Civil engineering insights on HS2 and alternative proposals

Overview

There is a growing need for additional rail capacity in the UK. By 2050 the population of the country will be 75 million,[1] an increase of nine million on today's figure of 66 million.[2] Even before this expected population growth, rail travel has seen a renaissance in use. Between 2012–13 and 2017–18, total passenger journeys increased from 1.5 billion (bn) to 1.7 bn.[3] Even as far back as 2014, 26% of morning peak trains arriving in London were over capacity,[4] and overall passenger numbers are expected to increase by a further 40% by the year 2040.[5]

Increased investment in new rail capacity and existing as well as new routes is needed to meet this expected demand and reduce overcrowding, as well as delivering the economic growth necessary to enhance the UK's position in the global economy. ICE's 2016 National Needs Assessment[6] called for the completion of all phases of High Speed Two (HS2) to address priority routes for capacity improvements, as well as the extension of the line to Scotland, the South West and across the region of the country designated to be the 'Northern Powerhouse'.

Addressing the challenge of climate change and delivering net-zero carbon emissions by 2050 will also need cleaner and more efficient methods of transportation. The transport sector accounted for 33% of all CO_2 emissions in 2018, with the majority of these originating from road transport.[7] 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 insights into the costs and benefits of HS2, as well as potential alternatives to the project. It combines insights from ICE Fellows, industry experts and the available published evidence.

What is clear from the analysis is the need for additional rail capacity that will boost the economy and help to reduce carbon emissions. This is especially important for the planned corridor between London, Birmingham, Manchester, Sheffield and further north to Scotland. What is contested is whether this capacity must be met through faster or new routes, whether alternatives could be delivered more cheaply with similar benefits and whether the proposed route is appropriate.

This paper provides an initial overview, and will be subject to periodic review as both HS2 and the debate surrounding it progress. The latest policy and insight from ICE can be found at www.ice.org.uk/news-and-insight/policy.

[1] ICE (2016) National Needs Assessment
[2] Office for National Statistics (2018) Overview of the UK Population: November 2018
[3] Office of Rail and Road (2019) How many people use the railway
[4] ICE (2016) National Needs Assessment
[5] Network Rail (2018) How the Digital Railway will grow capacity on the railway
[6] ICE (2016) National Needs Assessment
[7] Department for Business, Energy and Industrial Strategy (2019) 2018 UK Greenhouse Gas Emissions, Provisional Figures

About High Speed Two (HS2)

High Speed Two (HS2) is a planned high-speed railway line running from London to Birmingham and then splitting to form a 'Y' pattern, with lines running to Crewe and Manchester on one spur and to Leeds and Sheffield on the other.

The line is being delivered in three phases. Phase One will be new track running from London Euston to Birmingham, and is due to open by 2026.

Phase Two will consist of two parts, creating a 'Y' network from Birmingham, to be completed by 2033. Phase 2a will be a short extension from Birmingham to Crewe. Phase 2b's route is being consulted on until September 2019,[8] but will extend Phase 2a to Manchester and create a new line from Birmingham to Leeds.

Investment is expected to reach £4bn each year in the next decade,[9] with a total budget of £55.7bn at 2015 prices.[10] The line is expected to increase capacity and speed up journey times between London and multiple cities in England by allowing trains to travel at speeds of up to 400 km per hour – or 250 miles per hour.[11]

HS2 is named as a spiritual successor to High Speed One (Channel Tunnel Rail Link), which has serviced the Eurostar rail link since 2007 and is seen by some as the start of a nationwide high-speed network. Northern Powerhouse Rail, previously called High Speed 3 or Crossrail for the North, was given a 'green light' to proceed in 2014.[12]

Identified benefits

ICE's National Needs Assessment identified a need for investment to increase capacity on Britain's rail network. The Department for Transport, as sponsor, and HS2 Ltd believe that HS2 will meet future societal needs around capacity,[13] whilst also facilitating economic growth and productivity improvements and reducing carbon emissions from transport.

HS2 and capacity, resilience and overcrowding

One of the benefits identified for a new high-speed railway line would be the opportunity to move some intercity services from existing mainlines to a new, dedicated line. Proponents believe that a high-speed line would reduce journey times between cities at a cost similar to that of a new standard speed rail line.

The West Coast Mainline has very limited scope to handle additional services, and is currently operating at a higher intensity than major fast lines in other European countries, including purpose-built high-speed lines.[14] This has impacts on punctuality, reliability and the risk of cascading failure. This is particularly true when the line is blocked by a failed train or when engineering or upgrade works need to be undertaken.

It is notable that between 1997 and 2013 London and the South East had an average passenger growth of 102%, whilst Milton Keynes and Northampton experienced 120% passenger growth.[15] With demand on the West Coast line projected to increase by a further 100% by 2043,[16] even if the West Coast Main Line can be upgraded further or carry more capacity

[8] Gov.uk (2019) HS2 Phase 2b design refinement consultation
[9] National Infrastructure Commission (2018) National Needs Assessment
[10] HM Treasury (2015) Spending Review and Autumn Statement 2015
[11] Department for Transport (2010) High Speed Rail (Command Paper)
[12] Gov.uk (2014) PM and Chancellor give green light to develop HS3
[13] Network Rail (2019) Digital Railway
[14] Department for Transport (2017) Strategic Case
[15] Department for Transport (2017) Strategic Case
[16] Oxera (2012) Not in my kitchen: the economics of HS2

through new signalling technology being pioneered through the digital railway, there is still a need for additional capacity, through a new line, by the middle of this century.

Moving intercity services to HS2 as a dedicated track will allow for a greater number of signal block sections to be available for stopping and freight services on existing lines. It would also increase resilience for intercity travel and increase journey speeds on new and existing track. HS2 Ltd claim that the new line would supplement capacity on three major main lines, including the West Coast Main Line, the East Coast Main line and the Midland Main Line.[17]

The strategic case for HS2 sets out that Phase One is expected to increase capacity on the route corridor between London and Birmingham from 15 to 23 trains per hour for intercity services and from eight to ten trains per hour on metro-style services.[18]

HS2, economic growth and regional rebalancing

The initial assessment for HS2 sets out that the project will generate "significant levels of benefits totalling £92.2bn in 2015 prices" with a benefit-to-cost ratio (BCR) of 1:2.3, representing high value for money, and wider economic benefits of £17.6bn.[19] It is believed that the new line would be self-sustaining, with a potential operating surplus of £300m a year on average at 2015 prices over the assumed economic life of the railway.[20]

Proponents of HS2 argue that the project will allow for a wider catchment of people to fill vacancies and bring benefits to businesses in the north of England, rebalancing the economy by distributing businesses and professional services to major cities.[21] HS2 in and of itself is forecast to support at least 15,000 jobs by 2020 and twice as many once it reaches peak construction.[22] This includes 2000 apprenticeships over the life of the project.[23]

HS2 Ltd released research, undertaken in workshops with representatives from business, local authorities and universities, which suggested that the project would open up new markets and increase possibilities for collaboration, knowledge exchange and innovation. Participants also said that HS2 would connect industries and expand catchment areas for other transport sectors, including airports.[24]

The project may also enable other connective transport options. Northern Powerhouse Rail is being designed to integrate with HS2, sharing track and relying on the route for north/south connections. 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.[25]

HS2 and productivity

Gains from productivity improvements delivered by HS2 from 2037 could be as much as £8bn–£15bn per year.[26] This is based on the assumption that faster journeys would increase productivity, as only 10% of passengers spend most of their time on trains working.[27] This would allow for more productive activities to take place elsewhere for longer.

[17] HS2 (2019) Helping reduce overcrowding
[18] Department for Transport (2017) Strategic Case
[19] High Speed Two (2013) The Economic Case for HS2
[20] Department for Transport (2017) High Speed Two, Phase Two, Financial Case
[21] HS2 (2019) HS2 can help realise the potential of the North
[22] Gov.uk (2018) HS2 to support 15,000 jobs by 2020
[23] Gov.uk (2018) HS2 to support 15,000 jobs by 2020
[24] Department of Transport and HS2 (2017) Getting the best out of Britain
[25] Midlands Connect (2019) Access to HS2
[26] Department for Transport (2013) The strategic case for HS2
[27] Department of Transport (2019) Public attitudes towards train services: results from the February 2018 Opinions and Lifestyle Survey

Productivity is a problem for regions outside London and the South East. City regions in the North and the Midlands are 10–17% below the average UK productivity.[28] A lack of equivalent transport networks and other weaknesses in infrastructure and connectivity could explain this disparity.

HS2 and the environment

HS2's model assumes that by 2037 24% of HS2 customers will be making new journeys not currently served, largely as a result of future demand and population growth, whilst 3% of customers will shift from air travel and 8% from car journeys.[29] This represents 4.5 million trips moved from air to rail.[30] If the expected modal shift does occur, there will then be a net benefit to reducing local air and noise pollution due to reductions in overhead flights and emissions from road transport.[31]

Rail routes are also more environmentally friendly. According to Eurostar, a train journey between London and Amsterdam emits 80% less carbon per passenger than an equivalent flight.[32] Research conducted by Greengauge 21 on behalf of the Campaign to Protect Rural England, the Campaign for Better Transport and the Royal Society for the Protection of Birds found that emissions for HS2 would be 73% lower than those from making the equivalent journey by car and 76% lower than flying.[33]

HS2 would have the potential to compete on journey time and cost with, for example, internal flights between London and Manchester, Glasgow and Edinburgh. There are examples of equivalent air-to-rail shifts in Europe, such as Lufthansa providing an express rail service between Frankfurt and Cologne. This service replaced domestic flights on this route after a faster high-speed rail route was built.[34]

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 (CBA) of the high-speed railway line between Madrid and Barcelona found that cities on the line away from these two economic centres, like Zaragoza and Lleida, saw population increases following the arrival of high-speed rail. This suggests that these cities were now seen as more attractive areas in which to reside and work.[35]

Lille in northern France has managed to capture the benefits of high-speed rail through a major regeneration scheme that includes a new economic centre, whilst Lyon saw the creation of a new business district at the same time as its high-speed railway line, the first in France, struggles to accommodate demand.[36]

[28] ONS (2016) Sub-regional productivity in the UK (March 2016)
[29] Department for Transport (2012) Economic Case for HS2: Updated appraisal of transport user benefits and wider economic benefits
[30] Department for Transport (2012) Economic Case for HS2: Updated appraisal of transport user benefits and wider economic benefits
[31] Department for Transport (2102) Review of HS2 London to West Midlands Appraisal of Sustainability
[32] Eurostar (2019) Eurostar Introduces third direct daily service from London to the Netherlands
[33] Greengauge 21 (2012) High Speed Rail, The carbon impacts of High Speed Two
[34] Frankfurt Airport (2019) Lufthansa Express Rail
[35] European Commission (2011) High Speed railway – Madrid – Barcelona in Spain
[36] Independent Transport Commission (2014) Ambitions and Opportunities, Understanding the Spatial Effects of High Speed Rail

High Speed One (HS1)

An evaluation of the impacts of HS1 published in 2014 found, in broad terms, that the line had played a 'catalytic role' in enabling regeneration around high-speed stations, creating the right conditions for investment and co-ordination of regeneration activities.[37] The line also had a very significant impact on travel times for domestic and international passengers, yielded a 40% increase in capacity for domestic services, and led to a reduction in average overcrowding. HS1 also saw increases in the punctuality and reliability of services, increased demand for rail – seeing passenger growth of 20% in the first two years – and increased the trend in the modal shift from car to rail, thus improving the wider economy.[38]

Analysis by Volterra of the impacts was more optimistic. Combined additional rail and car park revenues and quantifiable transport benefits "offset the whole project cost" for HS1, whilst wider economic benefits and regeneration added additional value.[39] Regeneration, in particular, even as 'a conservative estimate' could be worth £10bn in 2009 value terms over 60 years, with additional drivers such as when communities along the line derive enhanced earnings and investment attractiveness as the ease of commuting into London becomes more apparent.[40]

Analysis by the Department for Transport (DfT) suggests that HS1 has a low BCR of 1:0.64 – somewhat below the HS2 ratio of 1:2.3.[41] This is in part explained by the fact that the four-year timescale from opening to evaluation did not capture forecast growth in housing. Further, the line is used in large part for leisure rather than business use. The evaluation was also conducted during a recession – with impacts on investment and time lags on economic activity. There is a wide range on the BCR forecast (between 1:0.4 and 1:1.2), reflecting a high degree of uncertainty about assumptions and forecasts.[42] Lessons should be learned from this for HS2, where part of the business and strategic case is difficult to quantify.

What the public need from rail

For rail, the largest impactors on satisfaction for passengers are punctuality and reliability (36%), with the frequency of trains of secondary importance (25%) followed by the level of crowding (15%).[43]

Despite more than a decade of sustained above-inflationary rises in revenue funding and record amounts of capital investment, rail satisfaction rates remain mixed. According to the latest rail passenger survey, overall satisfaction with long-distance journeys was 87%, with journeys in London and the South East scoring 79%. However, only 55% of passengers on long-distance journeys and 41% of passengers in London and the South East were satisfied with the value for money on the price of their ticket. The same passengers scored punctuality and reliability of services at 81% and 70%, respectively, and levels of crowding at 73% and 68%, respectively.

Forty-seven per cent (47%) of rail trips are made for the purpose of commuting to and from work, with 29% made for leisure and 9% for business.[44] Despite this, very few passengers use a train journey to be economically productive. According to a DfT opinions and lifestyle survey, just 10% of passengers spent most of their time on a long-distance train journey doing work for their job.[45]

[37] Atkins (2014) First Interim Evaluation of the Impacts of HS1, Final Report, Volume 2 – Appendices
[38] Atkins (2014) First Interim Evaluation of the Impacts of HS1, Final Report, Volume 1 – Main Report
[39] Volterra (2009) Economic Impact of High Speed 1
[40] Volterra (2009) Economic Impact of High Speed 1
[41] Department for Transport (2017) High Speed Two, Phase Two, Strategic Case
[42] Atkins (2014) First Interim Evaluation of the Impacts of HS1, Final Report, Volume 1 – Main Report
[43] Transport Focus (2018) National Rail Passenger Survey
[44] Department for Transport (2017) National Travel Survey: England
[45] Department of Transport (2019) Public attitudes towards train services: results from the February 2018 Opinions and Lifestyle Survey

Business sentiment

Business organisations see value in HS2. The Confederation of British Industry (CBI) believes that HS2 "offers a real opportunity to regenerate local economies, provide jobs and boost growth across communities".[46] The Federation of Small Businesses believes that major infrastructure projects such as HS2 are important, although they have reservations over underinvestment in road and a lack of availability of procurement opportunities for small firms on the project.[47]

Could HS2 meet these needs?

HS2 – or any alternative – should aim to increase the quality of rail services, ensure an increased number of trains and reduce levels of overcrowding. By providing longer and more frequent trains and by freeing capacity on the existing mainline network, the project should support public demands for more punctual and reliable services, greater frequency and reduced overcrowding on served routes.

HS2 – current status and concerns

Many major projects in the UK face opposition to some degree. For HS2, the key factors mobilising opposition are concerns about capital cost, disputes over the purported benefits, concerns about the routes' impact on the natural environment, including noise, loss of habitation and ancient woodland and the possibility of alternative technologies.

Concerns about costs and the business case

Recent time overruns and cost increases at Crossrail,[48] as well as concerns about the robustness of cost estimates for HS2,[49] have prompted public and political anxiety over the possibility of cost increases for the project. These concerns have prompted the Prime Minister to appoint Douglas Oakervee, a former HS2 chairman, to conduct a "whether and how we proceed" review of the project.[50]

A 2012 study also 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." The study also suggests that HS2 fails to demonstrate enhanced benefits, although it does conclude that the project has a net benefit.[51]

Particular concern has been raised about a failure to secure a notice to proceed on Phase One. The House of Lords Economic Affairs Committee noted that notice to proceed should have been delivered in April 2019 but will now "take place later in 2019".[52] Meanwhile, Meg Hillier MP, Chair of the Committee of Public Accounts, notes that this delay in providing notice to proceed has not, to date, been met with any extension in time to delivery. This might compress the schedule, driving similar additional costs and inefficiencies, as manifested on Crossrail.[53]

One concern that arises from the experience with Crossrail was the reduction in contingency following the 2010 comprehensive spending review, reducing the overall budget from £15.9bn to £14.8bn. Given the inherent lack of reliability

[46] CBI (2019) The CBI commented on HS2 and the Northern Powerhouse
[47] FSB (2016) FSB responds to HS2 route to Manchester
[48] National Audit Office (2018) Completing Crossrail
[49] House of Lords Economic Affairs Committee (2019) Rethinking High Speed 2
[50] Gov.uk (2019) Terms of reference for the Independent review of HS2
[51] Oxera (2012) Not in my kitchen: the economics of HS2
[52] House of Lords Economic Affairs Committee (2019) Rethinking High Speed 2
[53] Committee of Public Accounts (2019) Letter from Meg Hillier MP, Chair of the Committee of Public Accounts to Bernadette Kelly, Permanent Secretary, Department for Transport, 4th July 2019

of estimates, especially early on in a project's life, as highlighted in ICE's report, *Reducing the gap between cost estimates and outturns for major infrastructure projects and programmes*,[54] caution is advised when basing a budget on unrealised efficiency savings or reductions in contingency.

This makes it a concern that the budgets for the second phases of HS2 currently rely on efficiency savings being found. Phase 2a requires £745m of efficiency savings, with a target of £1.1bn, whilst Phase 2b requires £5.1bn of efficiencies in order to meet the budgets set out for these phases (£3.72bn and £24.83bn, respectively).[55]

How important is cost to the public?

Whilst cost is often the driver of debates on major infrastructure projects, this is not in fact a major question of 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.[56] 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 that the overall cost of constructing the project is low (3%).[57]

Whilst every infrastructure project should, and generally does, have a net positive value-for-money measure, it is important to consider social and environmental values and needs. Even if HS2's capital cost were to be reassessed in a way that delivered a lower BCR, it is still important that non-monetary benefits are properly assessed and considered alongside the direct and wider economic effects.

Conflicted benefit assessments

Whilst HS2 claims a whole package BCR of 1:2.3, providing £92bn in total benefits to the UK economy as a whole,[58] it is true that the benefit case for HS2 is difficult to quantify and monetise. As set out in the Strategic Case, many of the proposed benefits rely on appraisal assumptions, demand forecasts and wider economic impacts, which may not manifest,[59] which is a risk endemic to any forecasting effort.

Furthermore, alternative approaches, such as upgrades to existing lines, tend to have a higher than 1:2.3 cost–benefit, or value-for-money assessment, although these tend to have both much smaller costs and much smaller benefits than HS2.[60]

Whilst the overall economic impact on regions not served by HS2 could be offset by gains elsewhere, these regions are already less prosperous than the regions that would be served by HS2, with far poorer connectivity. Figures obtained by the BBC through a freedom of information (FOI) request concerning an economic impact report completed by KPMG in 2013 revealed that the impact on Cardiff would be between −£67.95m and −£70.6m or −0.6% as a proportion of GDP.[61] The combined impact on Norfolk East and West might be as high as −£220.12m or −1.7% of GDP. Impacts on Cornwall and Devon are more limited, with an estimated reduction of −0.2% as a proportion of GDP.

[54] ICE (2019) Reducing the gap between cost estimates and outturns for major infrastructure projects and programmes
[55] Department for Transport (2017) High Speed Two, Phase Two, Financial Case
[56] ICE (2019) Reducing the gap between cost estimates and outturns for major infrastructure projects and programmes
[57] ICE (2019) Reducing the gap between cost estimates and outturns for major infrastructure projects and programmes
[58] Department for Transport (2017) High Speed Two, Phase Two, Strategic Case
[59] Department for Transport (2017) High Speed Two, Phase Two, Strategic Case
[60] Oxera (2012) Not in my kitchen: the economics of HS2
[61] BBC (2013) Freedom of information request

Routing issues

Opposition groups, such as Stop HS2 and the Woodland Trust, are concerned about the proposed route of the new line, which would intersect or travel through 19 ancient woodlands.[62] The DfT released a consultation in June 2019 that is seeking views on realignments or relocations of Phase 2b of the project, including changing locations for vent shafts for tunnelling, enabling infrastructure such as railheads and maintenance facilities and realignment of the route at various sections of the proposed line.[63]

Alternative technologies

Even where the need for a new rail route is accepted, the technology employed might not be.

HS2 is designed to be built to a very high specification capable of a theoretical top speed of 400 km per hour.[64] The system is designed to reach speeds of 330 km/h when it opens, comparable to the fastest commercial high-speed trains in the world (the Chinese system tops out at 350 km/h and the French TGV operates at 320 km/h),[65] which has prompted some to question whether the UK needs such a fast route and whether a standard speed rail line, operating at 200 km/h, as the West Coast Main Line currently does, would suffice and be delivered at lower cost.

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. Whilst high-speed rail is tried and tested, it is considered by some as yesterday's technology. Advancements in 'maglev' trains in Asia, developed by German company Transrapid, promise faster, less noisy trains, that, it is claimed, would be cheaper to maintain as there is no wear on the track. The Chūō Shinkansen maglev line in Japan, which is currently under construction, is expected to cost ¥9030bn (£69bn),[66] whilst being 90% tunnelled and achieving an operating speed of up to 500 km/h, at a length of 285.6 km,[67] compared to HS2's total track length of 530 km.

Suggested alternatives to address concerns

Several potential 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.

Termination of HS2 at Old Oak Common rather than London Euston

The House of Lords Economic Affairs Committee raised concerns that the budget would not be met, suggesting cost savings could be made through reducing the top operational speed of the line and reconsidering the route. They proposed reviewing the impact of speed on capital cost and value and terminating outside of London at Old Oak Common, a planned new station that will be served by Crossrail, for journeys to Heathrow or other parts of London.[68] Whilst there is no estimate of the cost savings that could be achieved, the committee was concerned that the estimated cost of the redevelopment of Euston Station alone had risen from £2bn to £7bn by 2015.[69]

[62] StopHS2 (2018) The "final frontier" of the proposed HS2 route
[63] Gov.uk (2019) HS2 Phase 2b design refinement consultation
[64] Department for Transport (2010) High Speed Rail (Command Paper)
[65] House of Lords Economic Affairs Committee (2019) Rethinking High Speed 2
[66] Currency exchange rate of £1 to ¥129.87 taken on the 6th August 2019
[67] Central Japan Railway Company (2018) Annual Report – Promoting the Chuo Shinkansen Project Using the Superconducting Maglev System
[68] House of Lords Economic Affairs Committee (2019) Rethinking High Speed 2
[69] House of Lords Economic Affairs Committee (2019) Rethinking High Speed 2

The committee believe that doing this will have minimal, or even beneficial, impacts on journey times to various destinations. Delaying completion of the central London stretch of the line to Phase 2b would also allow additional time, as suggested by Sir Terry Morgan and an evaluation of the CBA of the two options.[70]

Whilst this could achieve significant capital cost savings, it would add an additional interchange to journeys to and from London and weaken the link between HS2 and HS1. It would also require the enhancement of the new Old Oak Common Crossrail station, which is not designed to carry the additional footfall of a terminus station and has limited physical space into which to expand.

Alternatives to delivering increased rail capacity

Opponents of HS2 have suggested that digital technology and signalling, alongside track improvements, could increase capacity on the West Coast Mainline.

The deployment of the Internet of Things within the rail network, with 12,000 rail infrastructure assets already connected to an intelligent infrastructure system of points, track circuits and signal power supplies, is already claimed to have avoided 153,000 delay minutes and provided savings of around £4.66m.[71]

The Digital Railway Programme[72] 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 more closely together.

The Digital Railway Programme is, however, in its infancy, and candidate schemes have only recently reported. Tests on the Moorgate Branch of the East Coast Mainline have been promising, however, allowing an additional 2–4 trains per hour at a cost estimate of £30m–£50m.[73]

The point must be made that Network Rail considers increased capacity through the building of Crossrail and HS2 to be vitally important for meeting future projected demand, with the Digital Railway Programme providing more efficient use of all capacity.[74] The new line is also expected to allow for longer trains with greater overall seating capacity. ICE believes that additional capacity, as well as more efficient use of that capacity, is vital, and whilst improvements to the existing infrastructure can be made, a step change in new capacity can only be met through new lines.

Oxera sets out that 'Scenario B', which includes upgrades to the East and West Coast main lines, could increase existing capacity by 56% at a cost of £10bn. This would compare with a greater-than-100% increase in capacity for HS2 at a cost of £25bn for the same portion of the route. The same analysis, however, shows consistently higher benefits for HS2 when wider economic impacts are included. Scenario B would deliver £16bn of wider economic benefits, whereas HS2 would deliver between £47bn and £58bn.[75]

Upgrading existing lines also comes with the cost of disruption, which was significant during the last upgrade of the West Coast Mainline, and would still need to deal with demand outstripping supply by mid-century if a new line were not built.

Changing the route

Some opponents of the scheme claim that HS2 will do damage to the natural environment, with groups such as the Woodland Trust claiming that "more than 40 hectares of rare ancient woodland will be destroyed by HS2".[76] Adopting a

[70] House of Lords Economic Affairs Committee (2019) Rethinking High Speed 2
[71] ICE (2016) National Needs Assessment
[72] Network Rail (2018) Digital Railways Programme Strategic Plan
[73] Network Rail (2018) Digital Railways Programme Strategic Plan
[74] Network Rail (2019) Digital Railway
[75] Oxera (2012) Not in my kitchen: the economics of HS2
[76] Woodland Trust (2018) HS2 green corridor nothing more than greenwash nonsense

greater use of tunnelling or changing the route to avoid certain areas of woodland or villages would incur additional costs for the project but might reduce these concerns as well as reduce the environmental damage itself.

Significant levels of mitigation have, however, already taken place. A significant proportion of the increased costs for Phase 1 are due to the increased lengths of tunnelling through Hertfordshire and Buckinghamshire. Additional mitigation would only increase these costs, and, given the high-speed nature of the track, a diversion would take miles to bring back into alignment. This course of action should only be undertaken if the overall cost can be reduced and certainty of programme delivery improved.

Tunnelling is more expensive than construction on the surface. On a per mile basis, Crossrail, at just over 60 miles long and with 26 miles of new tunnels,[77] costs more than HS2, which has a combined 'Y' network length of 330 miles.[78,79] The additional cost of tunnelling such a significant portion of the route for Crossrail is justifiable, given that the disruption and cost of building a surface railway in a heavily populated area would be immense.

Additionally, new changes to the 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, a potential increase in capital costs.

Other groups, such as IPPR North, have suggested changing the build priority of the route so that HS2 Phase 2a and Phase 2b are built in the North first so that "intra-north connectivity can be established before the project is complete, and so that Northern Powerhouse Rail can be accelerated using this infrastructure".[80] This is a suggestion that might have considerable merit if significant benefits can be delivered in a shorter timeframe and one that would reinforce the economic potential to regions outside of London and the South East.

Reducing speed specifications

One concern also highlighted by the House of Lords Economic Affairs Committee is the high-speed specification of the line. The committee made the recommendation that "The Government should review opportunities to reduce the cost of constructing HS2 through a change in the design of the scheme to one with a lower maximum speed."[81]

HS2 Ltd, for its part, has conducted a review of the costs and benefits, citing a study in evidence to the committee that a reduction in operating speeds down to 300 km/h would reduce capital expenditure by £600m, with a further saving of £1.25bn in long-term operating costs, but that this would reduce revenue and benefits by £6bn. Reducing the speed to 200 km/h would reduce costs by 9%, but reduce benefits by 33%, though the committee is not convinced that these figures are robust.[82]

Reducing the top speed of HS2 to 300 km/h would allow for capital and maintenance savings in a number of areas. A lower speed would allow for the tracks to be closer together, reducing land acquisition and materials costs. Tunnels could be narrower, directly reducing their cost, and noise mitigation would also be less costly. In terms of the overall budget, however, the savings would be low and the benefits loss would be of an order of magnitude higher.

If the core focus of the business case is one of capacity, not speed as at present, 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

[77] Crossrail (2019) Crossrail in numbers
[78] Railway Technology (2019) High Speed 2 (HS2) Railway
[79] Calculation is £15.4bn divided by 60 miles versus £55.7bn divided by 330 miles, or £256.6m versus £168m per mile
[80] IPPR North (2019) Transport Investment in the Northern Powerhouse
[81] House of Lords Economic Affairs Committee (2019) Rethinking High Speed 2
[82] House of Lords Economic Affairs Committee (2019) Rethinking High Speed 2

improvements, which are most impacted by faster speeds, and has set commuting and business travel as economic drivers. However, a slower top speed would still be transformational for much of the network and would cut journey times significantly.

Magnetic levitation (maglev)

The alternative to 'steel on steel' high-speed rail is the magnetic levitation ('maglev') rail technology being developed and built in Japan and China. Whilst high-speed rail is proven current-generation technology, it is thought that, in the long run, the maintenance and operating costs of magnetic levitation track will be far lower than those of existing conventional and high-speed tracks, whilst also achieving lower noise pollution and comparable energy usage.

The right decisions about tomorrow's infrastructure assets are crucial, and should be taken seriously, 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 using this technology is in 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.

One consideration to note is how HS2 would integrate with the rest of the transport network. Being on the same gauge as the existing rail network means that services can run on both lines. A dedicated maglev line would require interchanges to be made and would reduce the viability of run-on services or the ability to divert services to other lines.

Questions for further discussion and debate

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. 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.

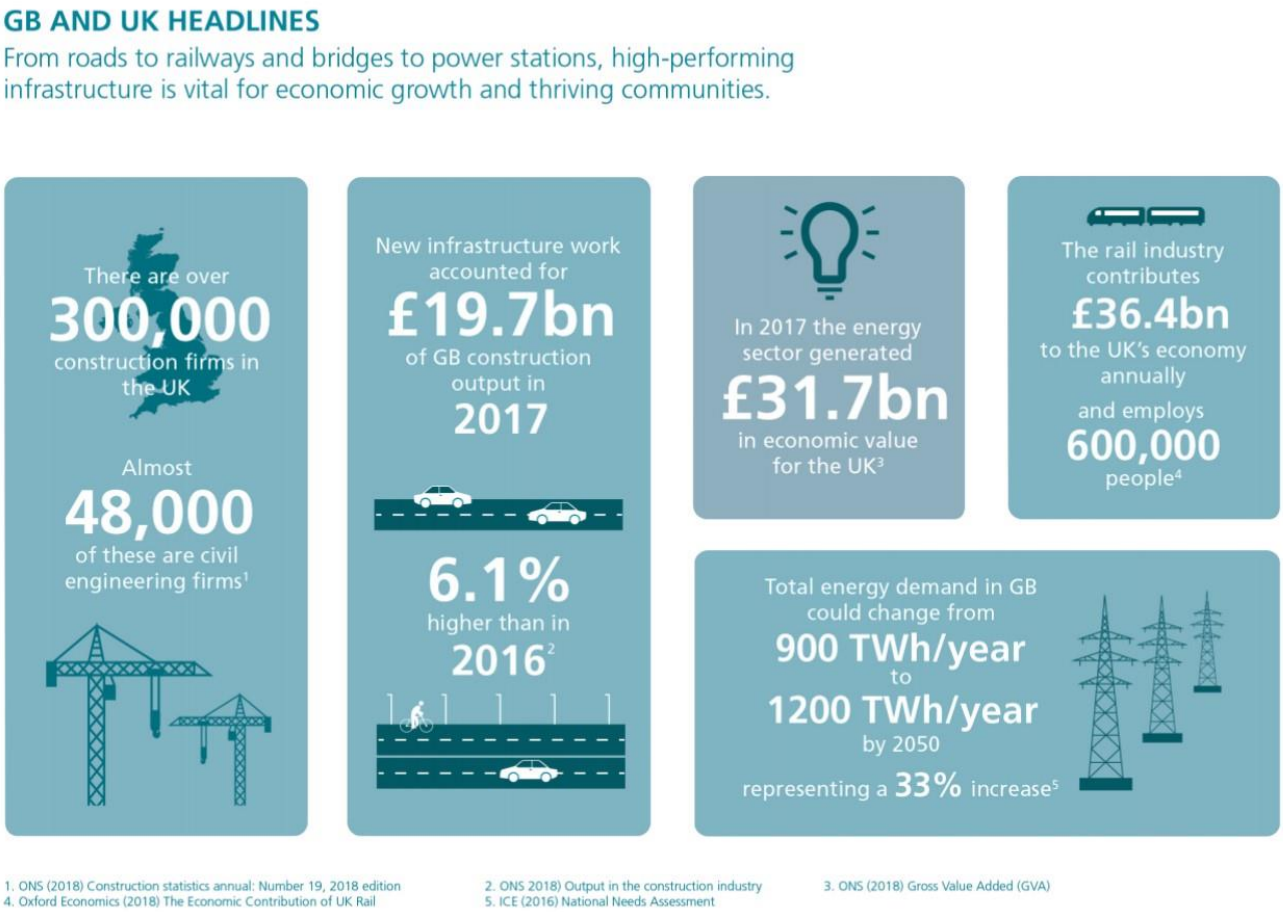
Future expansion – considerations for the National Infrastructure Strategy (NIS)

HS2 was never designed to be delivered in isolation; however, it has been treated as an isolated project. It is especially important that the National Infrastructure Strategy (NIS) provides a blueprint for joined-up thinking for major projects going forward. These projects should be directed and influenced by regional infrastructure strategies to ensure effective integration of infrastructure planning.

This is a point that the Institute for Government has repeatedly emphasised, arguing that the decision about whether to proceed with HS2 should be made as part of the NIS.[83] 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.

[83] Institute for Government (2019) How to transform infrastructure decision making in the UK

Just as HS2 must learn lessons from Crossrail in terms of governance and delivery, so too must future rail expansions learn from the process that HS2 will undertake should it be delivered.



About ICE

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