

Civil engineering insights on HS2 and alternative proposals

February 2022

Overview

There is a growing need for additional rail capacity in the UK. While the Covid-19 pandemic makes predicting long-term trends difficult, estimates suggest the UK's population could grow to 75 million by 2050¹, an increase of eight million people from 2020.² Prior to the onset of the pandemic rail travel had experienced a renaissance in use – between 2012/13 and 2017/18, annual passenger journeys increased from 1.5 bn to 1.7 bn.³ However, as far back as 2014, 26% of morning peak trains into London were over capacity⁴, and pre-pandemic estimates suggested overall passenger numbers could still rise by 40% by 2040.⁵

The pandemic has caused many uncertainties, however the underlying demand drivers behind transport usage will remain similar – a growing and ageing population, the need to decarbonise infrastructure and reducing regional inequalities. Investment in new rail capacity, new routes and upgrading existing lines is needed to meet this expected demand and support the economic growth necessary to enhance the UK's competitiveness in the global economy.

Delivering on the Government's commitment to reach net-zero carbon emissions by 2050 means the uptake of cleaner, more efficient modes of travel. The transport sector is the largest contributor of emissions in the UK, accounting for 27% of all domestic greenhouse gas emissions in 2019, mainly from road transport.⁶ Electrified rail, however, is significantly cleaner than existing road, air or sea traffic, especially when powered by renewable or carbon-neutral sources of energy.

Purpose of this paper

This paper provides an overview of the status of High Speed 2 (HS2), the costs and benefits of the project, and alternative options which have been considered. It combines insights from ICE Fellows, industry experts and published evidence and will be periodically reviewed as HS2 and the debate surrounding it progress.

It is clear from the analysis that there is need for additional capacity on key rail corridors, between London, the Midlands, the North West and North East of England and into Scotland, to help rebalance the UK's economy and deliver net-zero. What has been contested is whether this capacity should be met through new, faster routes or whether alternatives could be delivered more cheaply while offering similar benefits.

¹ ICE (2016) [National Needs Assessment](#)

² Office for National Statistics (2021) [Population estimates](#)

³ Office of Rail and Road (2021) [Passenger rail usage - Passenger journeys](#)

⁴ ICE (2016) [National Needs Assessment](#)

⁵ Network Rail (2018) [How the Digital Railway will grow capacity on the railway](#)

⁶ Department for Business, Energy and Industrial Strategy (2021) [2019 UK Greenhouse Gas Emissions. Final Figures](#)

About High Speed Two (HS2)

HS2 will enable a new fleet of high-speed trains to travel at up to 360 km/h (225 m/h) between London and multiple cities in the Midlands and North of England.⁷ The route was originally planned as a Y-network with a line running from London to Birmingham, where it would split, with a Western Leg running to Crewe and Manchester and an Eastern Leg to Sheffield and Leeds.

In 2019, amid concerns about the rising cost of the project, the Government asked former HS2 chairman Douglas Oakervee to conduct a review assessing whether and how to proceed with HS2. The Oakervee Review concluded that on balance the Government should go ahead with the project. However, it recommended that a further rail plan for the North and Midlands be developed to ensure HS2 was properly integrated with other transport strategies, such as Northern Powerhouse Rail (NPR) and Midlands Engine Rail.⁸

The route

The Integrated Rail Plan for the North and Midlands (IRP) was published in November 2021 and sets out revised proposals for HS2 and NPR, most notably a much-reduced Eastern Leg of HS2.

Under the IRP, HS2's Western Leg from Birmingham to Manchester via Crewe will proceed, with a station to serve Manchester Airport. There will also be a connection to the West Coast Main Line (WCML) enabling services to Scotland, currently proposed to run via the Golborne link.

However, the Eastern Leg will be shortened, with a new high-speed line between Birmingham and East Midlands Parkway, from where trains will be able to continue on the Midland Main Line, which will be further upgraded, to Nottingham, Derby, Chesterfield and Sheffield. Thereafter, the IRP states only that the Government will "look at the most effective way to run HS2 trains to Leeds".⁹

Delivery and costs

HS2 will be delivered in three phases. Construction of Phase One, which consists of new high-speed track running from London Euston to Birmingham, commenced in 2020 and is due to be completed between 2029 and 2033.¹⁰

Phase 2a will deliver a short extension from Birmingham to Crewe. The hybrid Bill authorising construction gained Royal Assent in 2021 and the line will be constructed at the same time as Phase One to also open between 2029 and 2033.¹¹

Phase 2b covers the Crewe to Manchester link of the Western Leg and the shortened Eastern Leg. It is expected to be completed by the mid-2040s, however it is still subject to parliamentary approval with the Government having tabled a hybrid Bill for the Western Leg component in January 2022.¹²

Prior to the revisions announced in the IRP, the projected cost of the full HS2 Y-network had risen from £55.7bn at 2015 prices to between £72bn and £98bn at 2019 prices. The Government cited the rising costs as one of its reasons for scaling-back the Eastern Leg.

⁷ HS2 Ltd (2021) [Building HS2](#)

⁸ Department for Transport (2020) [Oakervee Review of HS2](#)

⁹ Department for Transport (2021) [Integrated Rail Plan for the North and Midlands](#)

¹⁰ HS2 Ltd (2021) [Phase One: London to West Midlands](#)

¹¹ HS2 Ltd (2021) [Phase 2a: West Midlands to Crewe](#)

¹² Department for Transport (2021) [Integrated Rail Plan for the North and Midlands](#)

According to the IRP, completion of HS2 Phase One and 2a now has a provision of £42.5bn. The cost estimate for the Phase 2b Western Leg is between £15bn and £22bn (2019 prices) based on the introduction of services between 2035 and 2041.¹³ The Eastern Leg is part of a £12.8bn package that will include upgrades to the Midland Main Line and East Coast Main Line. Prior to March 2020, £8.3bn had been spent on HS2.¹⁴

Identified benefits

ICE's National Needs Assessment identified a need for investment to increase capacity on Britain's rail network.¹⁵ The Department for Transport and HS2 Ltd believe that HS2 will meet future capacity needs¹⁶, whilst also facilitating economic growth and productivity improvements and reducing carbon emissions from transport.

Capacity, timetable resilience and overcrowding

A new high-speed railway line would allow for some long-distance intercity services to move from existing mainlines to a dedicated line. HS2 Ltd argues this will free-up much needed capacity on three major North-South routes (the West Coast, East Coast and Midland main lines) for local and regional passenger services and freight trains.¹⁷ Proponents argue that a high-speed line would reduce journey times between cities and increase timetable resilience at a similar cost to a new standard speed line.

Currently, the WCML has no capacity to handle additional services without impacting performance and timetable resilience.¹⁸ This affects punctuality, reliability and the risk of cascading failure, particularly when the line is blocked by a failed train or when engineering or upgrade work needs to be undertaken.

While long-term demand is uncertain due to the impact of Covid-19, pre-pandemic trends suggested there would be significant additional pressure on the WCML by mid-century. Passenger journeys almost tripled from the mid-1990s, growing from 13.2m in 1996/97 to 39.5m in 2018/19 – growth of 199% compared to 119% on the wider rail network.¹⁹ Even if further upgrades and new signalling technologies allowed more capacity, there will most likely still be a need for additional capacity through a new line.

The strategic case for HS2 argues Phase One will meet this need by increasing combined capacity on the London to Birmingham corridor from 15 to 23 trains per hour for intercity services and from eight to ten metro services per hour.²⁰

¹³ Department for Transport (2022) [HS2 Phase 2b Western Leg: Crewe to Manchester – An update on the Strategic Outline Business Case](#)

¹⁴ Department for Transport (2021) [Integrated Rail Plan for the North and Midlands](#)

¹⁵ ICE et al (2016) [National Needs Assessment](#)

¹⁶ Network Rail (2019) [Digital Railway](#)

¹⁷ HS2 (2021) [Capacity - helping reduce overcrowding](#)

¹⁸ Office of Rail and Road (2020) [West Coast Main Line Capacity Assessment 2020](#)

¹⁹ Department for Transport (2020) [Full Business Case – High Speed 2 Phase One](#)

²⁰ Department for Transport (2017) [Strategic Case](#)

Economic growth and regional rebalancing

HS2 is a core part of the Government's levelling-up agenda, intended to rebalance the UK economy.²¹ By improving North-South and regional connectivity, proponents argue HS2 will catalyse investment and enable new skilled jobs to locate in the North and Midlands by widening their cities' travel to work catchments, which upgrades to existing lines cannot achieve alone.^{22 23} This will enable the redistribution of businesses and professional services outside of London.²⁴

Research for HS2 Ltd, conducted with businesses, local authorities and universities, suggested that the project would connect industries, open up new markets and enable greater collaboration, knowledge exchange and innovation. Participants also said that HS2 would expand catchment areas for other transport sectors, including airports.²⁵

HS2 itself is forecast to support around 34,000 jobs at peak construction and 2,000 apprenticeships over the life of the project.²⁶ The Government's analysis found that the benefits to the financial position of Britain's railways could range from £170m (Phase One) to £670m (Full Y-Network) per year.²⁷

The IRP sets out how HS2 could interact with and enable other local and regional connective transport links. Organisations like Midlands Connect argue that improvements to the Midlands Rail Hub which unlock greater regional connectivity to HS2 will mean a greater catchment area and possibilities for new jobs, housing and infrastructure.²⁸

HS2 and productivity

Boosting productivity in the UK's regions to drive economic growth has always been central to the case for HS2. In 2019, output per hour worked was 49.4% above the median in London and 21.7% higher in the South East. However, both the North East and East Midlands were 2.5% below the median and Yorkshire and the Humber 3.7% below.

While the Government has not yet published the economic analysis behind the IRP, it does reference research by the National Infrastructure Commission (NIC) suggesting the significant productivity improvements that could accrue to the North and Midlands through investing in the rail network to improve connectivity.²⁹

The NIC's work does not focus on HS2 alone but assesses a range of investment levels and rail packages. It suggests that prioritising investment in regional links could boost productivity in city centres by £30-71bn depending on the measures and level of investment, while prioritising long-distance links could deliver £25-58bn in additional productivity.

The environment and net-zero

To meet the UK's 2050 net-zero target there is an urgent need to decarbonise transport, which is the country's largest emitting sector, contributing 27% of total emissions in 2019.³⁰ However, these derived primarily from petrol and diesel use in road transport making modal shift to other forms of transport key to achieving net-zero.

²¹ HM Treasury (2020) [National Infrastructure Strategy](#)

²² Department for Transport (2021) [Integrated Rail Plan for the North and Midlands](#)

²³ Department for Transport (2020) [Full Business Case – High Speed 2 Phase One](#)

²⁴ HS2 (2019) [HS2 can help realise the potential of the North](#)

²⁵ Department of Transport and HS2 (2017) [Getting the best out of Britain](#)

²⁶ HS2 (2021) [Building skills to deliver HS2](#)

²⁷ Department for Transport (2020) [Full Business Case – High Speed 2 Phase One](#)

²⁸ Midlands Connect (2019) [Access to HS2](#)

²⁹ National Infrastructure Commission (2020) [Rail Needs Assessment for the Midlands and the North – Final Report](#)

³⁰ Department for Transport (2021) [Transport and Environment Statistics](#)

Electric rail is one of the cleanest forms of transport. According to Eurostar, a train journey between London and Amsterdam emits 80% less carbon per passenger than an equivalent flight.³¹ Research by Greengauge 21 found that emissions from HS2 would be 73% lower than those from making the same journey by car and 76% lower than flying.³²

A 2012 model by HS2 Ltd indicates the impact HS2 could have. It suggested that by 2037, while 24% of HS2 customers would be making new journeys not currently served, as a result of future demand and population growth, 3% of customers would shift from air travel and 8% from car journeys.³³ This would represent 4.5 million trips moved from air to rail.³⁴

HS2 would have the potential to compete on journey time and cost with internal flights, including between London, the North and Scotland. Equivalent air-to-rail shifts have occurred in Europe, such as Lufthansa's express rail service which replaced flights between Frankfurt and Cologne using a new high-speed rail link.³⁵ Research into correlations between journey times and how people choose to travel suggests that when rail and air travel takes the same amount of time more people choose rail.³⁶

The additional capacity for rail freight created by HS2 would also have an environmental benefit. Rail freight is one of the most carbon efficient ways to move goods over long distances – on average, freight trains emit around a quarter of the CO2 emissions of HGVs per tonne km travelled. However, only 8% of the 196 billion tonne kilometres of domestic freight moved within the UK went by rail in 2019.³⁷

High-speed rail – evidence from other schemes

High-speed rail is not new to the UK. High Speed One has operated between London and the Channel Tunnel since 2007. There are also highly developed high-speed networks in Spain, France, Germany, China and Japan.

International examples

A post-implementation cost–benefit analysis of the high-speed line between Madrid and Barcelona found that other cities on the line, like Zaragoza and Lleida, saw population increases following the arrival of high-speed rail, suggesting they were seen as more attractive areas in which to reside and work.³⁸

In France, Lille has captured the benefits of high-speed rail through a major regeneration scheme that includes a new economic centre, whilst Lyon established a new business district at the same time as its high-speed railway line, the first in France, struggled to accommodate demand.³⁹

In terms of the benefits of high-speed rail for freight, the Mercitalia Fast high-speed freight service in Italy has taken approximately 9,000 trucks a year of the road and reduced carbon emissions by approximately 80%.⁴⁰

³¹ Eurostar (2019) [Eurostar Introduces third direct daily service from London to the Netherlands](#)

³² Greengauge 21 (2012) [High Speed Rail, The carbon impacts of High Speed Two](#)

³³ Department for Transport (2012) [Economic Case for HS2: Updated appraisal of transport user benefits and wider economic benefits](#)

³⁴ Ibid

³⁵ Frankfurt Airport (2019) [Lufthansa Express Rail](#)

³⁶ Department for Transport (2021) [Union Connectivity Review](#)

³⁷ Department for Transport (2021) [Integrated Rail Plan for the North and Midlands](#)

³⁸ European Commission (2011) [High Speed railway – Madrid – Barcelona in Spain](#)

³⁹ Independent Transport Commission (2014) [Ambitions and Opportunities, Understanding the Spatial Effects of High Speed Rail](#)

⁴⁰ Department for Transport (2020) [Oakervee Review of HS2](#)

High Speed One (HS1)

HS2 is named as a spiritual successor to HS1, which has serviced the Eurostar rail link in South East England since 2007.

An early evaluation of HS1 found, in broad terms, that the line had played a “catalytic role” in enabling regeneration around high-speed stations, creating the conditions for investment and co-ordination of regeneration activities – but noted that the effect was considerably greater in London than Kent.⁴¹

More recent research on the impact in Kent found that 400,000 more workers now live within a one-hour rail journey of Central London, 15,000 new homes have been built in regeneration schemes enabled by HS1 and 47,000 young families, couples and singles have relocated to the HS1 catchment area since 2009. Those most likely to be able to access opportunities in London via HS1 compared to the wider rail network were lower-skilled and lower-income individuals.⁴²

The line substantially cut travel times for domestic and international passengers, yielded a 40% increase in capacity for domestic services, and led to a reduction in average overcrowding and an increase in the punctuality and reliability of services.⁴³ In the six years since 2010, demand on domestic high-speed services almost doubled.⁴⁴ It has also enabled modal shift, with research suggesting that 11 million domestic and 15 million international passengers use the line each year including almost four million who have switched from using cars and planes.⁴⁵

Analysis by Volterra suggested that combined additional rail and car park revenues and quantifiable transport benefits “offset the whole project cost” for HS1, while wider economic benefits and regeneration added additional value.⁴⁶

Do we still need HS2?

Construction on HS2 Phase One commenced in September 2020 and the recently published IRP sets out the Government’s updated vision for the entire network. However, the Covid-19 pandemic has prompted uncertainties about the future of public transport, so it is worth considering whether we still need HS2?

What the public want from rail

In 2019 rail accounted for 2% of all journeys but 10% of total distance travelled in England. In contrast 61% of journeys and 77% of distance travelled was by car or van.⁴⁷ On average people took 21 surface rail trips at 82 minutes per trip.⁴⁸

Commuting was the primary purpose of rail journeys (47%), followed by leisure (26%) and business (10%).⁴⁹ Despite this, very few passengers use a train journey to be economically productive – according to a DfT survey just 10% of passengers spent most of their time on a long-distance train journey doing work.⁵⁰

⁴¹ Atkins (2015) [First Interim Evaluation of the Impacts of HS1. Final Report, Volume 2 – Appendices](#)

⁴² Steer (2020) [Delivering for Britain and Beyond – The Economic Impact of HS1](#)

⁴³ Atkins (2015) [First Interim Evaluation of the Impacts of HS1. Final Report, Volume 1 – Main Report](#)

⁴⁴ Steer (2020) [Delivering for Britain and Beyond – The Economic Impact of HS1](#)

⁴⁵ Ibid

⁴⁶ Volterra (2009) [Economic Impact of High Speed 1](#)

⁴⁷ Department for Transport (2020) [National Travel Survey: England 2019](#)

⁴⁸ Ibid

⁴⁹ Ibid

⁵⁰ Department of Transport (2019) [Public attitudes towards train services: results from the February 2018 Opinions and Lifestyle Survey](#)

Reliability is a key factor in what the public want from rail services. According to the National Rail Passenger Survey (NRPS), the largest impactor on passenger satisfaction is punctuality (37%), while how companies dealt with delays was the biggest impactor on dissatisfaction (49%).⁵¹

Despite more than a decade of sustained above-inflationary rises in revenue funding and record amounts of capital investment, rail satisfaction remains mixed. The most recent NRPS, for the period immediately prior to the 2020 Covid-19 lockdown, found 84% of passengers were very or fairly satisfied with long-distance journeys. However, only 55% were satisfied with value for money, 73% with the level of overcrowding and 74% with punctuality on long-distance journeys.⁵²

The impact of Covid-19

Covid-19 has had an immense impact on how people live, work and travel. The average number of trips per person in England on surface rail plummeted from 21 in 2019 to 13 in 2020, and miles travelled from 625 per person to 241.⁵³ Research has suggested that while leisure travel was returning towards pre-Covid levels during 2021, commuter trips were still well down.⁵⁴ Changing patterns of work could see fewer commuter trips becoming the norm.

Nevertheless, research by ICE suggests that much of the UK's infrastructure will still be required to operate just as it did before the pandemic.⁵⁵ The underlying drivers behind demand will remain similar: the UK's population is still expected to grow and age, our infrastructure sectors will still need to decarbonise and become more climate resilient, and regional inequalities will still need to be addressed through infrastructure interventions.

The NIC has also cautioned against making planning assumptions based on short-term trends and advised taking a long-term, adaptive approach based on a range of possible demand scenarios.⁵⁶ In the IRP, the Government argues that it has followed this advice enabling the plan to evolve in light of future demand and cost information, for example in regard to the question of how best to connect HS2 with Leeds.

Business sentiment

Business organisations continue to see value in HS2 for their members. The Confederation of British Industry (CBI) has campaigned for HS2 to be built in full, arguing it is "a real opportunity to regenerate local economies, provide jobs and boost growth across communities".^{57 58}

The Federation of Small Businesses (FSB) believes that major infrastructure projects such as HS2 are important for small businesses to survive and create jobs, particularly in a challenging economic environment.⁵⁹ Following publication of the IRP the FSB called on Government to ensure the new plan would deliver the same benefits to passenger and freight capacity as the original proposal.⁶⁰

⁵¹ Transport Focus (2020) [National Rail Passenger Survey](#)

⁵² Ibid

⁵³ Department for Transport (2021) [National Travel Survey: 2020](#)

⁵⁴ Rail Delivery Group (2021) [Rail journey trends show leisure journeys nearly back on track but slower return of workers puts city centre recovery at risk](#)

⁵⁵ ICE (2020) [Covid-19 and the new normal for infrastructure systems – next steps](#)

⁵⁶ National Infrastructure Commission (2021) [Behaviour change and infrastructure beyond Covid-19](#)

⁵⁷ CBI (2020) [Government backs HS2 following CBI campaign for it to be delivered in its entirety](#)

⁵⁸ CBI (2019) [The CBI commented on HS2 and the Northern Powerhouse](#)

⁵⁹ Federation of Small Businesses (2021) [HS2 go-ahead marks positive step forward, say small firms](#)

⁶⁰ Federation of Small Businesses (2021) [Small firms worry levelling up going off track after HS2 update](#)

HS2 – concerns

Many major projects face opposition. For HS2, the concerns have focused on the capital cost, doubts over the purported benefits, impact on the natural environment, and potential alternative technologies.

Rising costs

In a recent report on the appraisal and delivery of major transport infrastructure projects the Transport Committee noted that the disparity between initial and current cost and delivery estimates for HS2 suggests that “initial costs and timescales were not properly assessed”.⁶¹ In the Government’s 2012 Economic Case for HS2, the cost of constructing the full Y-network was forecast to be £36.4bn (in 2011 prices).⁶² In the 2020 Notice to Proceed, the estimated cost had risen to £108.9bn (2015 prices).

The timescales have also slipped. Construction on Phase One finally commenced in 2020 but the projected opening has moved from 2026 to between 2029 and 2033. Phase 2 was projected to open in 2033 but the reduced network will only be fully operational by the early-mid 2040s.

Doubts about the robustness of the case for HS2 have been expressed throughout its development. A 2012 study argued that “many of the rationales behind the strategic case are based on non-monetisable benefits and other wider considerations that are not adequately captured in the economic case.”⁶³

Public and political anxiety about the costs of HS2,⁶⁴ alongside overruns and cost increases at Crossrail,⁶⁵ prompted the Government to commission the Oakervee Review in 2019.⁶⁶ The Review found that Phase One would likely require “rigorous cost controls” to stay within budget, while the cost estimates for Phases 2a and 2b were less mature and may need to be revised further upwards.⁶⁷

However, while concluding that HS2 was not affordable within its present funding envelope, the Review recommended that Government should commit to the full Y-shaped network with appropriate funding. Reasons for this included the cost of cancellation arising from sunk costs and the detrimental impact it would have on the supply chain. The Review also concluded that HS2 Ltd would need to demonstrate improvements in cost estimation, management and control.

In explaining its rationale for scaling back the Eastern Leg of HS2, the Government said that cost increases meant funding the full Y-network would “limit the opportunity for other important investments” put forward by the NIC.⁶⁸ It added that it will publish an updated assessment of value for money of the Western Leg of Phase 2b alongside the hybrid Bill deposit.

⁶¹ House of Commons Transport Committee (2021) [Major transport infrastructure projects](#)

⁶² Department for Transport (2012) [Economic Case for HS2: Updated appraisal of transport user benefits and wider economic benefits](#)

⁶³ Oxera (2012) [Not in my kitchen: the economics of HS2](#)

⁶⁴ House of Lords Economic Affairs Committee (2019) [Rethinking High Speed 2](#)

⁶⁵ National Audit Office (2018) [Completing Crossrail](#)

⁶⁶ Gov.uk (2019) [Terms of reference for the Independent review of HS2](#)

⁶⁷ Department for Transport (2020) [Oakervee Review of HS2](#)

⁶⁸ Department for Transport (2021) [Integrated Rail Plan for the North and Midlands](#)

How important is cost to the public?

Capital cost often drives debates on major infrastructure projects, but it is not in fact a major concern for the public.

In a poll conducted by YouGov for ICE, 74% of the public agreed that politicians should talk more about the benefits, rather than the costs, of major infrastructure projects.⁶⁹ The same survey found that the public were much more concerned with whether a project regenerates communities (30%), is reliable and cost-effective to maintain in the long term (27%) and strengthens growth (17%) than whether the overall cost of constructing the project is low (3%).⁷⁰

While every infrastructure project should, and generally does, have a net positive value-for-money measure, it is important that non-monetary social and environmental benefits are properly assessed and communicated alongside the economic effects.

Conflicting benefit assessments

The initial 2013 assessment for HS2 set out that the full Y-network would generate “significant levels of benefits” with a benefit-to-cost ratio (BCR) of 2.3:1, representing high value for money.⁷¹ Subsequent plans, including the 2017 strategic case, reiterated this, noting that it would provide £92bn in total benefits to the UK economy.⁷²

However, more recent analyses revised this assessment to a BCR of 1.5:1 for the full Y-shaped HS2 network including wider economic impacts, representing ‘low-medium’ value for money at 2015 prices.^{73 74} A BCR analysis of the revised HS2 plans set out in the IRP has not been published.

It is true that the benefit case for HS2 is difficult to quantify and monetise. Many of the proposed benefits rely on appraisal assumptions, demand forecasts and wider economic impacts, which may not manifest,⁷⁵ which is a risk endemic to any forecasting effort.

The Oakervee Review noted with surprise that the HS2 Business Case did not attempt to estimate a number of potential benefits to the UK economy in the BCR, such as changes to land-use, while also recognising the difficulties in developing robust estimates of many of these. It notes the Jubilee Line Extension which lacked a strong economic case during development, but has since seen commercial and residential development along its route grow far beyond expectation.

Alternative approaches, such as upgrades to existing lines, tend to have a higher than 2.3:1 BCR, or value-for-money assessment, although these tend to have both much smaller costs and much smaller benefits than HS2.⁷⁶

Doubts about purported “levelling up” and net-zero benefits

While the Government has made it clear that investment in transport infrastructure is key for its objective of “levelling up” underperforming parts of the UK⁷⁷, critics have argued that without detailed metrics or a clear definition underpinning the concept, infrastructure investment will not be as effective at contributing to the desired outcomes.⁷⁸

⁶⁹ ICE (2019) [Reducing the gap between cost estimates and outturns for major infrastructure projects and programmes](#)

⁷⁰ Ibid

⁷¹ High Speed Two (2013) [The Economic Case for HS2](#)

⁷² Department for Transport (2017) [High Speed Two, Phase Two, Strategic Case](#)

⁷³ Department for Transport (2020) [Oakervee Review of HS2](#)

⁷⁴ Department for Transport (2020) [Full Business Case – High Speed 2 Phase One](#)

⁷⁵ Department for Transport (2017) [High Speed Two, Phase Two, Strategic Case](#)

⁷⁶ Oxera (2012) [Not in my kitchen: the economics of HS2](#)

⁷⁷ HM Treasury (2020) [National Infrastructure Strategy](#)

There have also been concerns that too little consideration has been given to how public funds allocated to HS2 could otherwise be used to achieve the same socio-economic benefits.⁷⁹ It is though important to manage expectations given that transport investment alone cannot rebalance the economy but needs to be integrated with broader regional and local growth strategies.⁸⁰

Some studies have also cast doubt on the claims that HS2 will play a key role in delivering net-zero. Some appraisals have suggested that there will not be a substantial shift from cars to HS2 as most road trips are relatively short and thus few can be switched to HS2.⁸¹ The Oakervee Review noted that modal shift is likely to be greatest where the new track can be used for regional services or greater capacity enabled on the conventional network encourages more shorter trips by rail.⁸²

The Review concluded that on balance the construction and operation of HS2 is likely to be carbon neutral, but that it was unclear if the overall impact of HS2 will be positive or negative for carbon emissions. A further analysis of the Government's Full Business Case notes that for the full HS2 scheme, out of total net transport benefits of £74bn only £280 million, or 0.4%, is attributed to carbon reduction.⁸³

Routing and environmental impact issues

Opposition groups are concerned about the impact of HS2 on the landscape, environment and wildlife habitats. The Woodland Trust has argued that the project puts numerous ancient woods at risk of loss or damage, with Phase One directly affecting 32 ancient woods.⁸⁴

HS2 Ltd says it is creating a green corridor along the Phase One route to support new and existing wildlife habitats.⁸⁵ It has also published a Net Zero Carbon Plan, setting out its ambition for HS2's overall operations to be net-zero from 2035, including construction, the running of services and maintenance.⁸⁶ The plan highlights measures HS2 has already taken to reduce emissions, including through station design and piloting low carbon and recycled construction materials.

The choice of technology

Even where the need for a new rail route is accepted, some critics have questioned the choice of technology.

HS2 is designed to reach speeds of 330 km/h routinely, with a maximum speed of 360 km/h.⁸⁷ This is comparable to the fastest commercial high-speed trains in the world – the Chinese system reaches 350 km/h and the French TGV operates at 320 km/h.⁸⁸ This has prompted questions as to whether the UK needs such a fast route and whether a standard speed rail line, operating at 200 km/h, as the WCML currently does, would suffice and be delivered at lower cost.⁸⁹

Others take the contrary view that if the UK is to have a 'top of the line' rail link it should consider using cutting-edge technology. While high-speed rail is tried and tested, advancements in 'maglev' trains in Asia, developed by German

⁷⁸ Transport Committee (2021) [Major transport infrastructure projects](#)

⁷⁹ Institute for Government (2021) [HS2: Levelling up or the pursuit of an icon?](#)

⁸⁰ Department for Transport (2020) [Oakervee Review of HS2](#)

⁸¹ Institute for Government (2021) [HS2: Levelling up or the pursuit of an icon?](#)

⁸² Department for Transport (2020) [Oakervee Review of HS2](#)

⁸³ Institute for Government (2021) [HS2: Levelling up or the pursuit of an icon?](#)

⁸⁴ Woodland Trust (2021) [HS2 rail link](#)

⁸⁵ HS2 Ltd (2021) [HS2 and woodlands](#)

⁸⁶ HS2 Ltd (2022) [Net Zero Carbon Plan](#)

⁸⁷ Department for Transport (2020) [Full Business Case High Speed 2 Phase One](#)

⁸⁸ House of Lords Economic Affairs Committee (2019) [Rethinking High Speed 2](#)

⁸⁹ Ibid

company Transrapid, have prompted advocates to claim they would be faster, quieter and cheaper to maintain as there is no wear on the track.

Shanghai's Maglev train connecting Pudong airport with the city centre is the world's fastest commercial train, capable of speeds up to 431 km/h during the 30km journey. China is developing plans for a Maglev network, while in Japan the 438km Chūō Shinkansen maglev line, which is currently under construction, is expected to cost ¥9,030bn (£60bn)⁹⁰ and achieve an operating speed of up to 500 km/h.⁹¹

Alternative suggestions

Several alterations to HS2 have been proposed to reduce costs or environmental impacts. In this section we assess those alternatives based on insights from ICE's expert Fellows.

Terminating HS2 at Old Oak Common rather than London Euston

In 2019, the House of Lords Economic Affairs Committee proposed making Old Oak Common the London terminus instead of Euston to help cut costs. Old Oak Common is a planned new station in West London that will be served by HS2 as well as Great Western and Crossrail services, for connections to Heathrow and other parts of London.⁹²

However, the Oakervee Review called Euston an important part of realising the benefits of HS2 while noting the complex challenges linked to its re-development. The Government decided to proceed with the redevelopment of Euston, which is underway, although it recently announced the move from an 11 to a 10-platform design, which it claims is more efficient, can be built in a single stage and will still support the full operation of HS2 while easing cost pressure.⁹³

Once completed, Old Oak Common will serve as a temporary terminus to ensure work on Euston does not delay the start of HS2 services.

Upgrading existing lines to increase capacity on the WCML

Some opponents of HS2 have suggested that future innovations in digital technology and signalling, alongside track improvements, could deliver the required increase in capacity on the WCML.⁹⁴

According to a 2016 report, deployment of the Internet of Things within the rail network, with 12,000 rail infrastructure assets connected to an intelligent infrastructure system of points, track circuits and signal power supplies, had already avoided 153,000 delay minutes and provided savings of around £4.66m.⁹⁵

Network Rail's Digital Railway Programme⁹⁶ aims to deploy new digital technology to replace existing signalling systems with real-time digital systems. Digital train control and signalling has the potential to increase capacity on existing lines over the block section signalling technique by ensuring that more trains can run closer together.

However, the programme is still in its infancy. Tests on the Moorgate Branch of the East Coast Main Line have been promising, allowing an additional 2–4 trains per hour at a cost estimate of £30m–£50m.⁹⁷ In 2020, the Government

⁹⁰ Currency exchange rate of £1 to ¥150.55 in December 2021

⁹¹ Central Japan Railway Company (2020) [Annual Report](#)

⁹² House of Lords Economic Affairs Committee (2019) [Rethinking High Speed 2](#)

⁹³ Department for Transport (2021) [HS2 6-monthly report to Parliament: October 2021](#)

⁹⁴ Economic Affairs Committee (2015) [The Economics of High Speed 2](#)

⁹⁵ ICE (2016) [National Needs Assessment](#)

⁹⁶ Network Rail (2018) [Digital Railways Programme Strategic Plan](#)

announced that the East Coast Main Line would become Britain's first digital mainline rail link, with £350m of new investment.⁹⁸ Work is also underway to roll out digital signalling elsewhere on the network, including sections of the WCML and Midland Main Line from 2026.

Nevertheless, Network Rail has made it clear that it has yet to see any credible proposals for material increase in capacity on the WCML short of building a new line⁹⁹, with the Digital Railway Programme providing more efficient use of all capacity.¹⁰⁰

ICE believes that additional capacity, as well as more efficient use of that capacity, is vital, and while improvements to the existing infrastructure can be made, a step change in new capacity can only be met through new lines. Upgrading existing lines alone would merely delay addressing the issue of demand outstripping supply by mid-century. It would also mean years of disruption to services, which was significant during the last upgrade of the WCML.

Changing the route

Measures such as greater use of tunnelling or changing the route have been put forward to mitigate HS2's impact on the environment and landscape, including the destruction of areas of woodland or villages. However, such proposals would incur additional costs and, given its high-speed nature, any diversions would take miles to bring back into alignment.

Additionally, new changes to the HS2 route would need to consider the purchase, at a premium cost, of new land and the disposal of land already obtained, as well as the cost and delay of fresh feasibility, local impact and consultation reports. Consideration of route changes for a slower-running line, which would allow for more flexibility in the course of the track, led to six new routes being identified that would further minimise the impact on communities and the natural environment. However, there would be no net reduction in impacts and, as the line would be lengthened, there would be a potential increase in capital costs.

Tunnelling is more expensive than surface construction. On a project such as Crossrail, which is just over 60 miles long with 26 miles of new tunnels¹⁰¹, the additional cost is justifiable as the disruption and cost of building a surface railway in a heavily populated area would be immense.

Nevertheless, a number of mitigation measures have been developed. A significant proportion of the increased costs for Phase One is from additional tunnelling through Hertfordshire and Buckinghamshire to reduce the overall environmental impact. The DfT has also launched several consultations on changes to achieve environmental, technical, service and cost improvements, including changing the locations of vent shafts and realigning the route at various sections.¹⁰²

Some commentators have suggested changing the build priority to commence with Phase 2 in the North so that "intra-north connectivity can be established before the project is complete" and NPR can be accelerated.¹⁰³ This could have considerable merit if significant benefits could be delivered in a shorter timeframe and would reinforce the economic potential to regions outside of London and the South East. However, the Oakervee Review questioned the benefits to the wider network without having Phase One in place and concluded that such a change was no longer desirable given the significant amount of work already undertaken on Phase One.¹⁰⁴

⁹⁷ Ibid

⁹⁸ Department for Transport (2020) [Thousands of hours in delays to be saved as UK's first mainline digital railway introduced](#)

⁹⁹ Department for Transport (2020) [Full Business Case – High Speed 2 Phase One](#)

¹⁰⁰ Network Rail (2019) [Digital Railway](#)

¹⁰¹ Crossrail (2019) [Crossrail in numbers](#)

¹⁰² Gov.uk (2020) [HS2 Phase 2b design refinement consultation](#)

¹⁰³ IPPR North (2019) [Transport Investment in the Northern Powerhouse](#)

¹⁰⁴ Department for Transport (2020) [Oakervee Review of HS2](#)

Reducing the high-speed specifications

In 2019 the Economic Affairs Committee (EAC) recommended that Government review opportunities to reduce costs “through a change in the design of the scheme to one with a lower maximum speed.”¹⁰⁵

A lower top speed of 300 km/h would allow for capital and maintenance savings in a number of areas. It would enable the tracks to be closer together, reducing land acquisition and materials costs. Tunnels could be narrower and noise mitigation would also cost less. In terms of the overall budget, however, the savings would be low and the benefits loss would be of an order of magnitude higher.

In evidence to the EAC, HS2 Ltd cited a study that reducing operating speeds to 300 km/h would lower capital expenditure by £600m, with a further saving of £1.25bn in long-term operating costs, but that this would also cut revenue and benefits by £6bn. Reducing the speed to 200 km/h would cut costs by 9%, but also reduce usage by 19% and benefits by 33% - although the EAC questioned the robustness of these figures.¹⁰⁶

The Oakervee Review cites evidence that “super high speed, high capacity requirements have led to infrastructure costs in the order of magnitude 10% higher than if HS2 had been designed at more internationally comparable standards.”¹⁰⁷ It noted the lack of evidence that regular design reviews had been conducted to check whether the costs being driven by the standards were disproportionate.

Nevertheless, the Review concluded that significant changes to the Phase One specifications at this stage would be costly and any such review should be limited in scope. Construction of Phase One is underway and the Government has awarded the £2bn rolling-stock contracts to Hitachi-Alstom for trains capable of 360km/h.¹⁰⁸

If the core focus of the business case is capacity, not speed, there might be merit in a slower service. Ultimately, the question comes down to a policy driver. To date, the Government has placed a premium on productivity improvements, which are most impacted by faster speeds, and has set commuting and business travel as economic drivers.

Magnetic levitation (maglev)

The alternative to ‘steel on steel’ high-speed rail is the magnetic levitation (‘maglev’) rail technology being built in Japan and China. While high-speed rail is proven technology, proponents of maglev technology argue that it will provide far lower maintenance and operating costs in the long run and achieve lower noise pollution and comparable energy usage.

The right decisions about tomorrow’s infrastructure assets are crucial as they will likely last for 100 years or more. If maglev technology can demonstrate cost savings for both construction and operations over high-speed rail, it should be considered. One significant advantage of this technology is its potential for minimising environmental impacts and supporting decarbonisation, and there might be a case for future-proofing HS2 so that it can be upgraded or repurposed to maglev technology at some time in the future.

However, one consideration to note is how HS2 integrates with the rest of the transport network. Being on the same gauge as the existing rail network means that services will be able to run on both lines – a key part of delivering the ease of use and connectivity envisioned by the IRP. A dedicated maglev line would require interchanges and reduce the viability of run-on services or the ability to divert services to other lines.

¹⁰⁵ House of Lords Economic Affairs Committee (2019) [Rethinking High Speed 2](#)

¹⁰⁶ Ibid

¹⁰⁷ Department for Transport (2020) [Oakervee Review of HS2](#)

¹⁰⁸ HS2 Ltd (2021) [HS2 Ltd awards landmark rolling stock contracts to Hitachi-Alstom joint venture](#)

Questions for further discussion

Engaging with international partners

Whilst the UK was able to deliver HS1 on budget and on time, the country has a paltry length of high-speed track compared to almost all other nations deploying high-speed rail. In the UK, only HS1's 108 km of track qualifies for the above-250 km/h designation of high-speed rail.

A closer working relationship with high-speed rail operators in France, Spain and Germany, who have much greater experience of delivering high-speed projects, might well be desirable.

Future expansion and integration

HS2 was never designed to be delivered in isolation; however, until recently it has been treated as an isolated project.

The Government responded to the Oakervee Review by developing the IRP which, along with the National Infrastructure Strategy and Union Connectivity Review, provides a blueprint for joined-up thinking for major transport infrastructure projects going forward. These projects should be directed and influenced by regional infrastructure strategies to ensure effective integration of infrastructure planning.

Realising the benefits of HS2 depends on a wide range of government bodies delivering other projects, who will all need to co-ordinate with each other. Government also needs to assess not just whether HS2 is value for money but whether it is better value for money than alternative transport or other infrastructure projects.

HS2 must also be seen within the context of the wider infrastructure system. The IRP provides a strategic underpinning for how it can help unlock further benefits in the North and the Midlands, but a delivery plan is needed within the next 12 months to avoid further costly delays.

Learning lessons and improving project delivery

Just as HS2 must learn lessons from Crossrail in terms of governance and delivery, so too must future rail expansions learn from the development and delivery of HS2. The question of how we can do infrastructure better has been brought into focus in recent years, not least because of the challenges faced by high profile projects including HS2 and Crossrail.

The publication of the Construction Playbook in December 2020 addresses a number of barriers to improving the development and delivery of major transport infrastructure, including how to avoid guesswork on project costs and forecasts and improving the focus on outcomes from projects. Project Speed and the Department for Transport Acceleration Unit are also looking at how to improve project delivery.

Enterprise based delivery models are examples of emerging initiatives that could redefine how which major infrastructure projects are delivered in the future. The Infrastructure Client Group's Project 13, for example, is an industry-wide change programme to shift from a transactional business model to an enterprise model, which could also play a part in enabling greater use of off-site manufacture and enhancing industry productivity.¹⁰⁹

¹⁰⁹ ICE (2021) [ICE submission to the Transport Committee on major transport infrastructure projects: appraisal and delivery](#)

About ICE

Established in 1818 and with over 96,000 members worldwide, the Institution of Civil Engineers exists to deliver insights on infrastructure for societal benefit, using the professional engineering knowledge of our global membership.

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