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HS2 railway, UK – why the country needs it

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High Speed Two (HS2) will be the new backbone of the UK rail network, connecting eight out of ten of the largest cities. Cities are drivers of economic growth, but those in the Midlands and the North are held back by poor connectivity. HS2 will help to rebalance the economy. Demand for rail travel has more than doubled over the past 20 years, and continues to grow. Rail lines serving London, Birmingham and Manchester are under particular pressure, with overcrowding and unreliability. The government is investing £40 billion in the existing network, but capacity shortages remain. HS2 will take pressure off the existing network and add capacity where it is needed most, providing connectivity to support a twenty-first century economy. HS2 will create 30 000 jobs during construction and 3000 jobs in operation. By bringing new investment, employment and regeneration to cities, HS2 can support hundreds of thousands of jobs. The new National Colleges for High Speed Rail will deliver the skills for HS2 and a skills legacy. HS2 is being designed to minimise environmental impacts. It will set new standards in passenger experience and reliability in the UK. It will deliver value for money for taxpayers, with benefits more than double the costs.

1. Introduction

In February 2009, when Andrew McNaughton joined HS2 Ltd – the promoter of the UK's High Speed Two (HS2) railway – as chief engineer, all staff could fit comfortably in the back of a taxi. By the end of that first year, it was the collective effort of around 30 dedicated people working all hours in Department for Transport (DfT) offices who delivered HS2's first report to government, setting out the strategic approach for the new high-speed line and a route from London to the West Midlands – a report pushed breathlessly over the line ahead of the 31 December deadline by a margin of just a few hours. Since then, the workload has grown relentlessly and HS2 Ltd currently employs around 1500 people, with the majority of staff working at the headquarters in Birmingham.

Legislation for HS2 phase one passed through parliament in February 2017 with all-party support, the main works contracts have been signed and construction is starting. The route for phase two has largely been agreed, legislation for phase 2a has been deposited and detailed work on a whole host of areas is being taken forward to prepare for the day the first HS2 trains carry their first passengers in 2026.

The author is proud to have been there at the beginning and see the project – and HS2 Ltd itself – grow and mature. Over the last 8 years, a large number of staff and consultants with an extraordinary range of skills have been engaged in developing the scheme. It has not all been plain sailing of course, but as this paper demonstrates, as the project has grown and the programme progressed, the delivery team has learned and adapted where necessary. This publication is about sharing that knowledge.

1.1 What is HS2?

HS2 is a new high-speed railway that will form the backbone of Britain's rail network. It will run between London and Birmingham from 2026 (phase one), extend to Crewe by 2027

(phase 2a) and then link to Manchester and Leeds from 2033 (phase 2b) (Figure 1).

Two new stations will serve the West Midlands – at Curzon Street in Birmingham city centre and an interchange station near Solihull designed to serve Birmingham airport and the wider West Midlands. At Old Oak Common in West London, a new interchange will be built connecting HS2 with Crossrail. Euston station will be remodelled with 11 new high-speed platforms. There will be a new station at Toton, serving Derby and Nottingham and the wider East Midlands, and redevelopment at Manchester Piccadilly and Leeds to accommodate HS2. HS2 trains will also stop at Sheffield Midland by way of a spur from the main HS2 line.

HS2 conventional-compatible rolling stock will run at high speed along the new HS2 line and then switch over seamlessly to existing tracks beyond Birmingham following phase one, Crewe following phase 2a and beyond Manchester and Leeds following the completion of phase 2b. They will continue on up the east and west coast main lines, serving towns and cities in northern England and Scotland. This will provide millions of people with access to the new high-speed network.

2. The vision for HS2

The future prosperity of the UK depends on a modern, strong and growing economy that enables the country to compete on the international stage. Good rail links are a prerequisite for a strong economy, making it easier to import and export goods, for people to do business and get to work, creating opportunities and underpinning economic growth.

The HS2 programme will reduce journey times and increase capacity on the rail network as a whole. These are the outputs, but since its very conception HS2 has been more than just a transport scheme. HS2 is an economic project – although it is



Figure 1. HS2 line of route in phase one, phase 2a and phase 2b

about outcomes too. HS2 is part of the strategic answer to unlocking Britain's economic potential where poor connectivity is constraining growth. It is an integral part of the Midlands Engine and Northern Powerhouse agendas, which will help bridge geographic divides and deliver a more united and cohesive economy. The vision is for HS2 is to be a catalyst for growth across Britain (see Table 1). By transforming journey times, HS2 will bring more opportunities within reach for work, trade, leisure and education. For working people it brings new job opportunities within reach. For businesses it opens up new markets, bringing

Table 1. HS2 Ltd's strategic goals and objectives

HS2 will be a catalyst for sustained and balanced economic growth across the UK

- To enhance the productivity of the UK by connecting cities and supporting local, regional and rural growth strategies
- To maximise business growth opportunities for UK suppliers, including the sharing of international best practice and making bidding for appropriate contracts as accessible as possible for local businesses and small/medium enterprises
- To develop all stations and depots in ways that facilitate regional and local regeneration and development

HS2 will add capacity and connectivity as part of a twenty-first century integrated transport system

- To deliver the required capacity, journey times, reliability and availability
- To integrate seamlessly with complementary transport modes
- To maximise benefits for the whole UK transport network

HS2 will deliver value to UK tax payers and passengers

- To deliver the programme on time and on cost while achieving the expected benefits
- To deliver and operate a quality railway efficiently and to ensure commercial viability
- To actively seek innovative opportunities to achieve new standards and practices in order to increase whole-life value

HS2 will set new standards in passenger experience

- To be the mode of first choice and to deliver passenger experience and customer service that is recognised worldwide as leading the way in high-speed travel
- To place people at the heart of the design, setting new standards for travel and ensuring HS2 is accessible to all passengers

HS2 will create opportunities for skills and employment

- To create sustainable job opportunities for young people, local people and those from diverse groups
- To foster and develop talent and to create an engaged and highly skilled workforce for the delivery of HS2
- To be an exemplar of EDI (equality, diversity and inclusion) practice
- HS2 will create a railway designed, built and operated with world-class health, safety and security standards

To manage the health and well-being of all workers to create a new and better standard in occupational health

- To protect HS2 assets and those of its suppliers
- HS2 will create an environmentally sustainable solution and be a good neighbour to local communities
 - To design every part of HS2 and its service to be sympathetic to the people and places affected and to stand the test of time
 To communicate actively with neighbours and interest groups to minimise the impact of HS2 construction and operation on people and the environment
 - To design, construct and operate HS2 to reduce carbon dioxide and promote sustainably sourced resources

new clients and customers closer and widening the catchment area of their workforce to access skills and increase productivity. Those considering higher and further education will have more colleges and universities within commutable distance.

HS2 is being built using public money, and, of course, there is a duty to use that money efficiently and effectively, but the duty goes further. HS2 has an obligation to ensure that the scheme provides wider social, economic and environmental benefits for the people of this country. This is reflected in HS2 Ltd's strategic goals.

HS2 Ltd is thus working to deliver on everything from environmental standards to jobs and skills, from health and safety to community engagement. Yet it is recognised that these wider benefits to the country must be built on the foundation of the economic case for HS2 – and this rests on the twin outputs of increasing capacity and connectivity.

3. More capacity

Most of the UK's current rail infrastructure dates from Victorian times. In 1850, Britain's population was just 15 million and 60 million rail journeys were made that year. Today's population of 65 million made almost 1.7 billion rail journeys in 2015–2016. Passenger numbers have more than doubled since privatisation in the 1990s and growth is continuing. Despite a

constant programme of upgrades, in many places the existing rail network is overcrowded, unreliable and congested. Freight use has also grown substantially – by 37% since privatisation and is anticipated to grow by around 90% by 2033 (DfT, 2016a).

Growth has especially affected services in and out of London Euston. Demand for the Virgin West Coast Main Line (WCML) has been growing by more than the average for long-distance services (Figure 2). Since 2010–2011, annual passenger numbers increased by 24%, to 34.7 million. London Midland, the main commuter operator running to Euston, has experienced similar growth. As a result, peak services are overcrowded. London Midland trains regularly appear in the government's annual list of the ten most crowded services. More than 10% of passengers arriving on peak-hour services into Birmingham and Manchester were standing (DfT, 2016a).

The number of trains per day has been increased in response to this demand. In 1994 there were 17 trains per day from London to Manchester. By 2016, this had increased to 48 trains per day (DfT, 2016a). However, the WCML is reaching the end of its ability to squeeze more trains on to the existing rail network; it is becoming effectively full. Furthermore, operating so close to capacity leads to considerable performance risks because there is limited ability to recover from incidents and therefore knockon effects occur from one service to another.



Figure 2. Growth in intercity rail journeys by corridor, 1994 to 2013/2014



Figure 3. Forecast of long-distance demand and recent long-distance operator passenger numbers

There is no evidence that growth will stop. The DfT estimates that if growth continues at 3.7% per year, by 2033/2034, on a typical weekday in the evening peak, 3200 passengers would have to stand on intercity trains departing London on the WCML. Of these people, 40% would be standing for an hour or more. On Friday evenings this situation would be even worse, with substantial numbers of people standing for 90 min – as far as Crewe or Warrington. On commuter trains, in a similar growth scenario, overcrowding would become a serious operational issue by 2033 (DfT, 2016a).

As Figure 3 illustrates, the demand forecast used to make the economic case for HS2 is a conservative assessment as the modelling assumes no increase in passenger demand after 2036 and no changes to population or employment as a result of the scheme.

The government has a huge programme for investment in the existing network, with more than £40 billion between 2014–2019 available to Network Rail for enhancing, renewing and maintaining the railway (DfT, 2016a). However, even this scale of investment cannot keep pace with rising demand in the longer term, which, if constrained, will undermine economic growth. The experience for passengers will also deteriorate and become increasingly unsatisfactory

So something transformative is required. The patch-and-mend approach has reached the limits of its effectiveness. As a new line, HS2 will add extra capacity to the rail network from day one. By 2033, HS2 will provide for up to 18 trains per hour running in both directions to and from London, and an extra six trains per hour both to and from Birmingham. Each HS2 train will carry up to 1100 passengers. Once the full network is

More seats per passenger 34 900 30 300 23 200 11300 1600 6600 6800 6800 3900 6500 6500 6500 5800 1800 1800 1800 8300 15 400 19800 HS2 phase one and two Current HS2 phase one HS2 phase one initial service full capability full capability Peak-period departing Euston Commuter fast Commuter slow HS2 Intercity Over 300 000 800 lorries 13 extra trains passengers Off the road per day on HS2 services, on average, each day Potential increase in London Midland with connections to the commuter services during morning rest of the network peak due to HS2 phase one 2 extra lines Up to 40 100 freight trains towns extra per day to support and for Manchester Piccadilly local business cities freeing up space for could benefit from new local services or improved rail connections

Figure 4. Infographics of HS2 statistics

up and running, HS2 trains are expected to carry over 300 000 passengers a day (Figure 4). The government has planned for the future by making sure that the HS2 network can grow with increased demand. On the current proposed service schedule, HS2 will more than double the number of seats available out of Euston in the evening rush hour, relieving the pressure on commuters (DfT, 2017a).

As well as directly providing capacity on the new line, HS2 will release capacity on the existing rail network, thus improving performance and allowing train companies to provide new or more frequent services, including options for cross-country, commuter and freight services east to west and between the Midlands and the North. It could also double the number of peak-time seats available on busy services from Manchester Piccadilly towards Crewe and Stoke, and from Leeds towards Wakefield and Doncaster. It has the potential to almost double the number of peak seats from London to Peterborough and east coast destinations further north (DfT, 2017b).

Of course, decisions on new services are not a matter for HS2 Ltd. Service design, redesign and timetabling are normal processes that have well-established statutory, regulatory and administrative procedures. Network Rail's long-term planning process, franchise specifications, track access agreements and the Office of Rail and Road will all play a part in shaping the new service pattern as HS2 is introduced. It is clear, however, that the released capacity provides options for extra services between places that will not directly receive HS2 trains. HS2 will make a difference even for those who do not wish to use its fast long-distance services and in this way will contribute to resilience and better services across the whole network.

4. Connecting cities

The UK's city regions are the engine rooms of the economy, creating jobs at twice the rate than elsewhere (DfT, 2016a). Some 85% of the population lives in an 'urban economy' where employment is in city regions (ITC, 2016) (Figure 5). Over the last 20 years, rail and road travel between these city regions has grown at a faster rate than the national network as a whole, increasing the need for better intercity transport links.

Over the past 30 years or so, the structure of the UK economy has also changed away from manufacturing and towards services, especially knowledge-based sectors such as advanced manufacturing, digital, professional and creative services (DfT, 2016a). Jobs in these sectors have grown at nearly



Figure 5. Urbanisation in the UK, 2014 (ITC, 2016)

three times the rate of job growth in other sectors in recent years. Knowledge-based sectors now account for 17% of all jobs, 23% of national output and 34% of exports. Jobs in these sectors are more likely to be based in urban areas, reinforcing the role of our cities as drivers of economic growth (DfT, 2016b). They are also, therefore, the sectors that particularly depend on good intercity travel for their continued growth. Key for them is accessing intellectual capital and financial centres. Hi-tech industries in particular tend to cluster together where there is a high skills base and supply chains can be better integrated. Even with the growth of email and web-based meetings, evidence suggests that face-to-face meetings are particularly important for firms in knowledge-based sectors.

With its concentration of knowledge and service sectors, the rate of job growth has, for many years, been faster in London and the South East than elsewhere, contributing to a widening gap in prosperity with the rest of the country. Since 1997, gross value added per capita (the value of goods and services produced in a region divided by the population of the region) in London has grown from 59% above the UK average to 72% above (DfT, 2017a). Additionally, productivity in London was 32% higher than the UK average in 2015. However, city regions in the North and the Midlands are between 10–17% below average productivity for the UK (ONS, 2017).

Connectivity in the north of the UK is often poor, especially between the cities. The Northern Transport Strategy report (DfT, 2015), published in 2015, set out how better connected cities can help create more unified economies and labour markets in order to promote growth and agglomeration. This is at the heart of the Northern Powerhouse and Midlands Engine visions to rebalance and grow the UK economy through a radical increase in productivity in the North and Midlands supported by good transport networks.

HS2 will connect eight out of ten of the largest UK cities and their regions, with faster journey times between key economic hubs (Figure 6).

The improvements in connectivity created by HS2 will open up enormous opportunities for these city regions to function as a cohesive economic unit rather than as independent economies as they do today. HS2 will also improve connectivity by integrating with the existing network. HS2 trains will serve towns and cities on the east and west coast main lines after leaving the dedicated high-speed line, improving journey times to and from Birmingham and London. Liverpool, for example, will see the journey time to London improved by 41 min while a trip from Durham to Birmingham on an HS2 train will be almost an hour quicker. The trip from Glasgow to London will be 50 min faster (Figure 7). Stations like Darlington, York, Preston, Wigan and Carlisle all act as travel hubs for



Figure 6. Current journey times and journey times under HS2 full phase two

their regions. Overall, HS2 will serve over 25 stations, connecting around 30 million people.

The prospect of HS2 is already having a catalytic effect. HS2 growth strategies are now in place for phase one stations between London and Birmingham, and are in development along the phase two route. Local authorities and local enterprise partnerships are building HS2 into their plans to grow their local economies and regenerate their towns and cities.

In north-east England, HS2 will link the industries of Tyneside, the Tees Valley and Yorkshire to Birmingham and London. In the north-west, HS2 will open up the aerospace industries of Lancashire, the nuclear industries of Cumbria and the tourist industry of the Lakes to swift, frequent and reliable journeys to and from the Midlands and the south.

The transformational reduction in journey times means that regions are beginning to think about new ways of trading with each other in skills and products, so creating the critical mass of talent, innovation and accessibility that global cities like London take for granted.

5. Conclusion – HS2 the right solution

Studies undertaken by the government have shown that HS2 is the best way to deliver the capacity and connectivity needed for the future while minimising disruption and taking into account environmental and community impacts (DfT, 2013).

Domestic aviation has been ruled out as an alternative, as it is most economically viable for journeys over 400 miles (\sim 650 km), which is about the distance from London to Glasgow or Edinburgh. Check-in times mean that, for many shorter intercity journeys, road or rail will almost always be a better option than domestic aviation.

Additional road capacity also cannot alone cater for the predicted increase in passenger demand. Roads are not well suited to improving connectivity between city centres, because traffic speeds are limited, or for providing additional commuter capacity into major cities, because of the traffic constraints that exist there.

With regard to rail solutions, the government also considered whether fare increases could be used to restrict the growth in demand, but this would need to involve very significant fare increases and would discourage people from using this more environmentally friendly form of transport. Such a policy would not meet the objective of improving connectivity between cities and would have serious consequences for economic productivity and growth.

The government considered a number of rail infrastructure improvement options as alternatives to HS2, but research showed that they would not deliver such great improvements in connectivity between most points, would not provide the same level of additional capacity and so would not meet the long-term needs of the rail network. While some of the alternatives had similar cost-benefit ratios, they did not provide the same improvement in reliability and some of the options would involve significant disruption as they would involve work on existing, busy rail lines. Taking all these factors into account, the alternatives would deliver significantly less total benefits for passengers, the economy and the country as a whole.

At key points through the development of HS2, valuefor-money appraisals of HS2 have been undertaken, considering the benefits and revenues against the costs. These analyses used the DfT's recommended methodology, Webtag, and compared HS2 with the 'do minimum' option of what would happen without HS2. These analyses have consistently shown that HS2 offers good value for money, with benefits more than twice the costs. The results of these analyses have been subjected to a range of sensitivity tests, such as lower or higher demand growth, or lower or higher costs, which have demonstrated that the business case is robust in the face of a range of alternative futures.



Figure 7. Comparison of current journey times and HS2 journey times by phase

The updated economic case, published in July 2017, shows that for every £1 invested in HS2, the UK will receive $\pounds 2.30$ in benefits, delivering £92 billion in benefits overall. Some 80% of this will translate directly into higher gross domestic product. Of course, much of the money used to build HS2 will be recycled into the economy. Thousands of jobs will be created around the stations served by HS2. A total of 30 000 private-sector jobs will be needed to build HS2 and over 1000 people a year will be trained at the new National

Colleges of High Speed Rail in Birmingham and Doncaster when they are fully up and running. The goal is to provide Britain with a legacy of skills and experience that will benefit the whole of industry.

That is why the data in this paper are so important. By sharing the project team's knowledge, the hope is that it can help improve the way infrastructure in the UK is built. HS2 is likely to be followed by further major rail projects, not least the plans being developed for an east-west link by Northern Powerhouse Rail. Just as HS2 built on the example set by Crossrail, it is hoped that the experience of HS2 will be taken forward into new projects.

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