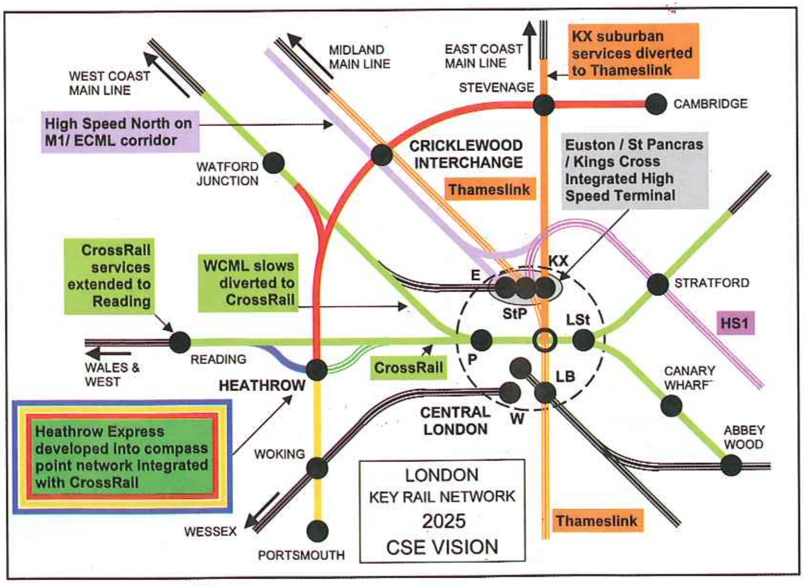

Figure 3 - Future London Key Rail Network

An Anglo-Scottish Spine Route?

But it need not be this way. Imagine instead a single Anglo-Scottish spine route, following the M1 corridor from London through the East Midlands to Yorkshire, then via Newcastle and Edinburgh to Glasgow. The spine would keep to the more favourable topography to the east of the Pennines, and would allow a single route to serve both Edinburgh and Glasgow. Two west-facing spurs, one to Birmingham, and the other to Manchester and Liverpool, would draw these outlying west side conurbations into the network, (see Figure 1).

The route would develop incrementally, northwards from London. The first stage, following the M1 and M6 to Leicester and Birmingham, would provide onward links to all Midland and West Coast Main Line destinations. Further stages would see all major Midlands, Northern and Scottish conurbations connected to the spine, and a comprehensive network created, for minimised route length, (see Figure 2).

The TransPennine spur to Manchester and Liverpool, routed via the abandoned Woodhead corridor, might seem a strange route to the North West, and it must be conceded that the London to Liverpool route via the Trent Valley is considerably shorter. But this drawback is far outweighed by the easier-east sided approach into Manchester, with redundant trackbeds available for most of the way to Piccadilly Station, the ability to maximise load factors by placing Liverpool, Manchester and Sheffield on the same through route, and also the opportunity created for a new TransPennine axis, at its extremities linking Lancashire and Scotland.

It is worth noting that with only four direct trains per day from Manchester to Edinburgh, and three to Glasgow, this sector is dominated by short haul aviation. This would change with a strong high speed TransPennine axis able to offer at least an hourly service with journey times below three hours. On a similar basis, the north-facing connection to the Birmingham spur would facilitate a major enhancement of the CrossCountry axis; and again rail would become the dominant mode over aviation, allowing major environmental gains.

Design Considerations

The importance of favourable topography should not be underestimated. Despite the ability of high speed rail to handle gradients as steep as 1:40, it is hugely constrained by the restrictions on horizontal alignment. Assuming 150mm cant and 100mm deficiency, a train running at 300kph will require a radius of approximately 4200m. (It should be noted that the recent Taiwan high speed rail project specified a minimum radius of 5500m, and a desirable figure of 6250m). These radii are only achievable in fairly level, open countryside; in more difficult areas, in particular the proposed Pennine crossing via Woodhead, much tighter radii would be required to ensure an environmentally acceptable solution. This will locally limit speeds to around 200kph.

Another aspect of high speed line design requiring the detailed consideration of engineers is the achievement of optimised economic construction. One way, already discussed, of achieving economies is to limit route length; but the other is to take all reasonable steps to reduce the 'per kilometre' price of construction. Currently the accepted figure stands at around £50M/km for a new section of 2-track main line; this seems to be derived from the experiences of HS1.

But, as previously noted, HS1 was a technically arduous project, with frequent tunnels and viaducts and a high requirement for environmental protection. For a high speed line north of London, however, closely following existing transportation corridors in more favourable topography, the opportunity exists to achieve major savings in construction costs. With little or no need for such environmental protection as noise barriers or earth bunds, or for disproportionate compensation and land purchase payments on sections paralleling an already noisy motorway, these costs can be stripped out at many locations. The cost build-up then reduces to that of:

1 - A formation of single-carriageway trunk road width, interspersed with frequent bridge structures and earthworks, £10M/km?,

2 - Two railway tracks laid on top of the formation, £1M/km?,

3 - An overhead electrification system, £1M/km?,

4 - A signalling system, £1M/km?,

5 - Secure lineside fencing, £1M/km?.

The simple 'engineering cost' is clearly far less than the £50M/km. It is the job of engineers to ensure that 'project costs', which might account for the balance, are rigorously controlled.

Domestic High Speed Terminal at Euston?

The new line would of course need its own dedicated central London terminus. St Pancras would be ideal, but it is already full with HS1 traffic. Fortuitously the nearby Euston Station has the ground plan to accommodate the 400m long trains that will be the norm on the new network. Much of its commuter traffic could be diverted to complement CrossRail and so address the curious imbalance between west- and east-sided services. And with a travelator Euston could be connected to the Underground and international hub some 600m away at Kings Cross / St Pancras, (see Figure 3). The forthcoming redevelopment of Euston presents a golden opportunity to establish this station as London's domestic high speed rail hub.

The Heathrow Question?

The question of Heathrow access is an important aspect of the high speed rail solution. Heathrow is the UK's premier international gateway, and the focus for many connecting flights from satellite provincial airports. If the environmental gains of high speed rail, accruing from a reduced requiremnt for internal aviation, are to be realised, it is essential that improved rail access to Heathrow is part of the solution. But this does not necessarily mean TGVs to Heathrow; the Greengauge21 proposals are ample illustration of the futility of this mindset. The smarter approach is to take a holistic view of surface access to Heathrow. Currently, it is a public transport disaster area. Its only rail links are to central London; all other axes are served by bus or coach. Yet the situation could be transformed, with relatively minor physical developments to Heathrow Express.

So far, all of the proposals for railway development at Heathrow have displayed a curious determination to leave the UK's premier international gateway at the terminus of several branch lines. This ignores its true need to be at the heart of its own network, capable of dispersing around 150,000 passengers, visitors and staff every day. Until now planners have been content to leave Heathrow Express as a limited, uniaxial system, and have failed to recognise the potential of its tunnelled infrastructure.

But this infrastructure extends to all airports terminals and could form the nucleus of a network that would revolutionise surface access to Heathrow. By integrating the existing Heathrow Express operation with the proposed Airtrack route to the southern network, by connecting back to CrossRail, heading west towards Reading and by the creation of a new northern orbital arm, mostly comprising existing routes with short connecting sections, Heathrow Express would be transformed into a 'compass point' network, with connections to all main lines radiating from London. No longer would it be necessary to bring the high speed line to Heathrow. With the proper surface connections in place, it becomes possible instead to bring Heathrow to the high speed line. A new interchange, constructed on plentiful redundant railway land at Cricklewood, would be the fulcrum of the system.

High Speed North and High Speed West The UK solution

The Anglo-Scottish high speed system described in the foregoing paragraphs has recently been published as High Speed North, (Reference 3). With a core system comprising a single spine route, two west-facing spurs and an orbital link to Heathrow, a superior network is created for a much reduced route length. Communities on both sides of the Pennines are kept happy, environmental gains are assured by obviating much of the need for UK internal aviation and surface access to Heathrow is radically improved. With the network to the north covering five of the six UK main line axes (ie all except Great Western) major capacity relief is achieved across most of the existing network. And with the route to the north established, it then becomes possible to switch the focus of high speed rail development to Wales and the West Country – as High Speed West – to complete the core network, (see Figure 2).

It almost seems too good to be true – but why not? A network configured to clear railway and engineering criteria should perform better than one developed in the absence of such guiding principles. But it will only happen if engineers take up the challenge. We have the skills – now is the time we should use them.

References

1 - 'High Speed Two – A Greengauge21 Proposition', Greengauge21, (2007)
This document can be found on www.greengauge21.net

2 - 'Because Transport Matters', Atkins, (2008)

3 - 'High Speed North - Joining Up Britain', Colin Elliff / 2M Group, (2008)
This document can be found on www.2mgroup.org.uk

Colin Elliff, in association with the 2M Group of London councils opposed to Heathrow expansion, has recently published proposals for 'High Speed North', an Anglo-Scottish high speed rail network complemented by radical improvements to Heathrow's local rail network.

What do you think? Do others share Colin Elliff's views or disagree with them? Is this a subject that the PWI should be involved with or is it outside our remit? Please contact the editor of the Journal with your opinions. He is keen to hear from you.