GREENGAUGE21

HS2's Eastern Arm ›

July 2020

Foreword

Ministers have instructed DfT to progress the western arm of HS2 Phase 2b into Manchester as a priority.

The eastern arm is lengthier and more expensive, but it provides balance, stopping HS2 becoming a west-side only story in terms of national coverage. Yet the eastern arm can support only half as many high-speed train paths to London as are available for western side services - even if the full 18 train/hour line capacity is delivered. In the next 10-15 years, the western side of the Midlands and North will scoop up all available connectivity benefits. Eastern arm delivery, on current form, cannot be expected before the 2040s, Northern Powerhouse Rail, probably even later.

At a time when re-balancing the national economy is a recognised aim, the sequencing of HS2 delivery will add to an east-west imbalance in the North and Midlands. Finding a way to get parts of the eastern arm built more quickly is therefore essential.

But infrastructure has to meet a purpose, and the purpose of the eastern arm of HS2 is not well defined and is therefore as yet unclear. Once that question is asked and then fully addressed, it becomes clearer how priorities can be set, some cost savings found and planning assurance delivered.

HS2 Ltd has shown remarkable resolve in keeping its 2010 plans broadly intact; east-side stakeholders have equally shown remarkable patience. In exploring here the options for the eastern arm, we cannot avoid questions of cost and value for money – questions to which the National Infrastructure Commission is seeking answers – and which regional stakeholders may be reluctant to address.

We hope the ideas in this report help to stimulate a positive debate and bring an east-west balance to the expected pattern of social and economic gains ahead.

Contents

Executive Summary

1. This report reviews the eastern arm of HS2 between Birmingham and Leeds, potentially a key element in the Department for Transport's Integrated Rail Plan for the Midlands and North expected later this year.
2. On current plans, the West Midlands and the North West will benefit from HS2 services at least a decade before the three regions to the east (East Midlands, Yorkshire/Humber, North East) which cannot expect to see the benefit of HS2 until the 2040s. We set out how this unwanted east-west timing distortion can be countered, and also examine how to extend connectivity benefits to places on the eastern side of the country that can feel 'left behind'.
3. The reason why the eastern arm was added to HS2 plans in 2010 was to balance the development stimulus it would bring across the north of England. In practice, this resulted in a plan for very fast journeys from London (and Birmingham) to Leeds. But other cities that could, and we argue here, should be served, were side-lined.
4. HS2 is being built first on a north west-south east (NW-SE) axis. What's needed as a complement is a NE-SW route, with the two high-speed routes intersecting at Birmingham. This will allow a transformed connectivity for a wide set of regional cities.
5. The original design focus for the eastern arm, centred on creating a very fast London-Leeds (non-stop) journey time, was too narrow. High-speed trains would shuttle between Leeds and both London and Birmingham. The current eastern arm design doesn't allow trains to operate both into and beyond dead end stations in either Leeds or Birmingham. Travellers would have to interchange to join high-speed services. The nationally-important long-distance cross country network of rail services, instead of gaining a speed-up across the central core of its route from Edinburgh to south west England, will need to continue to operate on the existing congested rail network. This is a wasted opportunity that can be put right by changes proposed in this report to be made at either end of the eastern arm, at Leeds and Birmingham.
6. Instead of a Y-shaped HS2 network, this will allow services to operate over a much more effective X-shape. The south western leg that needs to be added from Birmingham will be provided by extending electrification of the existing main line south westwards from Bromsgrove to Bristol Parkway – and thence to Cardiff and South West England – places previously unserved by HS2.
7. It makes no sense to contemplate designing any part of the eastern arm for a distant possibility of deploying double-deck high-speed trains. This merely increases capital costs for trains which cannot be accommodated on the existing network. Besides cost savings, designing the eastern arm of HS2 for the UK gauge opens up previously unexplored opportunities to accommodate HS2 trains at existing stations, including in Leeds, where separate, dedicated HS2 platforms would not be required.
8. We recommend early delivery of two sections of HS2's eastern arm, one building from the North, from Leeds to Sheffield (the busiest inter-city commuter market in the North) the other across the Midlands, from Birmingham to Nottingham (the most important strategic connection across the Midlands). Modifications are needed – not to the general HS2 route alignment, but to the arrangements to access city centres. The central section of HS2's eastern arm can follow later.

9. Shorter approvals timescales will become possible with planning powers sought for these two early stages in parallel. Each has an independent business case; together they would generate a large part of the benefits of the eastern arm at significantly less cost.

10. The northern part of the eastern arm between Leeds and Sheffield should be accelerated and its design changed, dropping the East of Leeds bypass and modifying the terminus configuration at Leeds. Here, the existing station (and its eastern approaches) should be upgraded instead to accommodate the expected increased number of HS2 and other local and regional rail services. The new T shaped element of the station should be deployed to provide new capacity for local services. The city's regeneration plans built around Leeds station need not be changed. With Leeds now put on a through high-speed route, its all-round connectivity will be boosted.

11. The design of the southern part of the eastern arm also needs to be changed so that it serves Nottingham directly. The route on northwards from Nottingham should be upgraded and a new connection added to the East Coast Main Line (ECML) at Newark to create a new, faster, NE-SW long distance route and a complement to the existing route via Sheffield and Derby.

12. Under these plans, the planned development around a new station at Toton can be accelerated. With a spur from the proposed accelerated Birmingham-Nottingham high-speed line, HS2 London services could be introduced earlier to Sheffield, using existing lines *via* Toton and Chesterfield. This requires completion of the Midland Main Line electrification programme.

13. The report leaves open the question of whether the central 50-mile section of the eastern arm is the best option available. We advance a new alternative proposal. We recommend that a detailed study is commissioned given the potential for much wider benefits from a similar length of high-speed line built in the ECML corridor, parallel to, but further east than the current HS2 design. A high-speed line in the ECML corridor could speed up all of its longer distance services, add valuable network capacity and resilience, and serve north east England better than the current HS2 plan.

14. As this report sets out, these early stages can help bring about better rail connectivity to a host of towns and cities across the east side of England. These places include Barnsley, Bradford, Chesterfield, the Dearne Valley towns, Derby, Doncaster, Hull, Ilkeston, Kirkby-in-Ashfield, Lincoln, Mansfield, Newark, Rotherham and Wakefield.

15. We recommend that a programme is set out with ambitious but achievable delivery dates for the eastern arm of HS2 and the related set of measures, so that the rail sector supply chain can plan accordingly and private sector investors can have confidence in the enhanced connectivity that lies ahead. This will no longer centre on fast journey times to London alone but on 360° connectivity, helping businesses invest and make better location decisions.

1. Introduction

Government has called for the eastern component of the Y-shaped HS2 network to be reviewed alongside the rail investment plans of Transport for the North (TfN) and Midlands Connect[1] and brought together in an Integrated Rail Plan. The advice of the National Infrastructure Commission (NIC) and the Infrastructure and Projects Authority (IPA) is being sought.[2]

The current set of reviews follows on from a recommendation in the Oakervee Review of HS2 in 2019.[3] Overall there has been at least a 2-year slippage in the timescale for delivery of HS2 during this period of reviews, although work on HS2 Phase 1 is now progressing at pace and Parliamentary approval and Royal Assent for its northern extension to Crewe (Phase 2a) is expected before the year end.

Government intends to release the Integrated Rail Plan by the end of 2020. In doing so, it recognises there is a timescale issue as well as an issue of how well places are connected together:

> "The government agrees that, on current plans, Phase 2b of HS2 will deliver connectivity for the East Midlands and the North of England considerably later than the rest of HS2, and that there are questions about whether its design maximises the benefits from connectivity." [4]

But this is not quite accurate. From around 2030 onwards, the West Midlands and North West of England (and Scotland and North Wales) will all benefit from the improved connectivity brought by HS2 Phases 1 and 2a which shortens journey times dramatically using the new infrastructure between London-(Birmingham)-Crewe. It is the East Midlands *and part, but not all,* of the North – the large part to the east of the Pennines (Yorkshire/Humber and North East England) – that completely miss out from the connectivity gains of HS2 Phases 1 and 2a. Current timescales for implementing Phase 2b of HS2 are not known but based on the timelines for Phase1/2a might be expected to be ten-fifteen years later (2040-45).

The hiatus between 2030 and 2040/45 risks undermining a key objective of the 'Y' shaped HS2 network which was to ensure a balanced positive impact on development east-west across the Midlands and the North.[5] Even when the eastern arm of HS2 eventually comes on-stream, ⅔ of the maximum possible number of train paths to and from London on HS2 will be taken up by services to the west side of the country, leaving only ⅓ of the paths available for trains using HS2's eastern

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[1]Transport for the North's proposals for a new 'higher' speed railway running east west and connecting the North of England's major cities between Liverpool and York is called *Northern Powerhouse Rail* and Midlands Connect's proposals – which are designed to make better use out of the existing rail network – are known as *Midlands Engine Rail*.

[2] The NIC is to advise on the 'rail needs' of the North and Midlands. The NIC in turn launched a consultation with stakeholders to help distil its advice. Some of the consultation responses have been published and have helped inform this report. The IPA is to advise on lessons that can be learned from HS2 Phases 1 and 2a on delivery of the project delivery and costs. On 13th July 2020, the IPA issued HS2 a red rating meaning that "successful delivery of the project appears to be unachievable", but DfT countered that this assessment was based on the 2019 position and had not taken into account the subsequent 'reset' – see https://www.yorkshirepost.co.uk/news/politics/hs2-delivery-time-and-budget-appears-be-unachievable-government-experts-rating-2912116 July 14th 2020

[3] See https://www.gov.uk/government/publications/oakervee-review-of-hs2 February 2020

[4] See https://www.gov.uk/government/publications/high-speed-north-an-integrated-rail-plan-for-the-north-and-midlands-terms-of-reference/terms-of-reference-for-an-integrated-rail-plan-for-the-north-and-midlands February 2020

[5] See Cmnd 7827 High Speed Rail, DfT, March 2010

arm.[6] This underutilisation of the eastern arm - and how that capacity can best be utilised - lies at the heart of why the question about the role and purpose of the eastern arm needs to be asked and resolved.

Reflecting the Oakervee Review recommendation to challenge the costs and scope of HS2 components that lie ahead, the announcement of the Integrated Rail Plan said:

> "The government wants to ensure that Phase 2b of HS2 and other planned rail investments in the Midlands and the North are scoped and delivered in an integrated way, including with the wider rail network, whilst driving down unnecessary costs and over-specification." [7]

The Department for Transport (DfT) has pressed HS2 Ltd in the past to secure major cost savings, but whereas for DfT HS2 is a matter of agreed Government policy, there is currently no commitment from HM Treasury to fund the full 'Y-shaped' network.

Apparently cheaper propositions such as an 'S-shaped' network (estimated earlier by DfT to save 15% of the costs of the Y-shaped network by serving Leeds on an arm of the network from Manchester rather than Birmingham)[8] no doubt have continuing appeal to budget managers, despite the loss of benefit for the whole of the East Midlands as well as South Yorkshire. Indeed, recent architects' plans for Manchester Piccadilly station suggest that there is some current interest in such an approach.[9] Their adoption would presumably be in place of HS2's eastern arm.

In drafting this report, we have taken soundings with key stakeholders, sharing an early draft. We are acutely conscious of the extent to which local authorities have created plans and gained support for private sector development based on the current designs of the full HS2 network. But we have seen:

- no arguments why reverting to a possibly lower-cost S-shaped network shouldn't be considered instead
- no overall phasing plan for the eastern arm of HS2
- no significant proposals to make capital cost savings.

Each of these are bound to be areas that Government will need to consider. It has a policy aim of levelling up which, we argue here, could be undone by plans that would leave whole regions without

[6] This assumes the original 17-18 HS2 trains/hour (tph) can be accommodated into Euston. Currently the design of the HS2 Euston terminus is being reviewed to see if it is possible to combine the current 2-phase construction plan and whether the dive-under along the tunnelled HS2 approach tracks is justified. If decisions are taken that preclude 17tph operation, then the Oakervee Review suggested 14 tph might be the limit. In this event, there would likely be no Newcastle-London HS2 trains, as observed in the Greengauge 21 report of 2018 ('Beyond HS2'). Until this situation is resolved with a firm commitment on London HS2 service levels, the value of the eastern arm as proposed is potentially compromised.

[7] *As footnote 4*

[8] Source Cmnd 7827, Table 4.2, *Ibid.* See also http://www.greengauge21.net/government-abandons-the-s-shaped-network/ November 2010

[9] See for example https://www.bdonline.co.uk/news/weston-williamson-draws-up-rival-plan-for-hs2s-manchester-piccadilly-redevelopment/5106704.article#:~:text=The%20High%20Speed%20Station%20Square,Piccadilly%20without%20having%20to%20reverse.

any of the connectivity gains from HS2 which would be enjoyed by adjacent areas. There is an east-west imbalance problem, as well as north-south, to be addressed. [10]

An effective phasing plan for the eastern arm, as described here, could lead to faster delivery timescales for parts of HS2 and allow key private sector developments to progress more rapidly, including at Toton and Leeds. Phasing could also generate the breathing space to ensure that later parts of an overall high-speed rail implementation plan bring greater benefits than the current Phase 2b plan provides.

The key questions, including around scope and capital costs, can only be effectively addressed if there is **clarity of purpose**. This is lacking with the eastern arm of HS2, certainly in comparison with HS2 Phases 1 and 2a which besides improving connectivity also bring a major boost to rail network capacity, for both passengers and freight.

[10] See http://www.greengauge21.net/the-uks-2070-transport-infrastructure-requirement/ November 2019

2. The Purpose of HS2's Eastern Arm

A key objective behind a Y shaped HS2 network from the outset was serving both sides of the Pennines and, critically, with similar journey times so as not to distort the economic balance east-west across the Midlands and the North – a view initially taken by the Labour Government in 2010[11] and then confirmed following a review by the Coalition Government later the same year.[12]

But the reality is that West Coast Main Line intercity services transferring to the HS2 line take two thirds of the new line's capacity into London, precluding a similar scale of transformation on the East Coast Main Line (or the Midland Main Line). The levels of planned utilisation of the eastern arm has always been lower in HS2 Ltd's service plans as a consequence. The West Midlands routeing also means that journey time savings to/from London are generally smaller on the east side of the country. Moreover, current phasing suggests the connectivity benefits will be delivered at least 10 years earlier to the west side than the east, exacerbating the existing east-west economic imbalance.

Various proposals by Midland Connect and Transport for the North in the last few years have sought to make increased use of the eastern arm There are proposals from local and regional stakeholders for new junctions to accommodate additional regional services, for example, but there has at no stage been a clear collective view from stakeholders or a clear response from Government.

The underlying question of the *role* of the eastern arm (and then its utilisation) has not been answered over the last ten years. And to some degree the problem has been made worse by the solution eventually reached to serve Sheffield – a lengthy loop using the existing network leaving hard to utilise spare capacity on the new high-speed line, diminishing its added value.

The question of the underlying purpose of the eastern arm is a ball now in the National Infrastructure Commission's court to try to resolve and advise Ministers in DfT and the Treasury on the choices available.[13] Infrastructure plans and priorities cannot be set in isolation: they need to be based on pursuit of agreed objectives and with service plans, which should extend to consideration of the surrounding rail network.

With so much focus on a north-south imbalance nationally, the east-west imbalance across the Midlands and North is easily overlooked. At a regional level, output (GDP) per head is higher in the North West and the West Midlands than in the North East, Yorkshire/Humber and the East Midlands[14]. Moreover, of the 40 worst ranking English local authority areas in terms of Social Mobility Index scores, 28 of the lowest ranked (70% of the total) are on the eastern side of the country, with a large proportion in the East Midlands and adjoining South Yorkshire.[15] The places affected are *not* the large cities that are likely to be served directly by new high-speed rail infrastructure and services, but a set of towns and places that have lost their primary sources of employment through de-industrialisation.

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[11] DfT Cmnd 7827 March 2010

[12] Philip Hammond MP then Secretary of State for Transport confirmed the Y shaped network on 4 October 2010 following a review https://www.gov.uk/government/news/proposed-high-speed-rail-network-north-of-birmingham-confirmed

[13] The NIC approach to this challenge is set out in an interim report of July 15th, 2020: https://www.nic.org.uk/publications/interim-rail-needs-assessment/

[14] See House of Commons Briefing Paper no. 06924, 17 July 2020, Regional and Country Economic Indicators https://commonslibrary.parliament.uk/research-briefings/sn06924/

[15] See data collated and presented in Annex A in *Beyond HS2,* May 2018, Greengauge21

The implication is that to achieve the 'levelling up' agenda in the North and the Midlands, the Government will need to think east-west as well as north-south. Moreover, it will not be enough to look at HS2 services between the major cities. The new Integrated Rail Plan will equally need to consider related projects that can enhance connectivity and the capacity liberated on existing lines to serve places that are at risk of being 'left behind'.

Strengths and Weaknesses

A strength of HS2's eastern arm is that it makes use of the fast capacity created by Phase 1 south of Birmingham to London. But there are weaknesses.

The first is the limited number of new fast London services that can be operated in comparison with those on the western side of the country.

This leads to a second problem: it is possible to replace only a proportion of East Coast Main Line services – and on current plans none of the Midland Main Line services to London – from Nottingham and (Sheffield-) Derby. This means that, unlike with the western side scheme, much less capacity is generated on the existing network to improve services to other key towns in the corridor where it will be built.

There is a third weakness: the eastern arm, as currently designed, provides only for frequent point-to-point (Leeds-Birmingham) high-speed movements along its cross-country corridor. This is not going to be attractive for (say) travellers from Edinburgh to Bristol (or between the many other station pairs that the over-stretched cross-country service accommodates) without the need for and inconvenience of changing trains *en route*, since to take advantage of the planned half-hourly fast Leeds-Birmingham trains would entail one or in some cases two interchanges. Leeds-Birmingham, on its own, is not a large rail passenger market. What is needed is for Leeds-Birmingham to be part of a through route, rather than its current conception which has a dedicated HS2 terminus at each end.

And this leads to the fourth weakness. While the corridor through which HS2 runs has a cluster of major cities – Birmingham, Derby, Nottingham, Sheffield and Leeds – planned HS2 services as currently planned only directly link one out of the possible 10 city pairs.

Objectives and Role

This assessment leads immediately to one simple conclusion: the eastern arm is not a mirror image of the western arm. It cannot fulfil as its primary function the eastern equivalent of HS2 on the western side: displacing intercity services from a parallel main line, replacing a 12 train/hour service with even quicker connections to & from London and releasing capacity for new and more convenient services for intermediate and currently poorly served locations and providing for more freight on rail. So what is its role to be if not the very limited one currently envisaged?

The key change in thinking to be made is to see the eastern arm of HS2's role as also being to provide better 'cross country' links:

(i) between the cities of the East Midlands/Yorkshire Humber/North East *and*
(ii) between these 'corridor' cities and major centres beyond that lie on a broadly-defined north-east south-west axis (so this adds in Edinburgh and other Scottish cities to the north, and to the south: the West Midlands, South Wales, the South West and South East England) *and*
(iii) extending the reach of HS2 where possible to incorporate poorly connected cities such as Bradford *and*

(iv) releasing capacity on the NE-SW long distance corridor so that important intermediate towns such as Chesterfield and Wakefield and currently off-(existing main) line locations such as Bradford and Mansfield can be better served.

Its important second role is to provide high-speed links to & from London from the major cities in the corridor: Leeds, Sheffield and Nottingham.

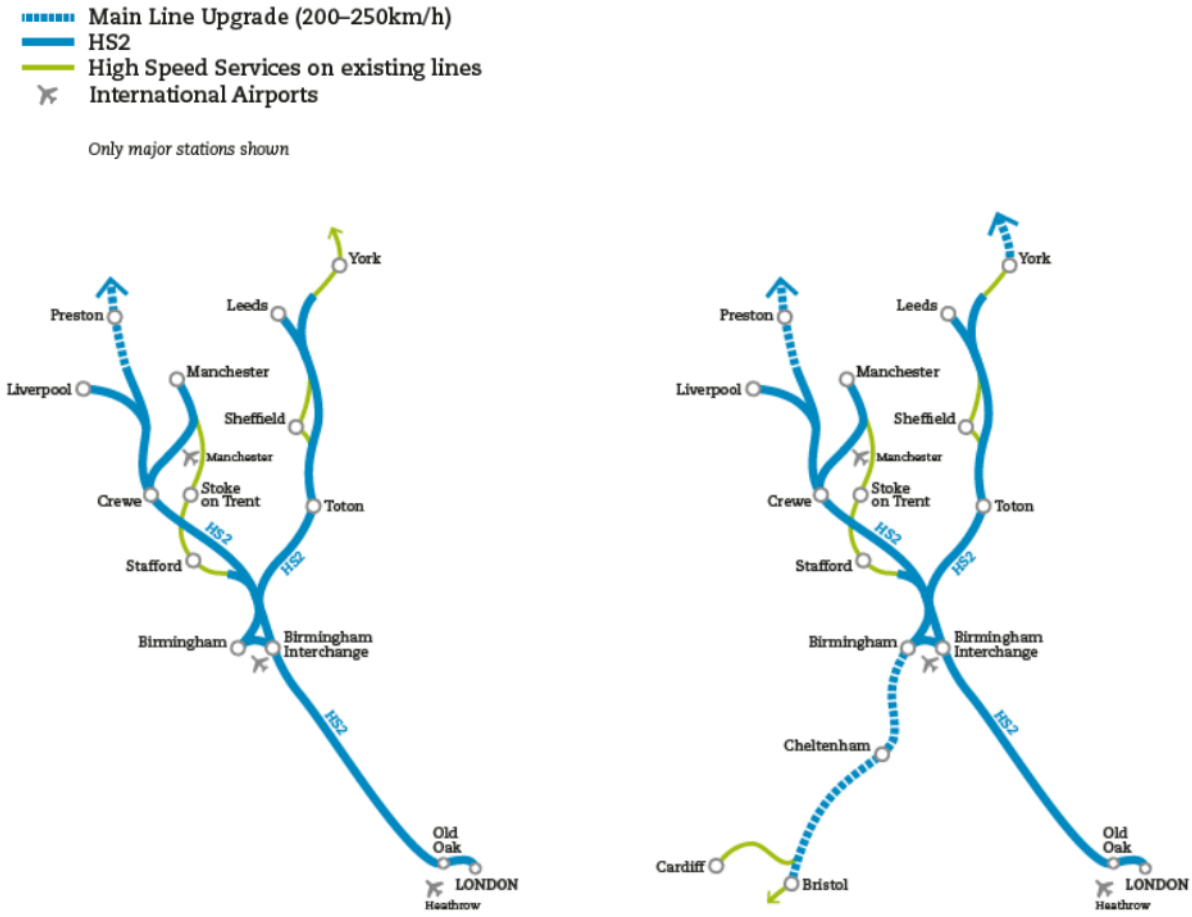
The changes to the planned infrastructure needed to achieve this shift in focus are not in themselves particularly dramatic, but revised arrangements are needed in both Leeds and Birmingham to make the faster through cross-country route possible. The changes can however make significant improvements for the convenience of the travelling public.

A New Shape for the HS2 Network

A solution for achieving a through service capability from the eastern arm across Birmingham was identified by Greengauge 21 in 2018. It increases the value and effective capacity of the eastern arm by removing the dependency on sending all services either onward to London or into a dead end station in Birmingham[16]. The answer proposed uses the planned Midlands Rail Hub to adapt the HS2 network into an 'X' rather than 'Y' formation[17] - see diagram on the next page. It supports the shift in emphasis on the purpose of the eastern arm towards 'cross-country' rather than London connections.

[16] HS2 shuttle services such as Leeds-Birmingham would have poor load factors.
[17] See *Beyond HS2* Chapter 6, Greengauge 21, May 2018

Changing HS2 from a 'Y' to an 'X'



Source: Greengauge 21, Beyond HS2*, May 2018*

Crucial to achieving this change is a new connection to the existing rail network from the eastern arm as it approaches Birmingham – and then use of the Midlands Rail Hub plan that adds platforms at Moor Street station, which adjoins the Curzon Street HS2 terminus.[18] This approach changes the balance of services that would utilise the new links into Moor Street and the infrastructure must allow for easy reversal at Moor Street to allow through north-south operation. It also requires electrification of the main line south-westwards from Birmingham. The benefits of both HS2 Phase 2b and of the Midlands Rail Hub would be widened, bringing Bristol and Cardiff, for example, into the pool of cities with HS2 services.[19] Moor Street and Curzon Street adjoin each other and would accommodate most longer distance services; New Street would remain the hub for an expanded set of city and regional services.

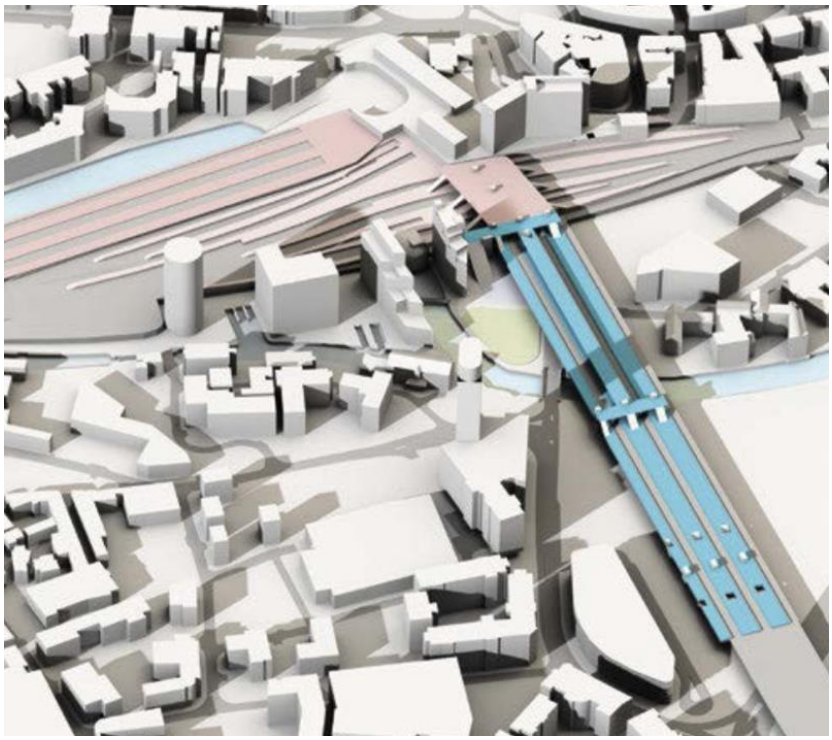
The change needed at the northern end of the eastern limb is to accommodate HS2 trains in the existing – and suitably updated – Leeds station (the details of which are discussed in section 4, below). The once separated station planned for Leeds (at New Road) is now planned to be conjoined

[18] See https://www.midlandsconnect.uk/publications/midlands-rail-hub-june-2019/

[19] Note that this significant broadening of the spread of HS2 service coverage would be attributable to the eastern arm, enhancing its business case.

with the existing station in a 'T' shape.[20] The key change needed is to revise the HS2 approach from the south and provide an exclusive access by taking over existing lines for the final approach through Hunslet with classic line services (from Barnsley, Wakefield and the 'five towns') switched into the new terminating platforms instead. This allows HS2 services to operate from the south *via* Leeds to reach York, the Tees Valley, Durham, Newcastle and Edinburgh.

Image of the current revised HS2 station design (HS2 platforms in blue) at Leeds



Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/480396/Higgins_-_The_Yorkshire_Hub.pdf, OGL 2, https://commons.wikimedia.org/w/index.php?curid=45825027

Taking over existing lines for the final approach and switching local services into the new terminating platforms avoids the re-instatement of a proposed additional connection at Stourton (on the southern approaches to Leeds), that has been ruled out on price grounds. It would be replaced with a new north-facing junction at Clayton or Hare Park instead, so that trains from the south on HS2 could leave the route there to reach Wakefield. This would make sense for additional services that could then serve Bradford directly[21], linking it to the south.

Summary

We have suggested a need for clarity on the role for the eastern arm. As suggested here, it is more substantial and extensive and, ten years on, is we believe better attuned to Government objectives of 2020 and beyond. We use the new formulation to help shape the discussion which follows on Phasing and on Value for Money. We answer the fundamental questions of whether the eastern arm is needed at all: **yes,** because without it 'economic levelling up' is going to leave some major gaps on the east side of the country; and does it offer the best use of the funds available? **Yes - but** there are

[21] Via a short re-instated curve at Wortley.

some options available both to save on capital cost and to secure greater benefits as we set out below.

HS2 outputs were originally expressed in terms of headline journey times – with the same timings for London-Leeds as London-Manchester. This has led to a narrow interpretation of the function of the eastern arm. Instead, the function of the eastern arm is seen here as being much more broadly based in a wide set of long distance rail connections for a large number of cities and their city regions and the scope to free up capacity on the Midland Main Line and the East Coast Main Line.

The way in which services can be built up through phased implementation as described next helps establish the functional change, infrastructure requirements and options and capital cost savings that can be realised.

3. Phasing HS2's Eastern Arm

Implementation Timescales

It is unlikely that the full HS2 project could now be delivered before the 2040s (based on HS2 project lead times to date). This means a lengthy period of better connectivity in the West Midlands, but not the East Midlands, and an advantage and head start in securing an economic stimulus for NW England over its east of Pennine neighbours.

The eastern arm is 123 miles (198 km) long.[22] In effect it comprises:

1. Birmingham – Toton where a new station is planned to serve Derby and Nottingham
2. Toton – Leeds
3. An onward connection bypassing Leeds to connect with the main line network south of York
4. Upgrades & electrification of existing lines and junctions and links to them to create a loop line to serve Sheffield.

Greengauge 21 has long argued that an early start on creating the link between Sheffield and Leeds would be a good priority with wide benefits – an approach that requires prioritising parts of the second and fourth elements above. It means that (belatedly) HS2 construction could be started in the north. There is no reason, once design standards are agreed, not to do so.

Midlands Connect, on the other hand, wants to see the first element to be the connection from the south to Toton. It has also proposed an advanced, staged, development of Toton Hub ahead of the arrival of HS2.[23] These seem to be the two candidate early phases, meaning that there could be a three phase implementation plan, with a central section coming last.

(i) Sheffield-Leeds first

If the hourly long distance cross-country service were diverted on to the new line (which should allow a long-sought after increase in service frequencies to two trains/hour (tph) via Leeds), it would free up capacity for better local services on the existing route via Wakefield and Barnsley[24] switched as described above to operate out of the newly built part of Leeds station.

Midland Main Line trains from St Pancras to Sheffield (2 trains/hour (tph)) could be extended over the newly-built part of the HS2 line to reach Leeds. A new service could be added southwards from Bradford using the potential new junction at Hare Park to access the new high-speed line. This could allow Bradford to be added to the cross country service network, with the north of Birmingham segment providing a set of valuable new connections: Bradford-Wakefield-Sheffield-Chesterfield-Derby-Birmingham. And the hourly Nottingham-Leeds train could also switch to the new line, creating a total of 4-5tph (and potentially more) to operate over this initial phase HS2 route, with Sheffield-Leeds journey times cut by 30%.[25]

With no trains operating onwards over other sections of HS2 to the south, there would be no need initially to restrict the route at this first interim stage to 200 mile/hour high-speed trainsets: services

[22] Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/567616/West_Midlands_to_Leeds_Route_engineering_report.pdf

[23] See https://www.midlandsconnect.uk/publications/access-to-toton/ May 2020

[24] Possibly subject to Network Rail plans to grade-separate Wincobank Junction at Meadowhall

[25] Source: https://sheffieldcityregion.org.uk/wp-content/uploads/2019/07/SCR_Integrated_Rail_Plan.pdf p 15

could run at say 125 or 140 mile/h[26]. But all routes supporting these trains would need to be electrified, and serious thought needs to be given to getting higher lines speeds on the existing line from Clayton Junction to Sheffield.

Besides the electrification implications of this option, there are issues for the main stations in Leeds and Sheffield, both of which would need early expansion since, with extra long-distance and local trains, there would be a net increase of services in both stations. Of course, these major station investments are very likely to be needed anyway given current capacity constraints, for both the full HS2 service and for Northern Powerhouse Rail (NPR) trains; this is very much a timing issue.

Switching HS2-line trains into the existing Leeds station is needed to be able to transfer the cross country service to the new line and speed it up (a change that would bring widespread benefits for passengers from as far away as Aberdeen & Penzance). So, the new Leeds HS2 terminus platforms are not needed for an early stage opening, although the planned new 'T'-shaped station platforms will serve a useful purpose accommodating local trains instead of HS2 services.

The revised use means that the new platforms would be (much) shorter and the junction at Stourton simplified. Rather than build the 8km long viaduct that has been proposed since 2019 to form the Woodlesford-Leeds section of line, the high-speed lines would run alongside the existing line.[27] This helps contain the costs of this possible first phase proposition, although the costs of enhancing Leeds and Sheffield stations to accommodate additional services are likely to be considerable. But rather than leaving these expenditures for later, it should be recognised that these stations are key hubs which need expansion for forthcoming trans-Pennine service improvements and increases in any event. These are not 'HS2-only' costs, and the benefits are extensive and to a large extent will benefit city-region level train movement and passengers: these investments should be a priority in any Integrated Rail Plan.

(ii) Birmingham-Toton first

In this second early phase option, the southern part of the eastern arm would be built first, in effect forming a new high-speed link across the Midlands and an extension of the Phase 1 HS2 line. Here, on the face of it, the service choices are simpler: which of the ultimate HS2 eastern arm service plan trains would be worth operating?

Unlike with Sheffield-Leeds, there are no suitable existing services that could benefit from being diverted onto this line.[28] Unless trains could continue further north, demand levels would rest entirely on business generated at Toton. A service of (say) 1tph from Toton to Euston, and a similar level of service to Birmingham (Curzon Street) would be a likely outcome and carryings would be

[26] As is current practice with South Eastern high-speed services running over HS1, using Class 395 'Javelin' train sets. Note that if the Midlands sections of Phase 2b opens, there *would* be the opportunity to extend services southwards over the core HS2 infrastructure, and such services would require operation with HS2-specification train fleets.

[27] This is a change in philosophy for HSR operation but is of course common practice in much of Europe with the TGV and ICE services of SNCF and DB for example.

[28] Nottingham-Cardiff trains (1tph) could be diverted to the new line but this would require addition of a new south <- > east junction at Trowell and electrification of the route into Nottingham; it would also mean that Derby would lose the connections these trains provide. These trains today are formed by short formation Class 170 trains, so demand levels are not substantial.

thin. Toton has substantial development potential, but demand levels for long distance travel are likely to take many years to build up.[29]

But clearly other services can be added to this candidate first stage scheme with an onward routing north from Toton to Sheffield *via* the Erewash Valley line and Chesterfield. This line might not otherwise be a priority for electrification given its low usage level, but the route northwards to Chesterfield is in fact more direct than *via* HS2 Phase 2b. So, potentially, initial HS2 services could operate over the new link from London and onwards *via* Toton to Sheffield. If the northern section of HS2 to Leeds was available, further extension to Leeds would be appropriate too, although journey times would be significantly slower than with the full Phase 2b infrastructure because of the *via* Sheffield routing.

Conclusion

Of the two candidate early opening schemes, ***Leeds-Sheffield looks the better option to 'go first'.*** It could help stimulate the Yorkshire economy and add valuable commuting capacity into two major regional centres. By speeding up the existing long distance Cross Country trains operating *via* Leeds, this would also generate benefits across a much wider catchment too. And its existence would strengthen the case for a second phase (which could be progressed in parallel) between Birmingham and Toton.

While early delivery of a London-Sheffield HS2 service is an attraction of the Toton-first alternative, it is hard to see how sufficient utilisation of this part of HS2's eastern arm, as it is current planned, would be achieved to make this a preferable first eastern arm step. But there are measures that could enhance the value of this phase of the project as discussed in chapter 4 (see p24) which would transform its value and advance its merit to be progressed without delay.

There are key advantages in breaking the eastern arm project into phases:

- Costs are spread out, and supply chain pressures are eased with a longer term programme allowing suppliers to invest further in green/low carbon construction techniques and in higher productivity approaches
- Shorter schemes will face fewer petitioners in Parliament and so Committee timescales will be shortened and overall project costs and delivery timelines improved.

A phased implementation approach may also allow acceleration of the consenting process by progressing some physical works through a Development Consent Order process, rather than by means of a Parliamentary Bill.[30] This could be applied to the city centre stations works, which will be needed under all scenarios to accommodate additional train services.

The need to expand existing city stations is fundamental to Northern Powerhouse Rail and HS2 and works to create new 'superhubs' should be considered for early implementation, with the expectation that they would stimulate much earlier private sector property development than will arise otherwise.

[29] Experience with Alfreton and Mansfield Parkway to the north and at East Midlands Parkway to the south of Toton, where demand has not reached 50% of projected usage levels, are not encouraging precedents.
[30] The Development Consent Order (DCO) process has been successfully used for rail projects such as the new line and flying junction built at Norton Bridge in Staffordshire.

4. HS2 Eastern Arm Adaptations – and defining Phases 1&2

Here we consider variants to the current HS2 Phase 2b plan on the eastern side of the country. Potential opportunities to save costs, so that prompt delivery of the eastern arm imposes less of a charge to the public account, are explored, along with ways to enhance project benefits.

The adaptations considered here derive from the clarity of purpose on the eastern arm outlined in Section 2 above. They help define our recommendations on Phases 1 &2 and they are:

1. Construction to the UK (rather than EU) rolling stock gauge
2. Leeds station
3. Shorter loop to access Sheffield
4. Extension of Sheffield Supertram to the Dearne Valley area
5. Upgrade of the existing route via Derby
6. Adoption of a DfT Strategic Alternative.

(i) Construction to UK rather than EU gauge

It is rather surprising that the Oakervee Review of HS2 failed to consider this proposition which would:

- reduce the cross-sectional area of HS2 construction with savings on tunnel[31] and other structure costs
- with a reduction in track centre spacing, slightly lessen the overall width needed for the new line, and
- do away with the need for separate platforms for HS2 trains.

It has after all now been decided that the entire HS2 fleet for Phase 1/2a will be built to the UK gauge.[32] True, the option is left open to provide EU-gauge trains at a later stage. But beside a modest extra 2 inches internal coach width, the great advantage of EU-gauge was always seen as the opportunity to deploy bi-level high-speed trains (France has a fleet of these in operation) at a future stage, since these can add up to an extra 40% seating capacity. But providing for what is no more than a future possibility is questionable since:

- It increases infrastructure costs
- Bi-level trains cannot be made compliant with disabled access regulations (except by adding lifts into each coach but this risks losing the extra seating capacity as well as adding cost)
- It precludes achieving level boarding of trains except at special-purpose HS2 platforms.

As it becomes clearer that the eastern arm of HS2 will very likely accommodate a more varied set of high-speed services than was originally envisaged, these points have added significance. All stations

[31] Tunnel diameters and transitional treatment for pressure waves are set by aerodynamic factors rather than simply the accommodation of the cross-sectional profiles of the high-speed trains. But if tunnels have to be designed for the impact of full EU-gauge high-speed trains which includes the later adoption of double-decker sets, captive to deployment on new HS2 lines, then the tunnel and overbridge cross-sections needed for EU-gauge trains will be greater and construction costs higher.

[32] This was described by HS2 Ltd as the 'classic-compatible' train fleet to distinguish it from a separate 'captive' fleet that could only operate on HS2 tracks. The option to add EU-gauge trains later remains open for any service that runs only on HS2 tracks, provided the infrastructure has been built – as will be the case with Phase 1 – to EU gauge. It might be time to drop the cumbersome jargon and speak in terms of the GB HSR train fleet.

off the new infrastructure will not be able to provide level boarding unless HS2-only platforms are built.[33]

The most critical factor allowing costs to be saved is at stations. A key example is at Leeds station where there will be no need to create separate platforms that exclusively serve HS2 trains. As we discuss in greater detail below, it is the assumption of the need to design for future deployment of EU-gauge trains with dedicated platforms that made it virtually impossible to accommodate HS2 trains on the existing station's through platforms and drove a more costly design solution.

Furthermore, it seems unlikely that the whole of the eastern arm would be built in a single phase. To get value from incremental stages identified in chapter 3, trains on the high-speed network need also to operate over existing lines, rather than operate short shuttle services on exclusively new-build lines. Even when the full line is built, eastern arm 'captive' trains – that is those that do not operate over anything other than HS2 infrastructure – will be a minority: only Euston-Leeds trains. Most services will be provided by what have been termed 'classic compatible' trainsets.

On the eastern arm, it is rather like the situation already faced by HS2 Ltd in deciding whether to have one or two fleets of rolling stock for the Phase1/2a HS2 network. The decision was taken then to go with a single unified fleet, built to operate over the UK-gauge network and this makes good economic and operational sense. It is hard to see why the eastern arm should not be built to UK-Gauge and achieve capital cost savings since the vast majority of its services, and potentially all of them as we set out in this report, will need to be UK-gauge compliant. Having two high-speed fleets adds to capital and operating costs and brings minimal benefit.

Provision of HS2-dedicated platforms (on the presumption that HS2 trains from London and Birmingham to Leeds, for example would be HS2-captive) and therefore built to EU-gauge are not then needed at either Toton or Leeds. This change, along with the adoption of through long distance services rather than a set of shuttles will also reduce the need for additional passenger interchange to take advantage of the shorter journey times HS2 will offer.

Is building to EU-gauge needed? The answer for the eastern arm, at least, we suggest is no.

(ii) Leeds

The new Leeds HS2 station is currently planned as a set of 400m long terminating platforms to be constructed on viaduct. While it provides good interchange with other rail services at the current Leeds station, it does not allow trains to operate over HS2 from the south into Leeds and continue northwards. This limits HS2 service options and is inconsistent with the key rationale for the eastern arm as described in Chapter 2. For example, the current HS2 service specification presumes separate Birmingham-Leeds and Birmingham-Newcastle HS2 services. This, as might be thought, simply (and roughly speaking) splits the patronage levels that would be achieved with a through Birmingham-Leeds-Newcastle train onto two separate services which would each be less well used as a consequence.

In fact, this arrangement also means some of the demand over the Birmingham-Leeds-Newcastle route has to be carried on a *third* service (Newcastle-Leeds). The congested GB rail network could do without multiple short trains using valuable line capacity inefficiently and taking up scarce city centre station platform space. Especially since a single (longer) train can better meet market requirements. Moreover, if selected city pairs are to be served by free-standing high-speed shuttle

[33] Such stations include (on current plans and aspirations) Leicester, Loughborough, Chesterfield, Bradford, Sheffield, Wakefield, York, Darlington, Durham, Newcastle and Edinburgh.

services, existing long distance NE-SW cross country services via Leeds and Derby would need to continue as today, instead of freeing up line capacity for more services to local/intermediate stations.[34]

The choice at Leeds should be recognised as this: *either* a separate set of terminating platforms for HS2 trains only, *or* accommodation of HS2 trains within an expanded Leeds station.

Both alternatives, as would be expected, were examined by HS2 Ltd and local partners including Leeds City Council several years ago. But in each case, it was assumed that HS2 services would need their own dedicated platforms. Moreover, these would need to be 400m long and straight, and, since the working hypothesis for HS2 operations is one where layover time is provided generously at the 'country' end of the route to ensure overall service punctuality, there would need to be multiple platforms for the exclusive use of not many trains.

These assumptions can be relaxed without damaging HS2's operational integrity. With a through station arrangement, assuming UK-gauge trains, London-Leeds trains could be provided with 3-5 minute platform dwell times, with onward operation say to/from a depot east of Leeds, or, indeed, onwards to the more-readily extendable station at York for layover[35], rather than occupying scarce Leeds station platforms for half-hour turnrounds.

While Leeds has a well-sited single city centre station, it has few local services operating on a cross-city basis. Eleven of its platforms can only be used by terminating trains[36], leaving just 6 through platforms. Additional through platforms might need to be provided for HS2 and NPR and higher frequency cross-city regional services. Either HS2 train lengths would need to be compromised a little (the longest Leeds platforms can accommodate around 340-360m long trains whereas HS2 plans 400m long trains) or Leeds station would need some platforms lengthened. This is where reduced use of bay platforms in the existing station (and the creation of more through platforms) would become a necessary (and beneficial) corollary. Retaining a simplified and shorter version of the planned T-station terminating HS2 platforms and deploying them to service Pontefract and Sheffield/Barnsley/Wakefield Kirkgate services would be a further good solution to add capacity. But the essential point is that the various ways in which HS2 services could be operated using through lines at Leeds station needs to be examined again, including options that relax some of the HS2 standard design rules.

Investment of this sort is likely to be needed in any event to accommodate plans for Northern Powerhouse Rail services alone.[37] The big picture implication is that Leeds would no longer be served by a branch of HS2, but instead sit astride a new north-south HSR line.

Enhanced access from the east (potentially with a third track added, or a third *and* fourth track) would likely be needed to allow more services to be operated on a cross-city pattern. This has already been identified in the recently published Network Rail study as an intervention needed to accommodate more rolling stock movements to/from Neville Hill depot even before any

[34] Because the existing long distance Cross Country also serve locations such as Wakefield, Derby, Tamworth and Burton upon Trent.

[35] Here consideration is being given to an additional island platform (that is, with two platform faces, although a use has not yet been identified for the second platform face.

[36] A new bay (terminating platform is currently under construction). Use of bay platforms requires trains to reverse and creates unwanted crossing movements on station approaches, reducing effective line capacity.

[37] There is also the question of expanding city region service frequencies and train lengths also to consider, regardless of the arrival of HS2.

consideration of the impact of HS2 and NPR train services is added to the picture.[38] A new station served by local services could be provided at Quarry Hill, and this station would offer a good added connection with local and city/city-region bus services. The provision of a section of new line to bypass the bottleneck created by the stations at Garforth and Micklefield, as emerged from the 'touchpoint' NPR/HS2 assessment, would be a further possibility that would allow city-regional as well as longer distance services to be expanded (and the latter speeded up).

With a through route *via* Leeds created for HS2 (and NPR) services, the value of the planned HS2 eastern bypass of Leeds would diminish. True it would offer a time saving for trains that don't need to stop at Leeds. But a good case could be made to remove it entirely and save the costs of its construction and the provision of costly high-speed junctions at its north and south ends. Fast journey times offered by HS2 services using this east Leeds bypass line between North East England and the Midlands could be achieved by other measures in future (as discussed in Chapter 6).

Revised local service patterns would reduce the need for wasteful use of bay platforms (where trains are allowed extended dwell/turnround timings) and conflicting train movements at Leeds Station and would also provide valuable improvements in connectivity to the towns and settlements in the surrounding area within the wider city-region. Connecting trains from the eastern side – York, Selby, and Pontefract (which could use a re-instated branch line *via* Kippax)[39] – to the western side – Halifax/Bradford, Skipton, Ilkley and Harrogate would obviate much of the need for wasteful terminating train arrangements and allow some through passengers to avoid the need to interchange. The works needed at Leeds station have some similarities to those recently completed at London Bridge station.

While such a development would be expensive, there would be no need for the lengthy (and therefore costly) section of HS2 on viaduct in south Leeds, or for the expensive junction at Stourton. Instead HS2 services would simply transition to existing tracks into Leeds station.

Overall, there is a clear case to accommodate HS2 trains within an expanded Leeds station and improve the connectivity benefits not only for Leeds but its wider city region. Carefully planned regeneration and development of the surrounding area need not be tied to a rail scheme that might be implemented 25 years hence: this can and should proceed now as a priority. The station upgrade can and should be progressed much sooner, bringing forward associated city centre private sector developments.

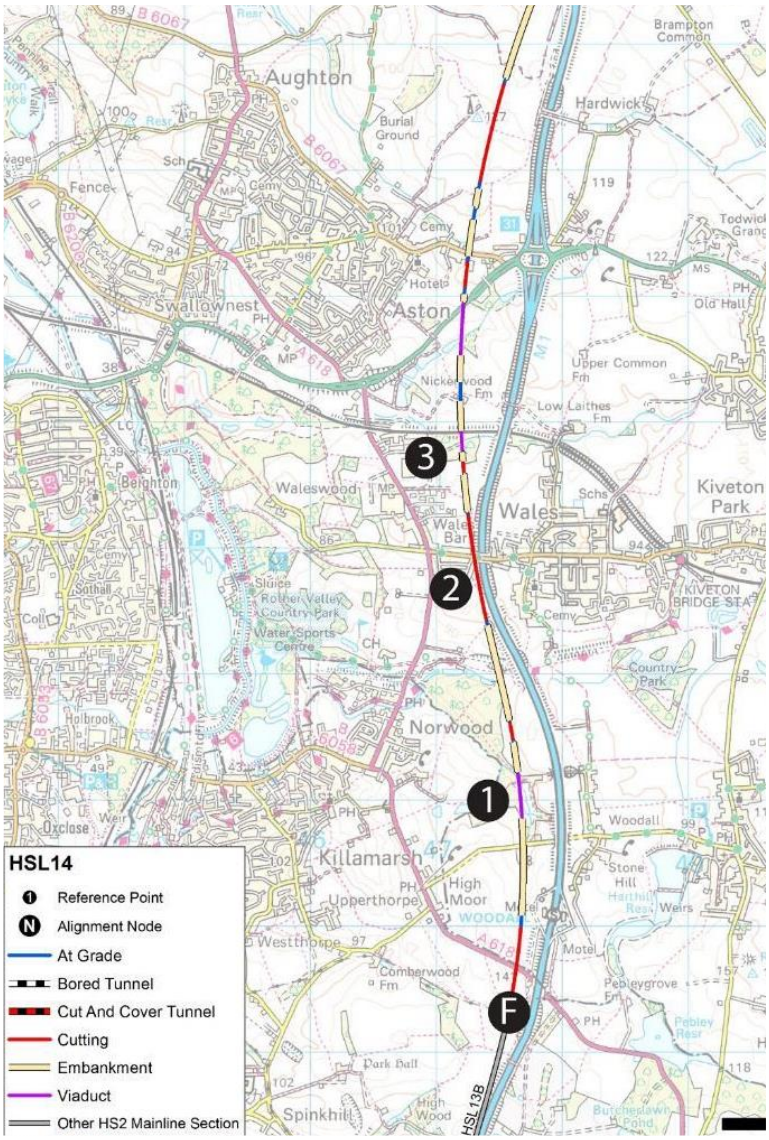
(iii) Shorter loop to serve Sheffield

To access Sheffield from the south, HS2 trains will need to use a new HS2 spur and around 15 miles of existing relatively low-speed railway via Chesterfield and Dronfield. This compromises Sheffield HS2 timings. A much quicker access route (only 8 miles over existing lines) together with a much shorter new HS2 spur could be established near where the HS2 route crosses the Retford-Sheffield railway (near reference point 3 in the map below). This would allow fuller use of the central section of the eastern arm of HS2, and faster London-Sheffield journey times. While this routing would not serve Chesterfield there are good opportunities to improve Chesterfield's connectivity as set out below on page 22.

[38] See https://www.networkrail.co.uk/wp-content/uploads/2020/07/Leeds-Area-Strategic-Study-2020.pdf

[39] The switch of route into Leeds from the Pontefract direction would also free up the approaches to the existing Leeds station for HS2 trains as noted. An alternative to a route *via* Kippax would be a new east-south chord at South Milford

HS2 alignment east of Sheffield



Source: High Speed Two Phase 2 West Midlands to Leeds Route Engineering report, DfT, November 2016

An off-setting disadvantage of this shorter access route (over existing lines which have more spare capacity than the line from the south via Chesterfield), is that it means that all HS2 trains would make the final approach into Sheffield station from the north rather than the south. This might:

- trigger the need for an additional running line into Sheffield station from the north
- would require Sheffield HS2 trains from the south to reverse before continuing onwards to the north.

To which it can be said that:

- it may well be that an additional running line (or lines) into Sheffield station would be needed in any event because of expected increases in train movements, regardless of the direction of approach from HS2 into Sheffield. In other words, this is a likely expenditure to be faced anyway with NPR and Sheffield City Region train service expansion ambitions
- even with a reversal, HS2 trains would still be able to call at Sheffield *more* quickly (in terms of through north-south journey times) than if the longer southern loop was used

- London-Sheffield HS2 times would be reduced
- trains from the south originating in say Nottingham or Leicester could continue without reversal onwards from Sheffield to Manchester.

This change reduces HS2 eastern arm costs somewhat – ***a shorter new HS2 spur is required and project benefits are increased with shorter HS2 Sheffield journey times. This alternative should be considered further.***

(iv) Extension of Sheffield Supertram to the Dearne Valley area

Between Clayton Junction and Sheffield, the current plan is for HS2 trains to use an existing railway that will need to be electrified. The line is used by a mix of local and longer distance trains. The local trains generally call at Thurnscoe, Goldthorpe, Bolton-upon-Dearne, Swinton, Meadowhall (and on a short loop line, Rotherham Central) stations en route, taking 34 minutes between Thurnscoe and Sheffield. This journey time is much slower than non-stop services would take and with additional (HS2) trains on the route, a significant amount of track quadrupling will be needed to avoid delays. Since the cost of such measures would fall to Network Rail and not HS2, the cost of the works is not currently being 'scored' against the HS2 project. But, as was noted earlier, the choices here are not about individual projects, but overall programme-level capital investment.

A possible resolution to the fast/slow train problem that could bring wider benefits would be to extend Sheffield Supertram, which now serves Rotherham Central and Rotherham Parkgate using tram-train technology, northwards to serve a new interchange at Swinton (which would retain its railway services) and the Dearne Valley area through a set of new Supertram stations and a separate right-of-way, replacing the existing hourly local train service.[40] With a much higher frequency and with the opportunity to access Sheffield (and Doncaster) quickly via interchange at Swinton, extension of Sheffield Supertram could offer a major benefit to the Dearne Valley communities which are ex-coal mining towns.

This would also remove some trains that access Sheffield station from the north, to some extent mitigating the concerns with respect to the quicker access route from HS2 to Sheffield noted above. With other capacity improvements to the line north of Sheffield it should be possible to increase services to Barnsley from the south and this could include extensions of HS2 services: London-Sheffield-Barnsley-Wakefield-Castleford-York, for example.

We can reach a view on the four candidate adaptations (i-iv) considered so far. Together they represent a way to reduce HS2 capital costs and bring substantial benefits. A suitable ***'Yorkshire Package'*** would involve:

- Creating a new rail hub at Leeds station, fully integrating HS2 and Northern Powerhouse Rail services (and in the process saving costs by dedicating the new T shaped station element to local services and simplifying the HS2 approach route into Leeds)

[40] A low-cost version of this approach would use the Tram-train technology simply to remove the local services from the Swinton-Sheffield section of line. But this would still leave major operating constraints north of Swinton: it really makes no sense to be operating tram-type vehicles and high-speed trains over the same line. So north of Swinton too, the tram-train would need to be on separate tracks, either alongside the fast lines or on a separate alignment (which could, of course, be at least in part on-street). The line north of Swinton was formerly a 4-track formation as far as Wath Road junction which could be re-used to accommodate a significant part of the parallel Supertram route. An alternative to creating a new Supertram right-of-way is to provide two new high-speed tracks in this corridor.

- The early delivery of a Yorkshire part of Phase 2b (Clayton to Woodlesford), meeting the Transport for the North ambition for faster links between Sheffield and Leeds and adding commuting capacity into both cities
- Establishing a new cross-city S-bahn style network for Leeds city region, with electrification of the York, Selby and Bradford Interchange lines
- Upgrading Sheffield station (and in due course providing the city with faster and more direct HS2 services)
- Bringing transformational benefits to former mining towns in the Dearne Valley (by extending Supertram) and possibly east of Leeds (by re-creating a new route *via* Kippax)
- Providing connectivity improvements for Bradford, Wakefield, Castleford and Barnsley as well as Sheffield and Leeds
- Dropping the HS2 plan for an east-of-Leeds bypass, but increasing capacity and line-speeds into Leeds station from the east
- Reducing HS2 overall costs (with construction to UK-gauge standards) while helping foster completion of the full eastern arm in due course.

In practice, the Yorkshire Package involves a short (c15 mile) length of HS2 from Woodlesford to Clayton junctions, along with electrification of some existing lines, works at Sheffield and (especially) Leeds stations and a Supertram extension. It benefits the largest cities, smaller cities, towns and indeed villages that need a transport connectivity boost. ***The Yorkshire Package can be recommended for early implementation.***

(v) Upgrade of route via Derby

The line should be electrified (a necessary precursor to the current HS2 plan for Sheffield) – and much of this is likely to happen as part of a (re-started) Midland Main Line scheme.

Upgrading the existing route via Derby would help accommodate the mix of freight, long distance passenger and commuter services this line accommodates. The 24-mile section of line between Derby and Tamworth could be 4-tracked *relatively* easily and this would allow high-speed running and an 'overtaking facility' with fast and slow trains running on separate tracks.

Once the southern cross-Pennine route *via* Edale is electrified with enhanced line capacity, it would also make sense to create a Leicester-Derby-Chesterfield-Stockport-Manchester link, providing rail connectivity that is currently missing**.** Chesterfield and Derby would also benefit from the suggested new Bradford-Wakefield-Sheffield-Derby to Birmingham and beyond cross country service, part of the 'Yorkshire Package' as noted above.

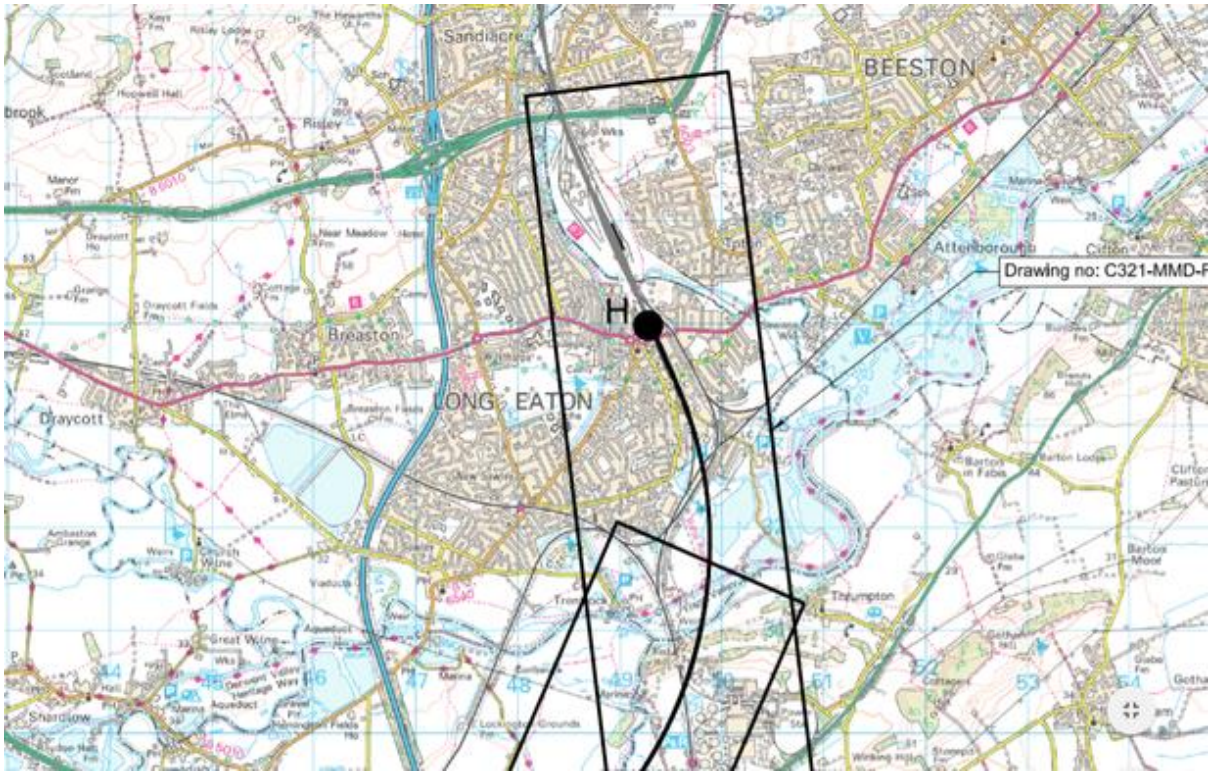
(vi) Adding in Nottingham: pursuing a DfT Strategic Alternative

Each part of HS2 has been subjected by the Department for Transport (DfT) to an assessment of whether there is a better alternative, essentially through upgrading existing railways instead. An upgrade of the route *via* Derby, for example, was tested in 2013[41] – and of course it was rejected by DfT at the time.

[41] Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/568309/strategic-alternatives-to-hs2-phase-2b-atkins-report.pdf (2016). While there are many caveats surrounding the appraisals of the Strategic Alternatives that led DfT to dismiss them and progress the full HS2 scheme including Phase 2b, estimated benefit:cost ratios were each broadly in the 'good' category at around 3:1.

One other Strategic Alternative to this part of Phase 2b presumes a very different approach and this opens up some interesting opportunities that have been largely overlooked. In this Strategic Alternative, a new HS2 line is built from Birmingham as far as Trent Junction, but there, instead of the currently planned HS2 alignment which veers at this point northwards towards Toton (see map below), proceeds directly to access Nottingham.[42]

The currently planned HS2 alignment at Trent



Source: High Speed Two Phase 2 West Midlands to Leeds Route Engineering report, DfT, November 2016

This Strategic Alternative envisaged ***HS2 linking Birmingham and Nottingham*** – the principal cities of the West and East Midlands respectively. Extended through Nottingham by upgrading the existing line onwards to Newark, this would in effect create a fast NE/SW cross country route axis and put Nottingham onto it – a complement to the existing cross-country route *via* Derby and Sheffield. It would be achieved by a new connection from HS2 at Trent, upgrading the Nottingham-Newark line, and creating a new connection with the East Coast Main Line (ECML) just north of Newark (as well as grade-separating the at-grade crossing of the ECML at this point).

In effect, this approach could form a **Midlands Package** – an alternative early phase of Phase 2b, with a connection made to connect with the existing line northwards through Toton. It would overcome the problem noted when considering prioritisation of the Toton-Birmingham section of the HS2 line (few high-speed service opportunities). This would create and support:

- A new Euston-Nottingham HS2 service (1h12 mins) – potentially extendable to Newark & Lincoln (freeing up a train path on the East Coast Main Line)
- A second, faster, NE/SW cross-country route: York-Doncaster-Nottingham-Birmingham to parallel the enhanced route via Leeds, Sheffield and Derby – the latter benefiting from the Yorkshire Package, electrification and capacity enhancements south of Derby

[42] Atkins 2016 *Ibid.* There is no reason why a connection to Toton could not be added to this variant.

- An early speed up of services to Chesterfield and Sheffield (*via* HS2, Toton and the Erewash Valley line).[43]

This should amount to a total usage level of say 5-6 tph, with the prospect of widespread journey time savings and significant new connections.

The availability of a fast route between York and Birmingham *via* Doncaster and Nottingham would form a good alternative to the HS2 bypass to Leeds for longer distance NE-SW cross country services, allowing the HS2 Leeds eastern bypass to be dropped – as prospectively envisaged in the Yorkshire package above. It would also place Doncaster on the network of HS2 services, enhancing connectivity with Hull and both sides of the Humber estuary.

This suggests that a much better approach to allow an early introduction of the southern part of Phase 2b exists if it is built to Nottingham. A new station at Toton would still be built early to serve the planned surrounding development and connect with Nottingham tram (NET) extension. It could benefit from a London-Toton-Chesterfield-Sheffield service using existing lines north of Toton (which would need to be electrified).

In short, if the southern part of the eastern arm is to be prioritised, it needs to serve Nottingham directly in the way described as a Midlands package to provide the necessary scale of connectivity benefit.

[43] The connection to Toton requires a junction to be built from the revised HSR line into Nottingham. Achieving this may require adoption of less than full-speed point-work.

5. The East Coast and Midland Main Lines

Here we consider issues around the inter-relationship of the eastern arm of HS2 and the East Coast Main Line and the Midland Main Line before turning to considering the middle section (phase 3) of the eastern arm.

East Coast Main Line (ECML)

If use of the stem of the Y' shaped network is restricted below its planned 17/18 tph capacity – as Oakervee suggested it needs to be – then some London HS2 services would need to be removed from the current service plan. On the basis that it is the Newcastle-London HS2 services that gain least time saving from using HS2, these services might need to remain on the East Coast Main Line.

This would strengthen the argument for seeking a line-speed improvement on the East Coast Main Line to compensate. The feasibility of lifting the current maximum from 125 mile/h to 140 or 150 mile/h varies along the line of route. The Selby diversion, built in the early 1980s was engineered for 140 mile/h for instance.

Capacity pressures that this might create (increased train-speed differentials) are eased by the transfer of daytime railfreight trains on to the parallel route between Peterborough and Doncaster (the 'GN/GE' line via Lincoln). Already a significant percentage of freight trains are diverted to this route and there is no reason why a full transfer couldn't be achieved when the Werrington 'dive-under' scheme currently under construction on the northern approaches to Peterborough is completed next year.

As with all such incremental schemes, there is a risk of creating bottlenecks at the limit of the area of improvement. In this case, it is evident that with growing freight and long-distance passenger train volumes, Doncaster – where a number of rail lines converge and where freight services would re-join the ECML – would be one such pressure point.

While restrictions, mainly due to track curvature would remain as speed-limiting factors[44], signalling systems would also be a constraint on higher speed passenger train operation over the ECML. But the adoption of cab-signalling delivered through the application of ETCS level 2 technology could lift the current restriction of 125 mile/h. This technology is presently being implemented on the southern section of the line from Stoke summit (between Grantham and Peterborough) to Kings Cross[45]. Its application over the whole of the Peterborough-York-Tees Valley-Newcastle section of line will follow in due course as signalling renewals fall due. While on current plans, this process would run through several 5-year control periods, as the costs of the digital transition falls (as is expected) the case for accelerating the programme could rest on speed improvements currently assumed not to be worthwhile because HS2 is assumed to remove the need.

It would be unfortunate for the east side of the country if the 2020s and 2030s pass by with HS2 to Birmingham, Crewe and Manchester in place but neither the HS2's eastern arm delivered (as seems very likely given delivery timescales) nor an acceleration of ETCS to allow higher speed operation on the ECML.

[44] These could be addressed by the use of tilting train technology as used on the West Coast Main Line Pendolino fleet – a train designed for 140 mile/h operation

[45] See https://www.railengineer.co.uk/2018/11/15/the-digital-railway-progresses-to-the-east-coast-main-line/ for a useful summary. The ETCS application which is part of the overall signalling renewals programme is costed at £1.8bn and will increase capacity over the Welwyn viaduct two-track bottleneck to 20 tph.

Regardless of the question of speeding-up operations south of York, it is clear that even with HS2 built and fully exploited, there is support for investment in the ECML northwards to Darlington, Newcastle and Scotland.[46] This is because there are severe capacity pressures at present (between Darlington and Newcastle) which will be intensified when NPR services are added to the network. Direct services to London from Middlesbrough could be added and connections from Tees Valley and Hull to Birmingham and Bristol would fill a key gap in national intercity connectivity (see diagram on p30 below).There is also an ambition to speed up the entire route which plays a key part in connecting the North East to all of the other English regions and Scotland.[47]

If the suggested 'second cross country' route using part of HS2 across the Midlands via Nottingham is created, there would be a good case to extend southwards from York the geography where ECML line-speed uplifts are sought. Helpfully, a good part of the Doncaster-York line (north of Temple Hirst junction) was built to 140 mile/h standards which could be exploited once ETCS is deployed. We expand on this point below.

Midland Main Line

All of the possible ways forward with the eastern arm rely on an extension northwards of the programme to electrify the Midland Main Line (MML) which currently has a northern limit at Market Harborough. This has carried the support of local authorities for nearly 30 years.[48]

The impact of the eastern arm, fully implemented, on the Midland Main Line is complex. Because of the need to retain connectivity with intermediate places over the route southwards to St Pancras (these include Loughborough, Leicester, Bedford and Luton Airport), current volumes of services from Sheffield, Derby and Nottingham are likely to continue. Indeed, Midlands Connect has promoted a new HS2 service that would serve some of these locations to the south, joining HS2 at Toton for fast onward transit north to Leeds. So HS2 is unlikely to free up train paths on the MML, although calls at intermediate stations might increase, but only if there are direct fast timings for long distance movements via HS2.

If Toton is developed ahead of HS2's arrival, complete with a new extension of Nottingham's LRT system, a new service to Mansfield could be provided, possibly linking this large town with a direct London service. If the suggested early phase Birmingham-Nottingham HS2 line is adopted, fast Nottingham-St Pancras trains could be removed from the MML and release the line capacity needed for such a service to be accommodated.

[46] See *Network Rail plans more platforms and tracks for North East railways,* Philip Haigh, *RAIL 909.* July 2020

[47] The East Coast Main Line has been the subject of a substantial programme of upgrades over several decades. These have been needed to try to retain good punctuality standards with growing numbers of train movements and have allowed a series of journey time improvements too. It is sometimes presumed that because the West Coast Main Line was subject to an upgrade (1998-2008), the ECML missed out. But the 1998-2008 West Coast programme was needed to deal with a huge backlog of renewals, decisions having been deferred through the previous 20 years. The East Coast, in contrast, kept on top of renewals and developed the good habit of making incremental improvements when they fell due. But these enhancements are now needed further north on this line.

[48] Electrification of the Midland Main Line, *Steer Davies & Gleave,* 1991, quoted in Applied Transport Economics, *Stuart Cole*, 2nd Edition

Summary

Regardless of the decisions taken on the eastern arm of HS2, ***the northern sections of the East Coast Main Line should be the subject of investment to improve connectivity with the North East. Doncaster is a location in need of specific attention to avoid it becoming a bottleneck***.

The Midland Main Line (MML) needs to be fully electrified. This is needed for the eastern arm of HS2 to work because so many of its train movements will also use the surrounding network (the MML) to complete journeys. ***MML electrification is a necessary precursor to the eastern arm, and its implementation can bring valuable benefits ahead of HS2.***

6. Phase 3 – The Middle Section of the Eastern Arm

A key question, once the southern and northern sections of the eastern arm are in place (as part of the Midlands and Yorkshire packages, as described), and ahead of the central section of the eastern arm having been built and commissioned is this: *what is the best way to serve the longer distance London-Leeds and London-Newcastle markets?*

Actually there is an interesting choice of route. London-Leeds HS2 trains could be operated *via* Sheffield without building the central section of the eastern arm. End to end journey times would be faster than *via* the East Coast Main Line but not as quick as the non-stop full eastern arm timings would support (which fail to serve Sheffield *en route*).

The Midlands package creates a high-speed/upgraded route from London to Nottingham and on to Newark and the East Coast Main Line (ECML). This could be used by London-Newcastle trains operated over HS2 *via* Nottingham and then over the ECML *via* Doncaster, and this combination would mean that some capacity could be freed up on the southern capacity-limited section of the East Coast Main Line. While the limited capacity on the stem of the Y for eastern arm London services means that only a limited number of ECML sevices can be switched to HS2, such a routing has the advantge of providing the North East and Nottingham with a London HS2 service while uilising only a single HS2 train slot.

So, some key released capacity benefits of the eastern arm and some (but not all of) the journey time gains could be delivered without building the central section of the eastern arm. If this was added later, of course, the full journey time gains would become realisable.

But before that option is pursued, another option merits serious consideration. Building a new high-speed line in the east coast corridor between Newark and the 'Selby Diversion' – (the section of higher speed route built in the 1980s) could offer better value. With this approach, *all* longer distance ECML services could be speeded up (as well as those operating *via* Nottingham and using HS2 to the south). This would be twice as many London trains/hour benefitting from high-speed line provision, and would be particularly advantageous for the North East. Long distance cross country trains via Nottingham could also use this route and gain a journey time advantage.

While there are many service comnbinations that become possible, the key infrastructure choice would be between two sections of high-speed line:

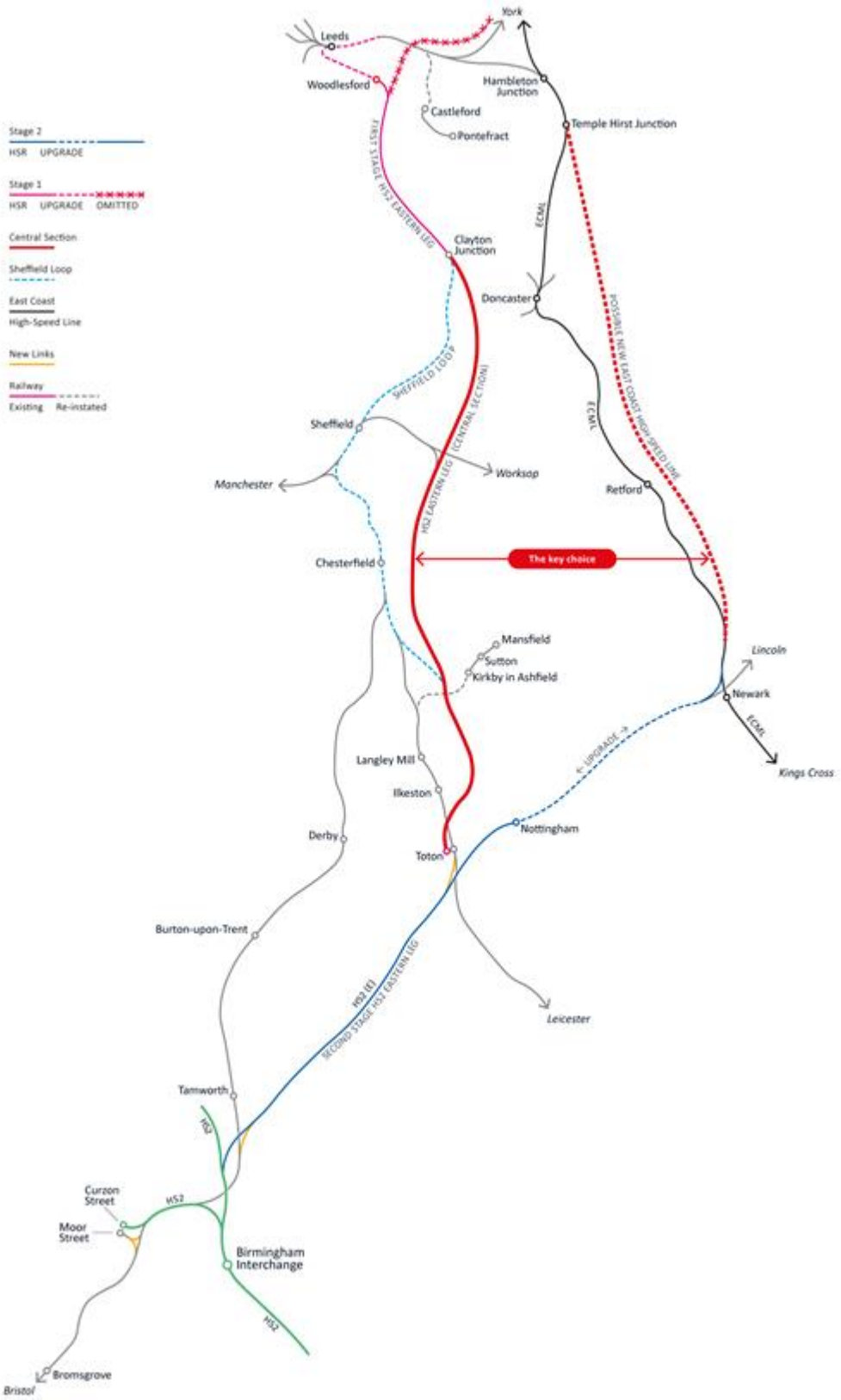
1. The currently planned HS2 eastern arm between Toton and Clayton junctions, *or*
2. A new section of high-speed line between Newark and Temple Hirst junction (which lies between Doncaster and Selby), connected at either end to the East Coast Main Line.

Each of these options entails about 50 miles of new high-speed line. The Toton-Clayton section of the eastern arm broadly follows the line of the M1 motorway (interactions with which are a source of some concern to Highways England because of the risk of significant disruption during construction).

The alternative of a Newark-Temple Hirst high-speed line parallels the M1 alignment to the east. It avoids former mining and hilly areas and the string of towns and villages in north Nottinghamshire and would pass to the east of Doncaster, passing Finningley (Doncaster/Sheffield Airport), over generally level and less populated terrain. It might turn out to be less costly to build. And the added capacity should avoid the need for major expenditure at Doncaster (on diversionary freight routes and grade-separated junctions).

A new section of high speed line between Newark and Temple Hirst Junction will certainly be busier than the central section of the current eastern arm plan, with all ECML long distance trains that don't need to call at Doncaster switched to the faster route and enjoying time savings accordingly. London-Leeds trains routed via the ECML and the new section of high-speed line would be able to operate onwards without reversal to Bradford and Harrogate. The Newark-Temple Hirst high-speed line and its relationship to the rest of the main line network and to the HS2 eastern arm is illustrated below.

Staged Implementation of The Eastern Arm: Options



Credit: Greengauge 21 (based, with thanks on S.R. Baker Rail Atlas of Great Britain and Ireland)

An advantage of a new high-speed line in the ECML corridor is that it creates operational and timetable flexibility between using the existing ECML to Kings Cross and HS2 to Euston, improving overall network resilience. It provides a way of avoiding over-loading the southern end of the ECML and allowing an expansion of services between Peterborough/Cambridge and London. But in favour of the current HS2 eastern arm alternative is that its design is well-established.

The central section of the eastern arm, with no intermediate stations, offers substantial end-to-end time savings (Leeds-London and Leeds-Birmingham) – achieved because it bypasses both Sheffield and Nottingham. But this seriously limits gains in city-city connectivity. If regional city to city connectivity matters more than the fastest possible end-to-end journey times for a single city (Leeds), then the ECML corridor high-speed line would offer a better approach. If retaining a very fast London-Leed HSR time remains a priority, then an additional section of new high-speed line between Nottingham and Newark could be added to the ECML high-speed option. This would not only deliver faster London journey times for York and North East England, it could free up two existing London hourly train paths – one into St Pancras, one into Kings Cross – for each hourly Leeds-Nottingham high-speed service.

7. Service Plans

In Chapter 2, we set out how the currently planned HS2 network shape can be adapted to a better balanced X-shaped concept.[49] As well as carrying some fast London services, the role of the eastern arm would be expanded to accommodate a high-value set of cross-country connections. This can significantly improve the connectivity of cities on a NE-SW axis which are currently not well connected at all.

The northeast-southwest axis is a hugely important corridor, *linking six out of eight English core cities* – Newcastle, Leeds, Sheffield, Nottingham, Birmingham, and Bristol – as well as Cardiff, Edinburgh and Glasgow. In railway terms it forms a complement to the main line links to London. It is a corridor which has weaknesses in terms of direct intercity linkages that HS2, as it stands, does little to resolve (see diagram, below).

City Pairs with weak rail connectivity

Source: Greengauge 21, Beyond HS2, May 2018

[49] See http://www.greengauge21.net/wp-content/uploads/Beyond_HS2WEB.pdf Chapter 6

The six English core cities, along with cities in Wales, Scotland and South West England can be better inter-connected, but only with the HS2 adaptations described in this report, including the formation of an X-shaped HS2 network.

Serving the Midlands better

The new leg needed for HS2, to the south west from Birmingham, is achieved by means of an upgrade of the line from Birmingham to Bristol Parkway[50] (including its electrification and provision for operation at speeds of 125 mile/h) south of Birmingham; and an additional HS2 junction in the West Midlands.

This proposition also requires the implementation of Midlands Connect plans to create the Midlands Rail Hub[51] so that integration of Moor Street and Curzon Street stations which adjoin each other can be integrated for easy passenger interchange. ***This will extend HS2's reach to a truly national coverage and improve the business case of both the eastern arm of HS2 and the Midlands Rail Hub***. It will place Birmingham at the heart of the national high-speed network, rather than on a branch line from it.

Achieving this also has positive implications for the development of local rail services in the West Midlands, and again the investment costs incurred should be recognised as being largely a city-region level investment. Rather than using the new chords into Moor Street primarily for local urban services[52], they would be used for long-distance trains. Trains from the eastern arm of HS2 would use the new northern chord to access Moor Street before reversal and an exit *via* the southern chord for onward journeys south west towards Bristol (or the Oxford-Southampton corridor). In effect, Moor Street/Curzon Street would replace New Street as the long distance hub station in the West Midlands. New Street, in turn, would become the hub of the city region network of services, and as per the Midlands Connect plan, enabled to accommodate an increased level of regional rail services.

A '**Midlands Package'** would comprise:

- Midland Main Line electrification (including north of Sheffield, the Erewash Valley line, and from Clay Cross to Derby and Birmingham)
- HS2 eastern arm built from Birmingham (Kingsbury) to Trent Junction where there would be connections to the 'classic lines' to Toton and the north and to Nottingham – built to UK gauge standards
- HS2 services introduced from Sheffield/Chesterfield to London and Lincoln/Nottingham to London at an early stage
- Toton station and interchange
- Nottingham-Newark route upgrade
- Midlands Rail Hub
- Electrification southwards from Bromsgrove to Bristol (and then onwards to the West Country)

[50] This additional south-western leg of the 'X'-shaped network is therefore assumed to be an improved existing line, rather a new-build high-speed line

[51] Midlands Rail Hub is the flagship project of Midlands Connect https://www.midlandsconnect.uk/midlands-engine-rail/midlands-rail-hub/

[52] Services at planned new stations on the 'Camp Hill' line would instead be routed into New Street

- Upgrade of the Moor Street-Snow Hill line to a high frequency with direct connections to the Black Country, Wolverhampton and Walsall
- A new MML service to serve Mansfield, Kirkby in Ashfield, Ilkeston and Toton direct to London (using the train path released by the Nottingham HS2 service)
- New cross country services with Nottingham added to the long-distance NE-SW network
- New Leicester-Derby-Chesterfield-Stockport-Manchester service (with enhanced junctions at Dore).

Serving Yorkshire and beyond to the North East better

The key change that needs to be made at the northern end of the eastern arm is to enable HS2 (and NPR) services to run through an expanded Leeds Station. This station would form one of the nation's superhubs, lying astride both a north-south HS2 line and an east-west trans-Pennine route and with an extended electrified city region rail network.

The changes envisaged would also spread the benefits of HS2 investment across Yorkshires cities and towns. In combination with the proposals to the south, a new cross-country route *via* Nottingham would accelerate cross country connections south to Birmingham and beyond for the whole of North East England, the Humber and Doncaster. If the ECML high-speed option is selected for the third phase, the North East would benefit even further with faster London connections than either the existing HS2 plans or the East Coast Main Line as it stands could offer.

A **Yorkshire Package** would comprise:

- Creating a new rail hub at Leeds station, fully integrating HS2 and Northern Powerhouse Rail services (and dedicating the new T shaped station element to local services)
- The early delivery of a Yorkshire part of Phase 2b (Clayton to Woodlesford) and faster links between Sheffield and Leeds, and adding commuting capacity into both cities
- Establishing a new cross-city S-bahn style network for Leeds city region, with electrification of the York, Selby and Bradford Interchange lines
- Upgrading Sheffield station (and in due course providing the city with faster and more direct HS2 services)
- Bringing transformational benefits to former mining towns in the Dearne Valley (by extending Supertram) and possibly east of Leeds (by re-creating a new route *via* Kippax)
- Providing connectivity improvements for Bradford, Wakefield, Castleford and Barnsley as well as Sheffield and Leeds
- Increasing capacity and line-speeds into Leeds station from the east and into Sheffield from the north.

A new Cross country network

Today's cross country services in the central part of the NE-SW/S corridor take two routes. Both services are hourly, but the trains that run *via* Doncaster rather than Leeds are about 30 minutes quicker:

- (NE-) York – Leeds – Sheffield – Derby – Birmingham (-SW/Southern England)
- (NE-) York – Doncaster – Sheffield – Derby – Birmingham (-SW/Southern England).

It is not currently possible to add a second hourly service *via* Leeds (due to network capacity constraints). With both the Yorkshire and Midlands packages in place, it would be possible to re-specify and speed up both services, with the Doncaster cross country route serving Nottingham rather than Sheffield/Derby (where an additional hourly train could be provided by a Bradford originating service as noted on p13 above).

Train lengths could be made longer than on today's services, and there may be scope to add further service frequencies and add variants noted such as adding Hull-Doncaster to the cross country network too.[53] But any such additional services on the East Coast Main Line would add to capacity pressures especially in the Doncaster area and may trigger the need for investment (such as the creation of a freight diversionary route and/or junction grade-separation).

All of this is achievable before the middle section of the eastern arm is built. At this interim stage, HS2 London services on the eastern arm would serve Nottingham-Lincoln and Chesterfield-Sheffield. The latter could be extended to reach Leeds or Bradford using the Leeds-Sheffield section of high-speed line as available. Capacity would be released on the Midland Main Line to the south for additional services to intermediate destinations (alongside continuing fast Leicester-London services).

HS2 journey times between Sheffield and London would be at this stage the same as is achievable with the whole of the eastern arm in place. While not having available HS2 infastructure to use north of Trent Junction, trains would be able to use the shorter-distance Erewash Valley line and the time-wasting divide and join operation at Toton would be avoided.

[53]Services south of Birmingham could serve a mix of South Wales, SW England and Oxford-Reading-Hampshire markets as today.

8. Value for Money

Capital cost savings

Current estimates of the cost of HS2 Phase 2b and Northern Powerhouse Rail total around £80bn. The estimates for HS2 are 'at an early stage of development' and are 'the least mature', according to the Oakervee review of HS2.[54] As that report points out, negotiating the planning approvals process has added substantial costs to the earlier phases of HS2, and the same pattern might be expected ahead for Phase 2b (and by implication for NPR too).

The eastern arm constitutes the largest part of Phase 2b; but the eastern part of NPR (i.e. east of the Pennines) accounts for less than half of that project. Little evidence has been placed on the breakdown of costings, but the combined current estimate of the cost of these two projects on the eastern side of the country would be around £60bn. To this total, an allowance should be added for Midlands Connect schemes – although these are much more modest in scale and price. But in current prices, allowing for the inflation that affects all these projects as designs are refined, total cost could be of the order of £100bn.

This large sum needs to be considered over a construction period which may well exceed ten years. A 20-year implementation programme would have annual costs of say around £5bn for this significant swathe of the country that covers three out of the eight English regions: the North East, Yorkshire/Humber and the East Midlands. To this sum, investments by Network Rail across the three regions would need to be added, and by Combined Authorities (which have access to other funding streams) for investment in public transport.

A 20-year programme means that commitment and phasing are both of very great importance. But so is the question of finding ways to save on project costs through smarter design and other project efficiencies. Changes in scope and specification were outlined above that would allow significant savings to be made. These are:

- The removal of the east of Leeds high-speed bypass
- The adoption of UK-gauge
- A simplified construction approach from the south into Leeds
- A scale-back of the planned additional south-side, 'T' at Leeds station
- Removing the requirement for dedicated HS2 platforms at Toton.

The planned phasing of the eastern arm allows for a better spread of works which will allow supply chain efficiencies which should be captured in lower contract prices.

Against these savings, expenditure would be increased in other areas with most of such cost increases falling into one of two categories:

- *Expenditure in major stations* (Leeds and Sheffield) which will be needed to accommodate increased trans-Pennine and city region services anyway: they should be scored primarily under a major city infrastructure heading, since volumetrically (in terms of train paths and user numbers) most of the capacity and connectivity gain will be experienced at a city region level

[54] See https://www.gov.uk/government/publications/oakervee-review-of-hs2 January 2020

- *Electrification of existing lines*, most obviously the Midland Main Line; for which there is a good case including, of course, a significant step in reducing the rail sector's carbon emissions.

Capturing the Value in HSR infrastructure for HM Treasury

There is a further, important, value for money factor that the NIC should take into account in assessing the case for supporting investment in the eastern arm of HS2. The NIC is obligated to work to a cap on national infrastructure levels of 1.2% of GDP.[55] But looking over a slightly extended period beyond the years of construction of new high-seed railway lines and the 'settling-in' period when new services are established (when the value of the new railway becomes proven and 'de-risked'), an opportunity arises. HS2 infrastructure can then be privatised, as was achieved ten years ago with HS1 (let on a 30-year concession). This produced a cash return to HM Treasury significantly offsetting the cash outlay made just a few years earlier.

The rail sector with its system of track charges and independent regulation is uniquely placed to generate this kind of reverse mega cash-flows to the Exchequer if new high-value infrastructure is created.[56] This point was acknowledged by DfT to be relevant to HS2 in the Phase 1 Business case published earlier this year.[57] The NIC should surely be entitled to note that, uniquely, high-speed rail infrastructure has a commercial value that can create value to the public account off-setting investment outlay soon after project completion.

With the phased approach proposed here for the eastern arm, a rolling cash flow wave can be created to offset the costs of successive phases of HS2.

Services with strong margins (revenue/operating cost)

The service plans that the phased eastern arm infrastructure can support have more intermediate station calls and much less down-time at station terminus turn-rounds: shuttles are replaced with longer distance services and passenger volumes will be higher. This improves service economics, with the greater prospect of contract (or franchise) premiums payable to DfT.

[55] https://www.nic.org.uk/wp-content/uploads/RNA-Interim-Report-Final.pdf July 2020. Interestingly this formula implies an unintended counter-Keynesian effect at a time of major downturn such as the UK economy is experiencing in 2020, with an automatic reduction in the maximum value of permitted investment spend

[56] The concession for HS1 was let as the only major asset 'sale' that could be found by the Cameron-Osborne Government.

[57] See https://www.gov.uk/government/publications/hs2-phase-one-full-business-case April 2020

9. Conclusion

The initial purpose of HS2's eastern arm was to achieve as fast as possible journey times from each of London and Birmingham to Leeds – matching or improving on those that would be delivered for Manchester. As a consequence, none of the important intermediate cities – Derby, Nottingham and Sheffield – are served directly by the resulting HS2 network.

While a connection onwards towards York was added in to allow trains for Newcastle to run over HS2, the journey time gains for such services over using the existing East Coast route are relatively modest. And with all other services precluded from onward operation, with services running into dead-end terminals in each of London, Birmingham and Leeds, not only are intermediate cites left unserved or indirectly served, but places beyond the eastern arm corridor cannot be reached.

To make better use of eastern arm capacity, various suggestions have been made to add connections to the classic network. But these don't allow the eastern arm to take over the routing of the long distance cross country trains on what is essentially a NE-SW axis.

As this report shows, it is possible, with changes at Leeds and Birmingham to overcome this limitation and remove NE-SW cross country services from congested parts of the existing network. In effect ***the 'Y' shaped HS2 network would become an 'X' shape*** with the addition of a south-western leg being achieved through electrification and an upgrade of the Birmingham-Bristol line.

In this way, the role of the eastern arm changes from a narrow focus on a very limited set of ultra-fast London HS2 trains to one in which the primary function is to improve connectivity between a large set of cities in the North and the Midlands and extend the geographic reach of HS2, bringing benefits to regions that otherwise don't gain from HS2 at all. There would still be fast London HS2 services, but they would not be the majority use made of the eastern arm.

With this shift in focus, there is no value in contemplating a mixed fleet of 'captive' and 'classic compatible' trains for use on the eastern limb. Nearly all trains will leave the new high-speed infrastructure somewhere – and this effect is magnified once a phased implementation approach is contemplated.

A key cost saving can be made from the adoption of UK Gauge (rather than EU-gauge) for the eastern arm. As a consequence, there is no need for dedicated platforms for HS2 trains, so station designs can be more compact and easier for customers to use. Passengers will also benefit from less need to change trains, with through services replacing the current plan for a set of city-city shuttles.

Two sections of the eastern arm have been identified for early progression – one in the North (linking Leeds and Sheffield) the other in the Midlands (linking Birmingham with Nottingham – a city that is not served directly in current plans but which could be with a new junction being provided at Trent). With the route from the south-west into Nottingham extended over (an improved) line north-eastwards to Newark and Lincoln and the East Coast Main Line, ***a huge expansion of regional city inter-connectivity is possible***, as described in the report.

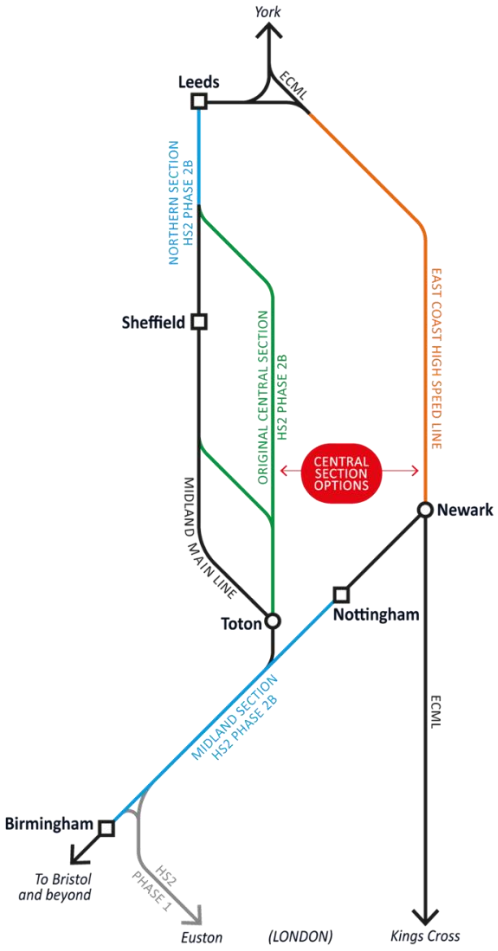
Cities that could join the national long-distance cross country network using HS2*

Aberdeen, Bradford, Bristol, Cardiff, Cheltenham, Darlington, Doncaster, Dundee, Edinburgh, Exeter, Glasgow, Hull, Lincoln, Middlesbrough, Oxford, Newcastle, Nottingham, Plymouth, Portsmouth, Reading, Southampton, York.

**These cities would be served by a higher speed cross country network that uses either the Leeds-Sheffield or Nottingham-Birmingham sections of HS2 or both*

The two early phases could be progressed in parallel. They work well in combination (that is, ahead of building a central section of the eastern arm), but their benefits can be realised independently.

Whether it would be better to build the central 50-mile section of the eastern arm or instead create a new high-speed line in the ECML corridor identified in this report as a candidate alternative should be made the subject of detailed study (see summary diagram below). We recommend that this is commissioned forthwith given the potential for greater and much wider benefits with a similar length of high-speed line built in the ECML corridor. Given the phasing approach we recommend, such studies need not delay any aspect of the project.



In terms of achieving an improved London-Leeds journey time, either approach would be acceptable, with the original HS2 route fastest. But the central 50-mile section of the eastern arm, if built as planned, might not represent such good value for money. A high-speed line in the ECML corridor could speed up *all* of its longer distance services, bringing much wider benefits. And as we

suggested on p32, if a high-speed connection is also created between Nottingham and Newark, each Leeds-London HS2 service could free up two valuable train paths into London by virtue of serving Nottingham *en route.*

A phased implementation approach for the eastern arm is needed to ensure that the east side of the country does not have to wait until the 2040s to see the benefits of HS2. Shorter sections of new line and upgrades of existing lines will have shorter planning approval times and help the supply chain plan for a programme of schemes rather than a single very large project.

Even before the two identified priority sections of high-speed line are started, work should focus on the cities of Leeds and Birmingham where works are needed to meet the growing needs of the city-region and regional services, as well as to accommodate the revised service pattern for east-side HS2 services that this report envisages.

The changes proposed here need not disrupt existing development plans at key locations such as Leeds, Toton and Chesterfield-Staveley (all beneficiaries of the early phase programme recommendations), although service plans would be changed for the better and detailed station designs can be improved, and in some cases simplified. The key super-hub stations at Leeds, Nottingham, Sheffield and Birmingham[58] need to be designated as such and their expansion need not wait until a full HS2 scheme comes on-stream: their upgrade is a national priority.

In summary:

- There is a strong case to accelerate delivery of both ends of the planned eastern arm, providing valuable connectivity and capacity improvements for Leeds-Sheffield and Birmingham-Nottingham – and a stimulus to the economies of all four cities and their surrounding regions.
- The design of the southern part of the eastern arm should be changed so that it serves Nottingham directly. The route onwards from Nottingham should be upgraded and a new connection added to the East Coast Main Line north of Newark to create a new, faster NE-SW long distance route.
- A link should be created from this revised HS2 line to the existing rail network leading to Toton (and beyond to Chesterfield and Sheffield), where the new station should be built on the existing railway. Surrounding development could then proceed without delay – in the 2020s rather than the 2040s.

As this report sets out, these early stages can help bring about better rail connectivity to towns and cities on the east side of England that need an economic stimulus. These places include Barnsley, Bradford, Chesterfield, the Dearne Valley towns, Derby, Doncaster, Ilkeston, Kirkby in Ashfield, Lincoln, Mansfield, Newark, Rotherham and Wakefield.

We recommend that a programme is set out with ambitious but achievable delivery dates for the eastern arm of HS2 and the related set of measures, so that the economies of the East Midlands, Yorkshire/Humber and North East England do not experience a down-wash effect from the gains that HS2 will bring to the West Midlands and North West England economies – development gains that are already being experienced, especially in Birmingham – and which will get a further boost when HS2 services come on-stream *c*2030.

[58] Derby station having recently been upgraded

Phased implementation plan

Step	Programme element	Implementation period	Comment & consequence
1	Complete electrification of MML	2020-25	Early benefits to the East Midlands and a necessary precursor to steps 4 and 7
2	Implement Trans Pennine Route Upgrade Manchester-Leeds	2020-25	
3	Progress East Coast Main Line improvements	2020-30	Concentrated on Newcastle-York
4	Implement the Yorkshire package	2025-30	Allows 5 years to refine designs and obtain powers
5	Implement Midlands Rail Hub	2025-30	*-ditto-*
6	Implement the Midlands package	2025-30	With step 5, allows the re-shaping of HS2 from a Y into an X
7	Implement Toton-Clayton (HS2) *or* Newark-Temple Hirst high speed line (HSE)	2030-40	Allows time for detailed comparisons and as necessary design development
8	Implement revised NPR[59]	2035-45	

This programme will save significantly on HS2 capital costs: no Leeds eastern bypass, a simplified at-grade approach to Leeds station from the south; adoption of UK-gauge throughout. It is true that greater pressure will be placed on the existing main line through Sheffield, and it may be that some further capacity enhancements will turn out to be needed. But much of this entails incremental schemes that Network Rail can progress, often under permitted development rights.

It advances two parts of the eastern arm for accelerated delivery, one in the North, one in the Midlands. It will, in summary:

- Connect the two key cities at the heart of the East and West Midlands
- Connect Sheffield and Leeds, the busiest intercity commuting route in the north of England
- Transform city region, regional and long distance services at Leeds which would become a rail 'superhub'
- Bring much faster London services to Nottingham and Sheffield with HS2 connectivity gains sooner than if the whole of the eastern arm is attempted in a single Bill and build

[59] Taking account of the revised arrangements at Leeds

- Provide connectivity gains and new services to towns across the East Midlands and Yorkshire, including: Mansfield, Kirkby-in-Ashfield, the Dearne Valley, Bradford, Barnsley, Castleford, for example.
- Through the switch from a Y to an X-shaped network for HS2, will add benefits and expand the national coverage of HS2 services to more major cities and their catchments spread widely across the country.

Regardless of the decision that emerges in respect of the best location for the 'central section' of the eastern arm, this programme will allow expansion and acceleration of the nation's long distance cross-country network. With the demise and decline of airline services in this sector, this is needed as a priority to help businesses seeking to develop away from the capital.

In Summary

The recommended approach is to progress stages 1 and 2 of the eastern arm in parallel and defer stage 3 (the 50-mile central section) pending further studies of its need and a new option located in the East Coast Main Line corridor.

The overall programme combines significant early builds and gives a stimulus to existing redevelopment plans at key stations by bringing forward the introduction of new high-speed services.

Places left off the existing main line network can gain new services just as soon as stages 1 and 2 are up and running, but not before because of limitations of network geography. These places include Bradford (which can join the long distance cross country network once stage1 is built) and Mansfield which can be given a path to London St Pancras once stage 2 is up and running with the proposed fast Nottingham-London service switched to HS2.

The programme adds high-speed long distance services to regions that otherwise would not benefit from HS2: South West England, South central England (the Solent area), South Wales, the English Economic Heartlands, North East Scotland. But the X-shaped network can only be delivered if the Midlands Rail Hub is created in Birmingham and configured to allow the efficient reversal of long-distance services at Moor Street station.

The effects of coronavirus have led some to question whether city centres with their concentrations of activities and attractions will survive the economic downturn. Demand may be reduced for daily commuting for some time, it must be recognised. But an efficient, electrified, national rail network is crucial for longer distance travel, where the alternatives (short haul air travel/long distance car travel) have very poor environmental outcomes.

In practice the national rail network is formed of sets of services that come together at key hub stations, generally located in city centres.[60] This pattern is not going to change, and the programme here strengthens the role of both the longer distance rail network and the opportunity to improve rail services at a city-region level.

Delivery of the staged programme for the eastern arm and associated works requires strong management – extending beyond normal individual project management disciplines. An approach where two strong regional delivery agencies – one in Yorkshire and one in the Midlands – might be

[60] See: http://www.greengauge21.net/cities-coronavirus-and-public-transport/ July 2020

appropriate. The key will be a strong focus on the objectives that tie together the programme elements, with commercial rail operations and engineering on-board.