HS2 : High Speed to Nowhere : Main Report

Putting HS2 Ltd's Promise of a Higher-Speed and Better-Connected Britain to the Test

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4	12/09/2017	Publication version 2
5	12/10/2017	Printed version 1
6	27/11/2017	Printed version 2 : Title Amended : Main Report

High Speed to Nowhere – Executive Summary

The HS2 project has stood for many years as the cornerstone of successive Governments' commitment to developing the nation's infrastructure for the growing pressures of the 21st Century. Over the past 8 years a broad political consensus has grown in support of the project, and this consensus has overwhelmed the objections of protestors against HS2's excessive environmental impact and very limited economic benefits.

So far there has been no effective scrutiny of the most crucial consideration – whether HS2 will work efficiently as a railway network and deliver its core objective of multi-billion pound economic benefits based on predicted step-change improvements in capacity and connectivity. As former HS2 Ltd Technical Director Andrew McNaughton stated on 30th November 2015, in evidence to the HS2 Select Committee:

"The aim of the HS2 project is to deliver hugely enhanced capacity and connectivity between our major conurbations"

With the publication in November 2016 of official proposals for Phase 2 of HS2 it has at last become possible to put this promise to the test. This study has used HS2 Ltd's published information on proposed HS2 services, journey times, stations, routes and connections to the existing network to measure its performance as a national intercity network. This has involved detailed calculation of timings for 496 separate intercity journeys between 32 key centres, extending from London and Heathrow to the principal towns, cities and airports of the Midlands and the North journey times. This is part of a wider investigation of HS2's capability to deliver its objective of **"hugely enhanced capacity and connectivity"**.

Exactly the same methodology has been applied to the High Speed UK (HSUK) proposals for an integrated national network of high speed lines. HSUK provides the necessary 'exemplar alternative' against which the performance of HS2 can be compared and evaluated, to ensure that it does deliver the greatest possible capacity, connectivity and journey time benefits for the least cost and environmental impact.

The comparisons with HSUK paint an entirely different picture to that which HS2's proponents have sought to portray. They make it utterly plain that HS2 will not bring about the better-connected, higher capacity rail network that the nation needs. They illustrate HS2's failure to perform on almost any conceivable comparator, and they reveal for the first time two highly inconvenient truths:

HS2 Ltd's failure to address the need for an improved national network means that HS2 can never deliver its promise of "hugely enhanced capacity and connectivity" between the UK's major conurbations, and it can never deliver the huge economic benefits that have also been promised.

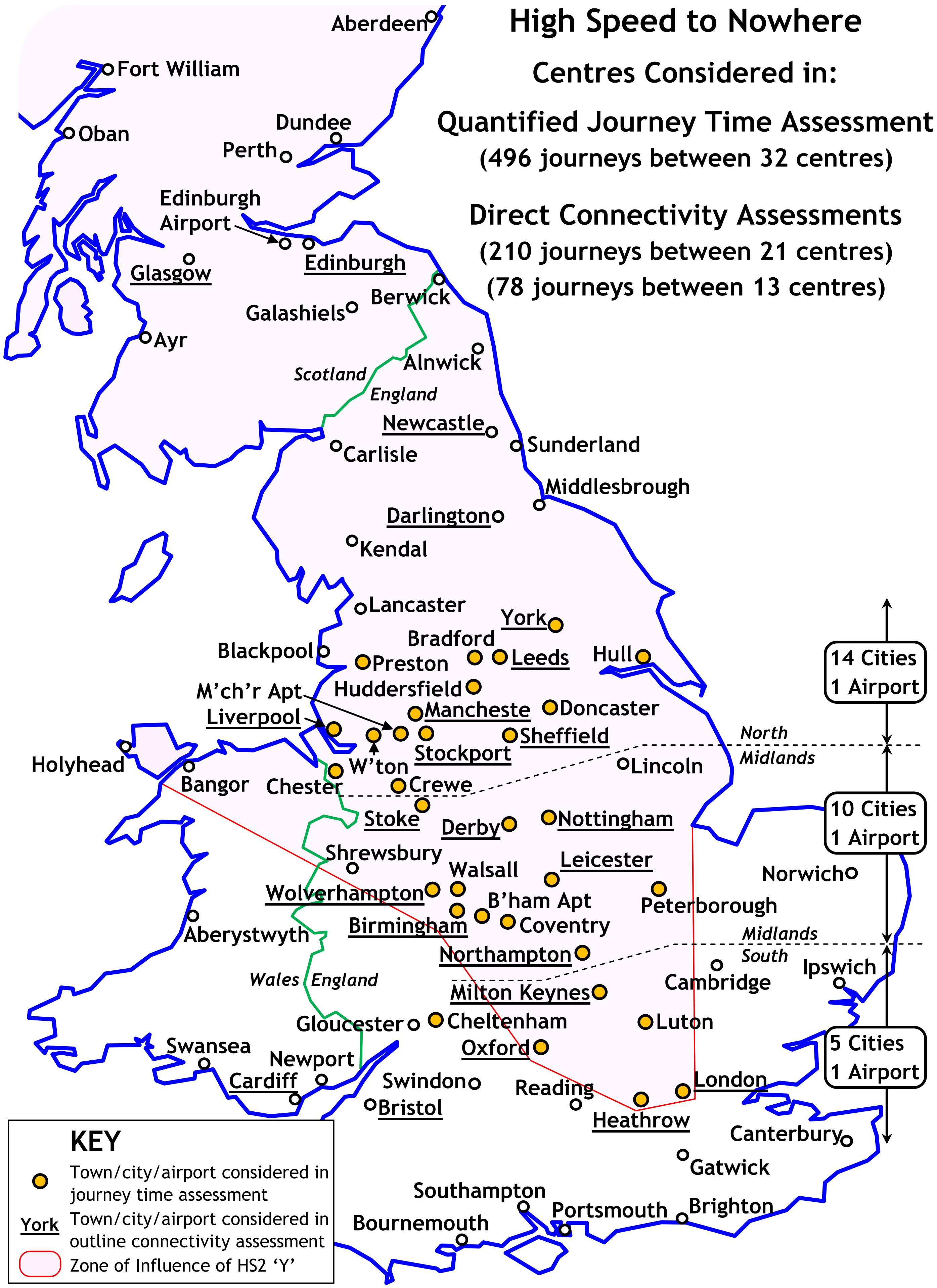


Figure ES1 : HS2 Zone of Influence and cities considered in Study

This study has identified a huge range of failures that affect every aspect of HS2's performance as a national transport system.

1. HS2 will only benefit a select group of primary cities

HS2's journey time reductions are largely restricted to the much-promoted headline journey times between the key primary cities of London, Birmingham, Manchester and Leeds; only 18% of journeys will see any improvement in journey time and a greater proportion will be made worse.

2. HS2 has insufficient capacity to serve other major cities

HS2's 2-track stem lacks both the capacity and the connections to the existing network to provide high speed services to other cities currently enjoying premium services on the existing intercity network. All of HS2's capacity will be consumed in improving just 18% of journeys – the remaining 82% will either see no improvement or will be damaged through proposed withdrawal of existing intercity services. The majority of UK cities will see a reduction in intercity services as a result of HS2's introduction.

3. HS2 fails as a high speed railway system

HS2's achievement of 9% average journey time reductions across the national network compares very poorly with HSUK's figure of 46%.

4. HS2 provides no extra capacity for local services in regional cities

HS2 generates little or no extra capacity for improved local services in regional conurbations.

5. HS2 is not 'future-proofed'

HS2's new capacity is already fully allocated before construction has even started. HS2 cannot satisfy the reasonable demand of all cities served by the existing intercity network to enjoy high speed services. There can therefore be no question of HS2 being future-proofed for anticipated increased demand for intercity rail travel.

6. HS2 has never been designed as a network

HS2's routes have been developed with no consideration of an optimised national network. All design effort has been confined to the question of how the new lines will perform, largely in isolation from the existing railway.

7. HS2 will damage the existing national rail network

No explanation has ever been provided for how the existing national rail network will operate, with HS2 in place. All the outputs of this study indicate strongly that the introduction of HS2 will have an overall negative effective upon the performance and the integrity of the network.

8. HS2 – the fastest railway in the world but the slowest network?

HS2's design for a future maximum operating speed of 400 km/h dictates intrusive and expensive rural routes and prevents effective integration with the existing network. High Speed UK has been designed for a lower maximum speed but id capable of delivering far greater network-wide journey time reductions and far greater overall gains in connectivity and capacity. This indicates clearly that design for extreme speed is incompatible with optimised functioning of the national network.

9. HS2 will reinforce the North-South divide

HS2's greatest connectivity and capacity benefits will be concentrated in London, which already enjoys the highest per capita income and the greatest connectivity. HS2 will also damage links between the UK regions (especially Scotland) and its London-centric design will prevent efficient HS3 transpennine links. Hence HS2 seems certain to reinforce the current North-South divide and possibly even to threaten the integrity of the United Kingdom.

10. HS2 has never been technically optimised as a railway system

The vastly superior performance of High Speed UK on almost any conceivable comparator shows clearly that HS2 has never been technically optimised in a proper and professional manner to provide the greatest possible gains in capacity and connectivity for the least cost and environmental impact.

The simple statistics laid out in the diagram below, and replicated in Charts ES3-ES9 on the following pages, give a fair summary of HS2 Ltd's complete failure to design the national rail network that the nation needs.

Figure ES2 : HS2 - FAILURE BY NUMBERS

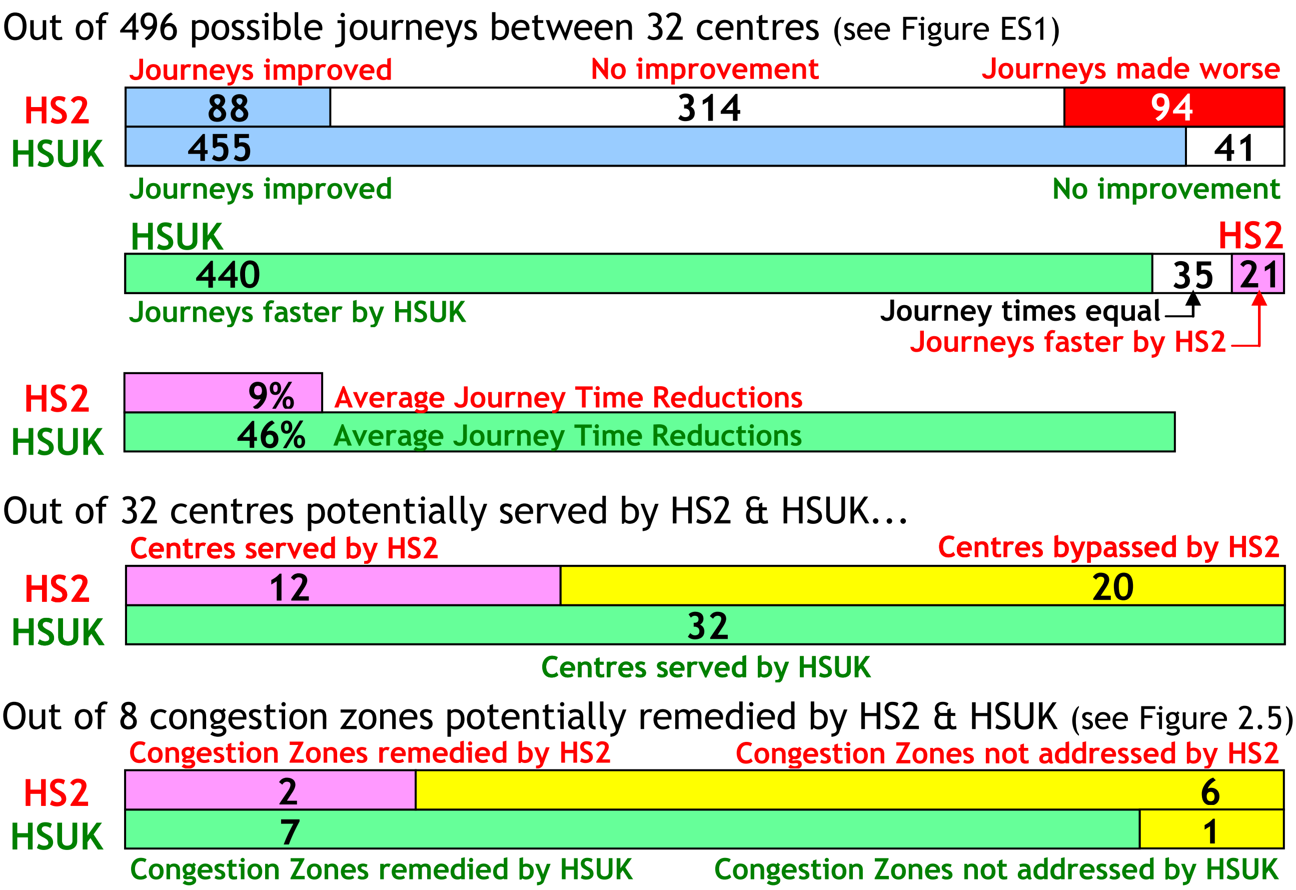
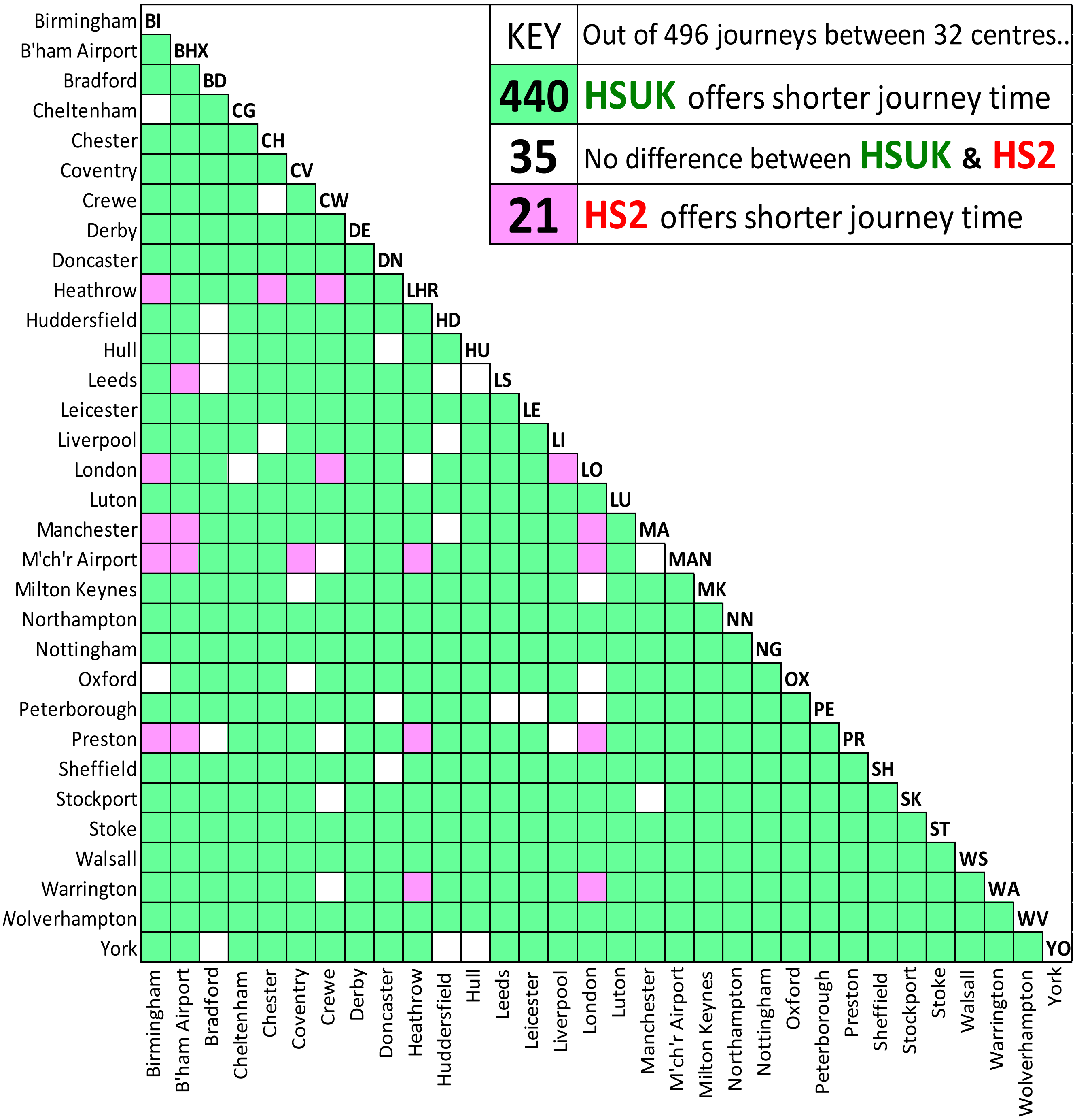


Chart ES3

HIGH SPEED UK & HS2

COMPARATIVE PERFORMANCE IN ACHIEVING JOURNEY TIME REDUCTIONS ACROSS NATIONAL NETWORK



KEY	Out of 496 journeys between 32 centres..
440	HSUK offers shorter journey time
35	No difference between HSUK & HS2
21	HS2 offers shorter journey time

Chart ES4

HIGH SPEED 2

NETWORK PERFORMANCE :

JOURNEYS IMPROVED/MADE WORSE

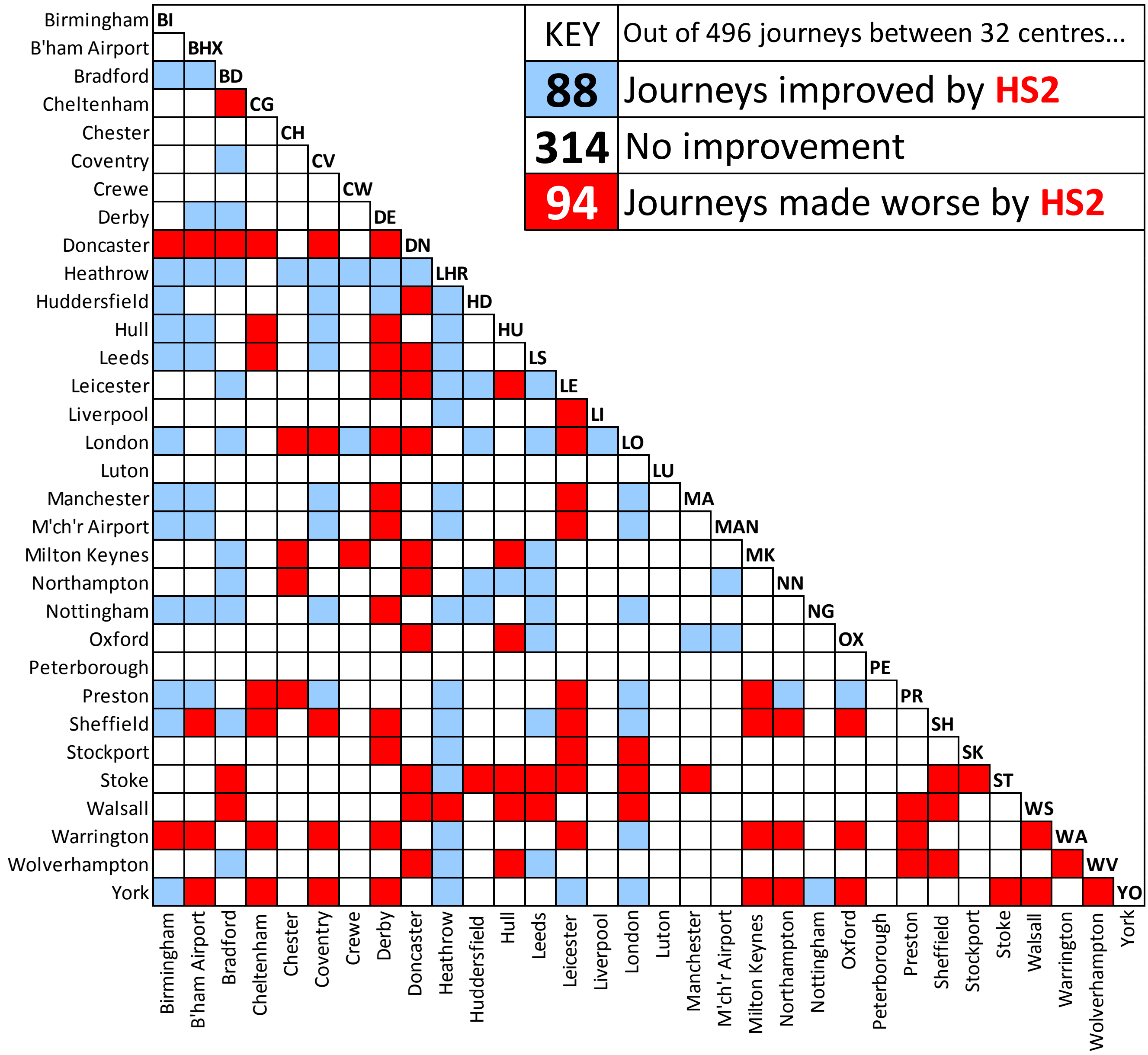


Chart ES5

HIGH SPEED UK

NETWORK PERFORMANCE :

JOURNEYS IMPROVED/MADE WORSE

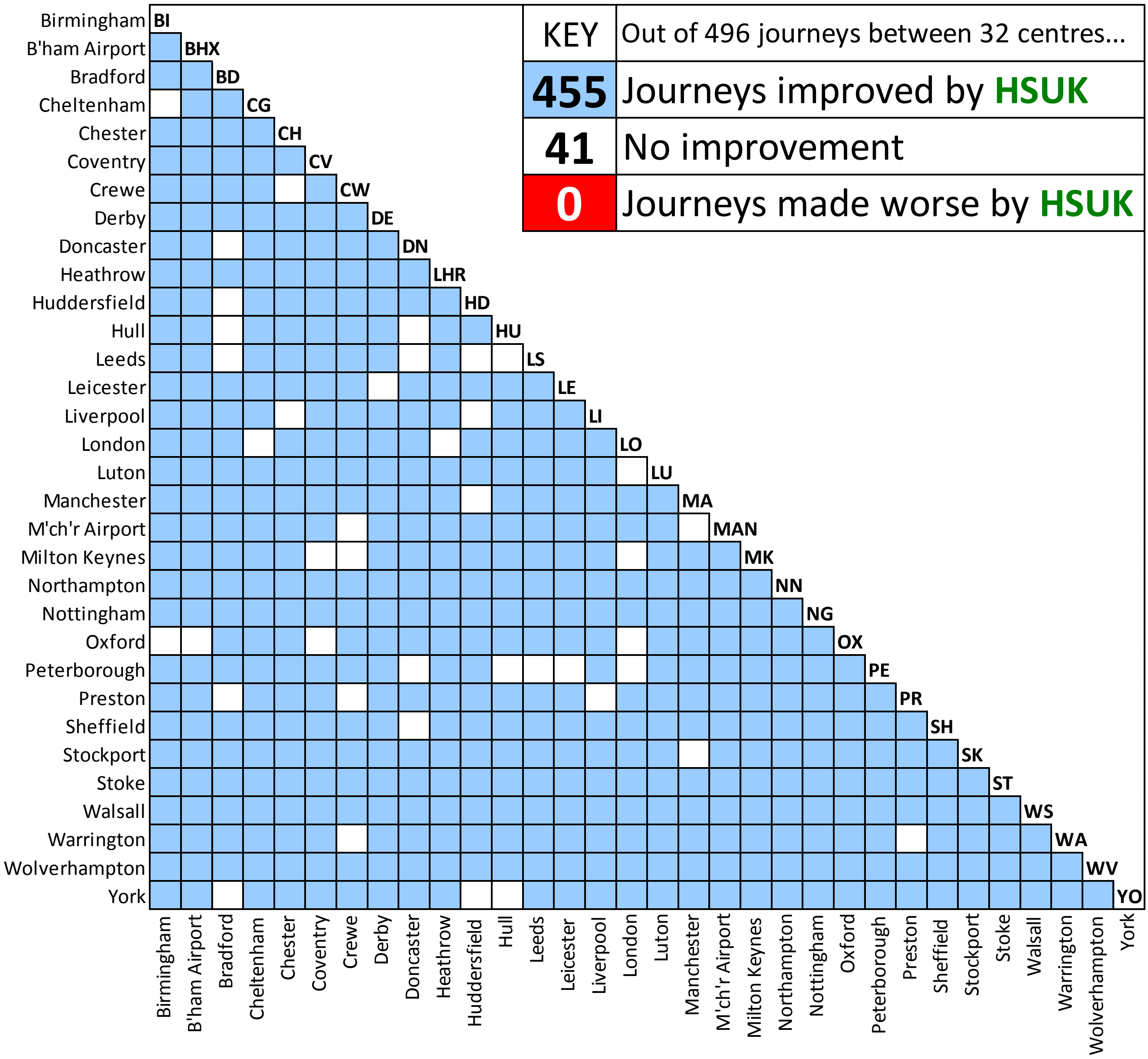


Chart ES6 : HSUK & HS2 INTERCITY LINKS

SUMMARY COMPARISON TABLE

Northern Powerhouse city/airport / Midlands Engine city/airport	HIGH SPEED UK				HS2			
	Average journey time reduction	Cities directly linked by HSUK services	Journeys made faster (out of 31)	Journeys made worse (out of 31)	Average journey time reduction	Cities directly linked by HS2 services	Journeys made faster (out of 30)	Journeys made worse (out of 30)
Birmingham	36%	29	28	0	23%	8	12	2
B'ham Airport	43%	24	29	0	20%	6	9	4
Bradford	50%	12	25	0	13%	0	12	4
Cheltenham	28%	17	29	0	0%	0	0	8
Chester	42%	12	29	0	2%	0	1	4
Coventry	48%	24	29	0	9%	0	9	5
Crewe	32%	20	25	0	6%	4	2	1
Derby	47%	27	29	0	2%	0	4	12
Doncaster	37%	16	25	0	1%	0	1	16
Heathrow	50%	22	30	0	33%	0	23	1
Huddersfield	40%	17	26	0	8%	0	8	2
Hull	32%	16	26	0	3%	0	5	8
Leeds	50%	30	26	0	20%	4	12	5
Leicester	62%	27	29	0	6%	0	5	12
Liverpool	43%	27	28	0	4%	2	2	1
London	31%	27	25	0	19%	11	13	8
Luton	62%	17	30	0	HS2 performance not assessed for Luton			
Manchester	42%	29	28	0	13%	4	6	3
M'ch'r Airport	43%	13	29	0	18%	4	7	2
Milton Keynes	46%	22	28	0	1%	0	2	8
Northampton	60%	18	31	0	5%	0	6	5
Nottingham	56%	27	31	0	10%	0	9	1
Oxford	38%	21	27	0	2%	0	4	5
Peterborough	32%	14	26	0	0%	0	0	0
Preston	35%	19	27	0	12%	5	7	7
Sheffield	53%	31	30	0	8%	3	5	11
Stockport	45%	28	29	0	2%	0	1	4
Stoke	46%	26	31	0	1%	0	1	11
Walsall	59%	18	31	0	0%	0	0	10
Warrington	43%	23	29	0	4%	3	2	12
Wolverhampton	47%	27	31	0	2%	0	3	6
York	42%	24	28	0	9%	2	5	10
Average	46%	22	28	0	9%	1.8	5.5	5.9

Chart ES7

HIGH SPEED UK & HS2 : WINNERS AND LOSERS

Interpreting this table. The table below lists the 32 towns, cities and airports considered in this study. From each place it is possible to make a journey to each of the other places, a total of 31 journeys. Taking London as the example, HSUK offers the fastest journey to 18 destinations, HS2 is fastest to 7 destinations and journeys to 6 destinations remain the same as today. Taking Wolverhampton and 5 other cities as the examples, HSUK offers the fastest journey to all 31 destinations.

	Number of journeys (out of 31) with shortest journey time offered by:			Journeys made worse by HS2
	HIGH SPEED UK	No difference	HS2	
London	18	6	7	7
Heathrow	24	1	6	1
Birmingham	24	2	5	2
M'ch'r Airport	24	2	5	2
Preston	24	3	4	7
B'ham Airport	27		4	4
Manchester	25	3	3	3
Crewe	25	4	2	1
Warrington	28	1	2	12
Leeds	26	4	1	5
Liverpool	27	3	1	1
Chester	28	2	1	3
Coventry	28	2	1	5
Bradford	26	5		4
Huddersfield	26	5		2
Hull	27	4		8
Peterborough	27	4		0
Doncaster	28	3		16
Oxford	28	3		5
York	28	3		10
Cheltenham	29	2		8
Milton Keynes	29	2		8
Stockport	29	2		4
Leicester	30	1		12
Luton	30	1		N/A
Sheffield	30	1		11
Derby	31			12
Northampton	31			5
Nottingham	31			1
Stoke	31			11
Walsall	31			10
Wolverhampton	31			6

Chart ES8

HS2 NATIONWIDE CAPACITY ASSESSMENT

Ref	Location	Congestion relief/Capacity improvement achieved	Score
C1	**Scottish Central Belt** *between Edinburgh and Glasgow*	HS2's west-sided approach to Scotland, with separate routes to Glasgow and Edinburgh splitting at Carstairs, is poorly aligned with the Scottish aspiration for a new high speed intercity route directly linking Glasgow-Edinburgh Airport-Edinburgh. Any Glasgow-Edinburgh high speed route based on current HS2 proposals will offer poor journey times and will probably fail to include Edinburgh Airport.	1/10
C2	**West Yorkshire** *local network focussed on Leeds*	Although new terminus platforms will be built for HS2 trains at Leeds, HS2 will do nothing to relieve present congestion in the existing platforms. Instead, congestion at Leeds seems likely to increase given the inability of HS2's proposed layout to accommodate through services from London to Bradford, Harrogate and the Aire Valley.	0/10
C3	**Transpennine lines** *Manchester to Leeds & Sheffield*	HS2 does nothing to improve the capacity of any transpennine route. Instead, proposed HS2 routes to and stations in Leeds, Sheffield and Manchester, all developed to London-centric priorities, will compromise future delivery of efficient HS3 transpennine links. Hence a negative score has been awarded.	-5/10
C4	**Greater Manchester** *local network focussed on Manchester Piccadilly*	Although new terminus platforms will be built for HS2 trains at Manchester Piccadilly, HS2 will do nothing to relieve present congestion either in the station or on its primary approach route via Stockport. Current 'Northern Hub' strategies are only incremental and will not deliver the required step-change in capacity; moreover, the entire Greater Manchester network will remain critically dependent upon the existing 2-track railway from Manchester Piccadilly (Platforms 13/14) via Oxford Road to Deansgate.	0/10
C5	**West Midlands** *local network focussed on Birmingham New Street*	The selection of Curzon Street as HS2's Birmingham station will achieve only minimal congestion relief at New Street. However, any new capacity at New Street will be compromised by the disconnection between local/regional services at New Street, and high speed services at Curzon Street.	1/10
C6	**West Coast Main Line** *from Euston to Rugby*	HS2's congestion relief to the WCML is greatly compromised by its lack of interconnection with the WCML, and the political need to maintain express intercity services to bypassed cities such as Coventry and Stoke. Moreover, with only 2 tracks, it lacks the capacity to serve all major cities within its 'Zone of Influence', or to provide direct regional links to Heathrow.	8/20
C7	**Greater London** *all quadrants, NW,NE,SW,SE*	Any capacity relief that HS2 will deliver for Greater London will naturally be confined to the north-west quadrant. The extra capacity that it will bring to the WCML is compromised by the continued need for commuters to transfer to the Tube or Crossrail 2 at Euston, and by the huge disruption associated with the proposed expansion and reconstruction of Euston Station.	3/20
C8	**Great Western Main Line** *incl. Severn Tunnel*	HS2's general north-south orientation prevents it from providing significant capacity relief to the GWML. Additionally, HS2's design with a terminus station in Birmingham effectively prevents HS2 services extending to Bristol, Cardiff etc.	0/10
	Nationwide Capacity Score (out of 100)		**8**

Chart ES9

HSUK NATIONWIDE CAPACITY ASSESSMENT			
Ref	Location	Congestion relief/Capacity improvement achieved	Score
C1	**Scottish Central Belt** *between Edinburgh and Glasgow*	HSUK's east-sided approach to Scotland creates a unified high speed route to Edinburgh and Glasgow. This allows direct high speed services from Edinburgh and Glasgow to most principal UK cities. HSUK's proposals also align with Scottish aspirations for a new high speed intercity route directly linking Glasgow-Edinburgh Airport-Edinburgh, and provide 2 new tracks between the 2 cities.	10/10
C2	**West Yorkshire** *local network focussed on Leeds*	HSUK's strategy to create a dedicated route for high speed services through Leeds, achieved through 4-tracking of approach routes, will greatly increase capacity for local services. Construction of a new Stourton-Neville Hill link will allow many terminating services to be converted to through services. Together these 2 measures will allow capacity for local services to be approximately doubled.	10/10
C3	**Transpennine lines** *Manchester to Leeds & Sheffield*	HSUK's 'spine & spur' configuration incorporates a transpennine link (via the restored Woodhead corridor) as an integral part of network development. This will relieve congestion on all existing transpennine routes, and also creates the opportunity for a new transpennine freight route and a Sheffield-Manchester lorry shuttle	10/10
C4	**Greater Manchester** *local network focussed on Manchester Piccadilly*	HSUK's transpennine spur, serving both Manchester and Liverpool, demands a new east-west cross-Manchester tunnel with underground platforms at Manchester Piccadilly. This new facility - linking to Huddersfield, Sheffield and Stockport in the south and east, and to Liverpool and Bolton in the north and west, will also provide major new capacity for local services. This will greatly augment and reinforce current 'Northern Hub' strategies, and also offer a much more resilient local network.	10/10
C5	**West Midlands** *local network focussed on Birmingham New Street*	HSUK's strategy of 4-tracking key approach routes into Birmingham New Street (from Coventry, Derby and Wolverhampton/Walsall) enables local services to be segregated from express intercity services. This creates a step-change in capacity, and with the additional benefit of new routeing options created by HSUK, it is no longer necessary to terminate or reverse services at New Street; comprehensive 'through' operation will hugely increase platform capacity and allow much more frequent local services.	10/10
C6	**West Coast Main Line** *from Euston to Rugby*	HSUK's 4 tracks and its frequent interconnection with the WCML will deliver much greater congestion relief and resilience than HS2. With 4 tracks, HSUK has sufficient capacity to serve all major cities within its 'Zone of Influence', including Coventry and Stoke.	20/20
C7	**Greater London** *all quadrants, NW,NE,SW,SE*	HSUK will deliver capacity relief for Greater London in both the north-west quadrant and – on account of its transformation of Heathrow's rail links – in the south-west quadrant also. Unlike HS2, its strategy to transfer commuter flows to Crossrail, or to a future 'Westlink' tunnelled route linking Euston and Charing Cross, will have massive beneficial effects upon current WCML commuter flows, eliminating the need to transfer to Tube lines at Euston.	10/20
C8	**Great Western Main Line** *incl. Severn Tunnel*	HSUK's general north-south orientation prevents it from providing significant capacity relief to the GWML. A complementary 'High Speed West' scheme is currently under development. Proposed HSUK services via Birmingham New Street will ensure full connection of Cardiff, South Wales, Bristol & West Country to national network.	2/10
	Nationwide Capacity Score (out of 100)		**82**

1 Introduction

The HS2 project has been sold to the UK public, and to the politicians who represent them, on the promise of major gains in rail network capacity and connectivity, and the economic benefits that should flow as a consequence. The HS2 promise is encapsulated in evidence given to the House of Commons HS2 Select Committee on 30th November 2015 by former HS2 Ltd Technical Director Andrew McNaughton:

> **"The aim of the HS2 project is to deliver hugely enhanced capacity and connectivity between our major conurbations"**

HS2 Ltd has made great play upon the step-change journey time reductions that will be achieved on its 'Y-network' linking the primary cities of London, Birmingham, Manchester and Leeds, and also upon the increased capacity that its 2 new tracks are claimed to deliver between London and the West Midlands will undoubtedly bring.

However, in all the reams of reports and publicity material that have been issued in support of the HS2 project, there appears to have been little structured consideration of the following questions:

- Can HS2's headline journey time reductions be translated into similar improvements across the wider UK rail network?
- Will HS2's 2 new tracks provide sufficient new capacity to achieve these improvements?
- What will the overall journey time reductions be?
- Will the intervention of HS2 deliver extra capacity for improved local services in regional conurbations, especially the West Midlands, Greater Manchester and West Yorkshire?
- Is HS2 sufficiently 'future-proofed' against growing demand for rail services, given currently rising trends and projections of increasing population, and the need for step-change road to rail modal shift to enable CO_2 emission reductions?
- How will the entire intercity rail network ie new high speed lines and existing routes operate, with HS2 in place?
- Has the routeing of HS2's new lines and the provision of links to existing main lines been correctly chosen to optimise the function of the entire network?
- Is HS2 Ltd's adoption of a maximum operating speed of 360 km/h, with allowance for a future operation at 400 km/h, compatible with optimised network performance?
- Will HS2 deliver economic benefits to the UK regions and help reverse the North-South divide?
- Has HS2 has been properly and professionally optimised to deliver the greatest possible capacity and connectivity for the least cost and environmental impact?

There can be no dispute that the investment of over £55 billion of public money will only be worthwhile if HS2 can:

- bring about an improved and optimised national network delivering its aim of **"hugely enhanced capacity and connectivity"**;
- offer these capacity and connectivity benefits to the greatest possible proportion of the UK population.
- achieve improvements in journeys between the UK's regional conurbations at least as great as for journeys to London.

These 3 considerations, of technical excellence, inclusivity and regional rebalancing, are essential if HS2 is to be a successful public project. So far, however, neither the Government nor HS2 Ltd have provided any proof that HS2 is the correct and the best technical solution to address the national priority for a higher-capacity, better-connected and more inclusive rail network. It seems simply to have been assumed that the addition of 2 new tracks along the specific axis of the network's busiest route must, almost by definition, achieve this aim.

With the publication in November 2016 of the Government's definitive proposals for Phase 2 of HS2, to complete the 'Y-network' as far north as Wigan, Manchester, Leeds and York, it at last becomes possible to assess HS2 as a complete design for an intercity network that will supersede the existing national intercity network.

At the same time, the High Speed UK (HSUK) scheme for a national network of high speed lines interlinking all principal population centres provides the necessary 'exemplar alternative' against which HS2 can be assessed, to ensure that it does indeed justify all the claims of its proponents.

This study sets out to examine how the rival interventions of a) HS2's new stand-alone high speed lines and b) HSUK's programme of new high speed line construction and upgrade/restoration of existing routes will address the issues of rail network capacity, connectivity and inclusivity.

This involves far more than a simplistic consideration of the handful of journeys from regional primary cities to London that HS2 Ltd has sought to promote. Instead, timings for 496 separate journeys between 32 key centres, extending from London and Heathrow to the principal towns, cities and airports of the Midlands and the North, are calculated to provide the necessary detailed assessment of the UK railway network.

The study also examines HS2's and HSUK's performance in improving direct connectivity between the UK's principal population centres, and in relieving the principal areas of congestion across the national network.

This study establishes for the first time the models and the methodologies necessary to determine HS2's effectiveness as a railway network. In essence, it is the network performance study that HS2 Ltd should have undertaken – but regrettably never troubled to do so. The study conducts a rigorous examination of all aspects of HS2's performance, and it demonstrates that HSUK sets a standard which HS2 catastrophically fails to reach.

This comparison with the HSUK 'exemplar alternative' is essential to fully illuminate HS2's multi-faceted failure. In whatever performance measure – journey time, connectivity between cities or capacity of its 4-track spine – HSUK hugely outperforms HS2, and this superior performance is replicated for every single city and airport considered in this study.

HS2's shortcomings can be attributed to one central failure – its design as a stand-alone high speed line, with no effective consideration of its performance as a national network, and no attempt to design it to integrate with or to enhance the existing network. As such, its introduction threatens the very integrity of the national rail network, and it also threatens the prosperity of every community that depends upon this network.

Perhaps the most astonishing feature of HS2, a project intended to deliver widespread economic benefits across the UK regions, is just how few places it serves, and how few journeys it improves. For this reason, we have chosen to entitle this study: *HS2 – High Speed to (Almost) Nowhere*. In order to appreciate the full scope of HS2 Ltd's technical failure, this study should be read in conjunction with its companion volume *HS2 – High Speed to Failure*.

2 Rationale of Study

2.1 High Speed Rail and Public Policy

Building new high speed lines with the aim of delivering **"hugely enhanced capacity and connectivity"** might appear a desirable end in itself, but a public project on the scale of HS2 cannot exist in isolation. It can only be worth spending double-digit billions of pounds on HS2 if it brings about commensurate benefits and if both its costs and benefits align with all relevant objectives of public policy.

The principal aspects of public policy relevant to high speed rail are as follows:

2.1.1 Budgetary Restraint

The universal imperative for budgetary restraint dictates that the cost of the HS2 project must be kept to a minimum.

2.1.2 Technical Optimisation

Closely allied with the imperative for budgetary restraint is the requirement that HS2 should be rigorously optimised to deliver the greatest practicable enhancements in capacity and connectivity and thus offer greatest value for money. The existence of an alternative scheme of identical geographical scope and broadly similar cost, yet offering much greater capacity and connectivity, would of course indicate that HS2 contravenes this most fundamental aspect of public policy.

2.1.3 Protection of Communities and Natural Environments

There is a presumption in UK planning policy that impacts upon communities and natural environments (such as Sites of Special Scientific Interest and Ancient Woodlands) must be kept to a minimum. This dictates that wherever practicable, new routes must follow existing transport corridors, with associated development on brownfield rather than greenfield sites.

2.1.4 Inclusivity

With all UK taxpayers bearing the financial burden of HS2, it follows naturally that the benefits of HS2 should extend to the greatest possible proportion of the UK population. Whilst it is never possible to ensure that a public project will not leave specific groups or areas disadvantaged, considerations of inclusivity dictate that a) in numerical terms, the number of 'winners' should vastly outweigh the number of 'losers', and b) any 'losers' should generally be those who gained undue advantage from the previous system.

2.1.5 Economic Benefit

The new connectivity and capacity created by HS2 should facilitate trade, and bring about economic benefit.

2.1.6 Environmental Benefit

If HS2 were to achieve its objective of delivering **"hugely enhanced capacity and connectivity"**, it should give rail a huge competitive advantage over road transport. The resulting modal shift from high-emitting cars and lorries to lower-emitting trains will bring about step-change reductions in CO_2 emissions.

2.1.7 Rebalancing UK Economy

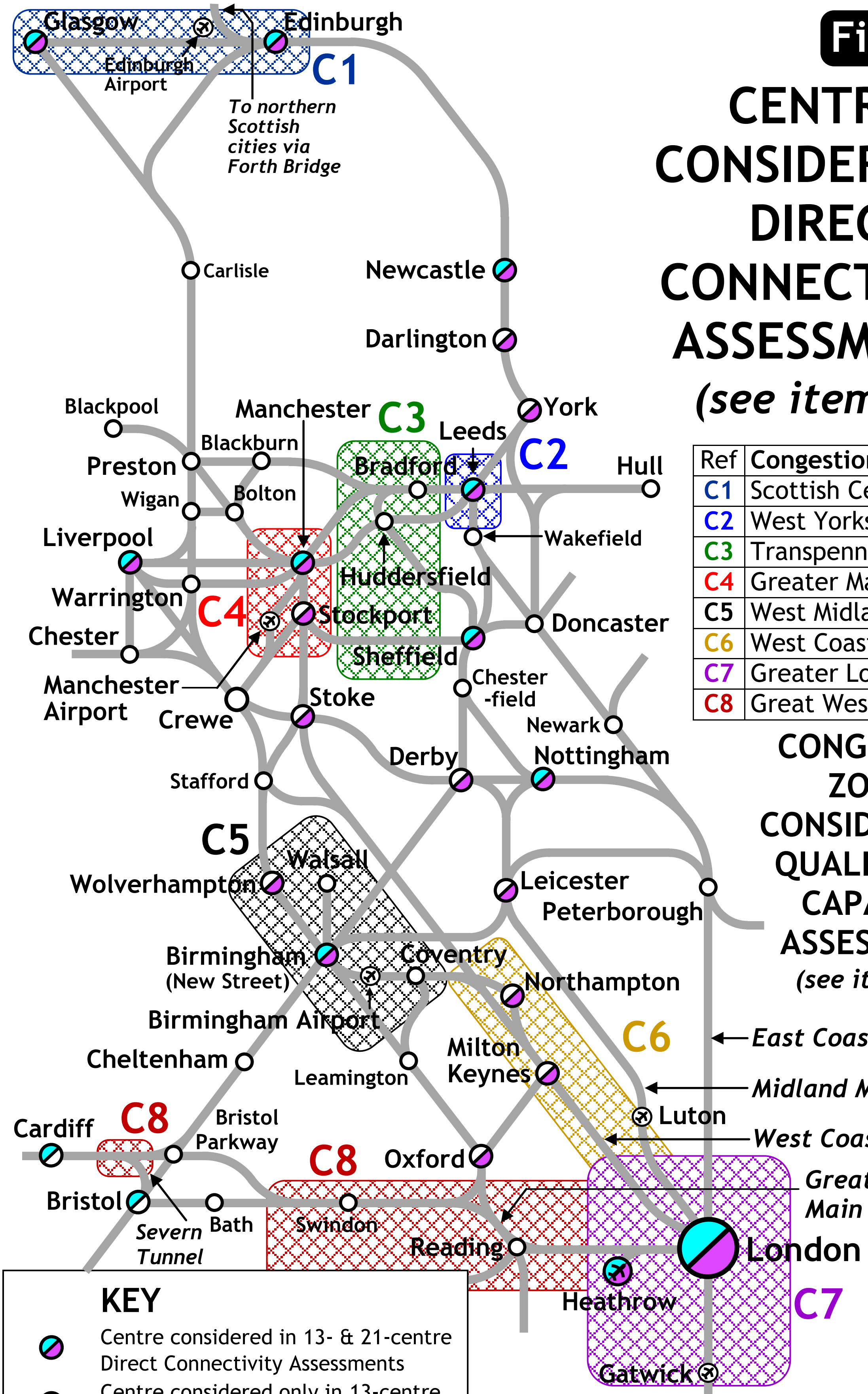
To redress the North-South Divide and other economic imbalances that afflict the UK economy, HS2 should deliver greater connectivity and capacity benefits for the UK regions than it delivers for London and the South-East.

All of these public policy considerations would appear to be uncontroversial, and above party politics. If HS2 is to be a success as a public project, it must be developed in line with the principles listed above.

Figure 2.1

CENTRES CONSIDERED IN DIRECT CONNECTIVITY ASSESSMENTS

(see item 2.4)



Ref	Congestion Zone
C1	Scottish Central Belt
C2	West Yorkshire
C3	Transpennine lines
C4	Greater Manchester
C5	West Midlands
C6	West Coast Main Line
C7	Greater London
C8	Great Western Main Line

CONGESTION ZONES CONSIDERED IN QUALITATIVE CAPACITY ASSESSMENT

(see item 2.7)

KEY

- Centre considered in 13- & 21-centre Direct Connectivity Assessments
- Centre considered only in 13-centre Direct Connectivity Assessment
- Centre considered only in 21-centre Direct Connectivity Assessment
- Zone of serious network congestion
- Existing main line of UK network

210 possible journeys between 21 centres	78 possible journeys between 13 centres

Figure 2.1

2.2 The Connectivity Imperative

The word ‘connectivity’ has many definitions and usages, but for the purposes of this study, the principal factors determining the connectivity of an intercity rail project can be defined as follows:

- The speed of the train, and hence the journey time.
- The frequency of the train service.
- The quality of the train.
- The opportunity to make a direct journey with no changes of train.
- (If a direct journey is not possible) the quality of interchange.
- The elimination of existing congestion.

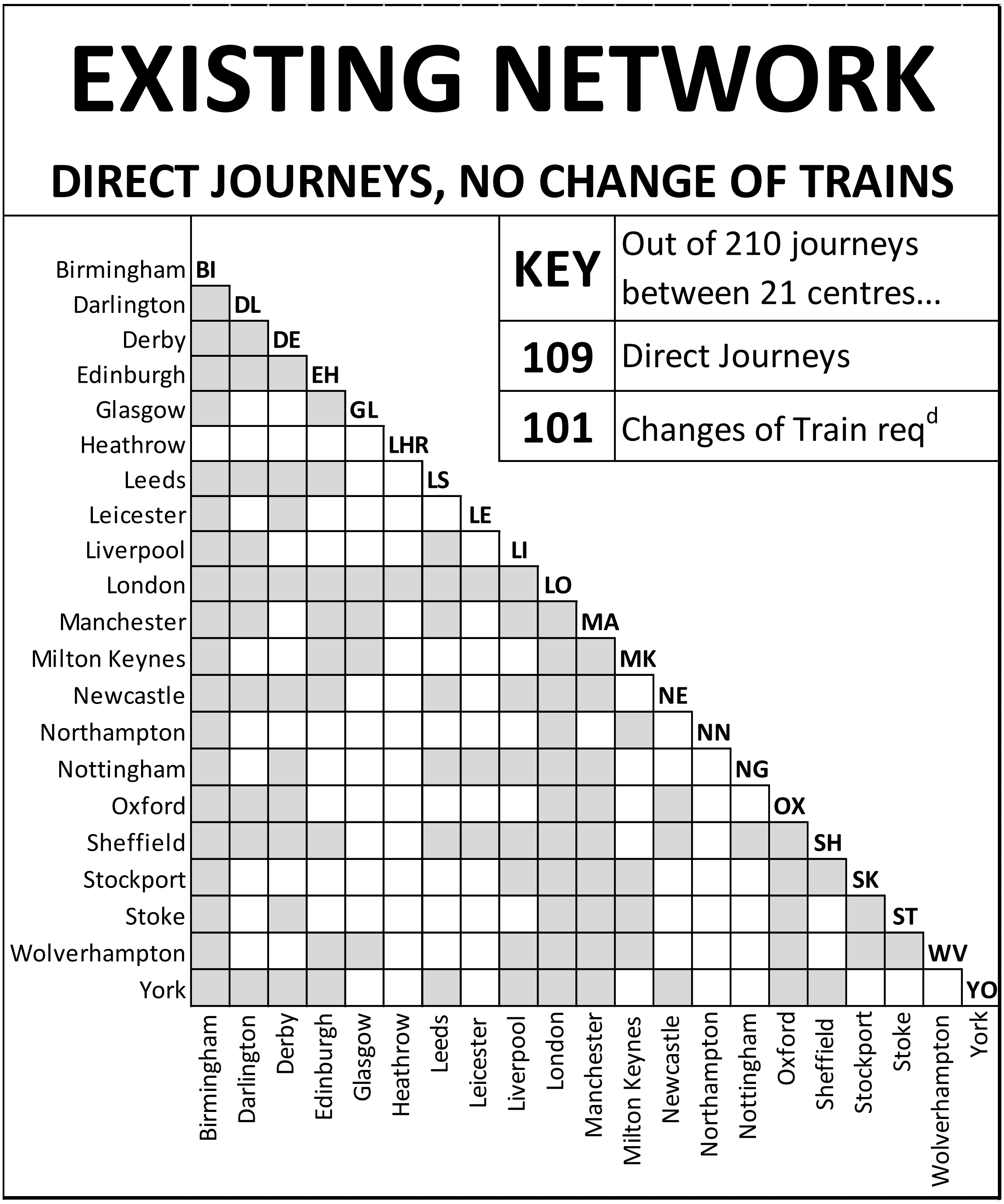


Figure 2.2 : Direct Intercity Connectivity offered by existing UK rail network

As illustrated on Figures 2.2 and 2.3, the existing rail network does not provide efficient and comprehensive direct links between the UK's many regional cities/conurbations. This leads naturally to an aspiration that the HS2 project should enable all major UK cities and conurbations to be directly connected with high speed trains of 'intercity' quality operating at hourly (or better) frequency. This would certainly represent **"hugely enhanced… connectivity"** between the UK's major conurbations.

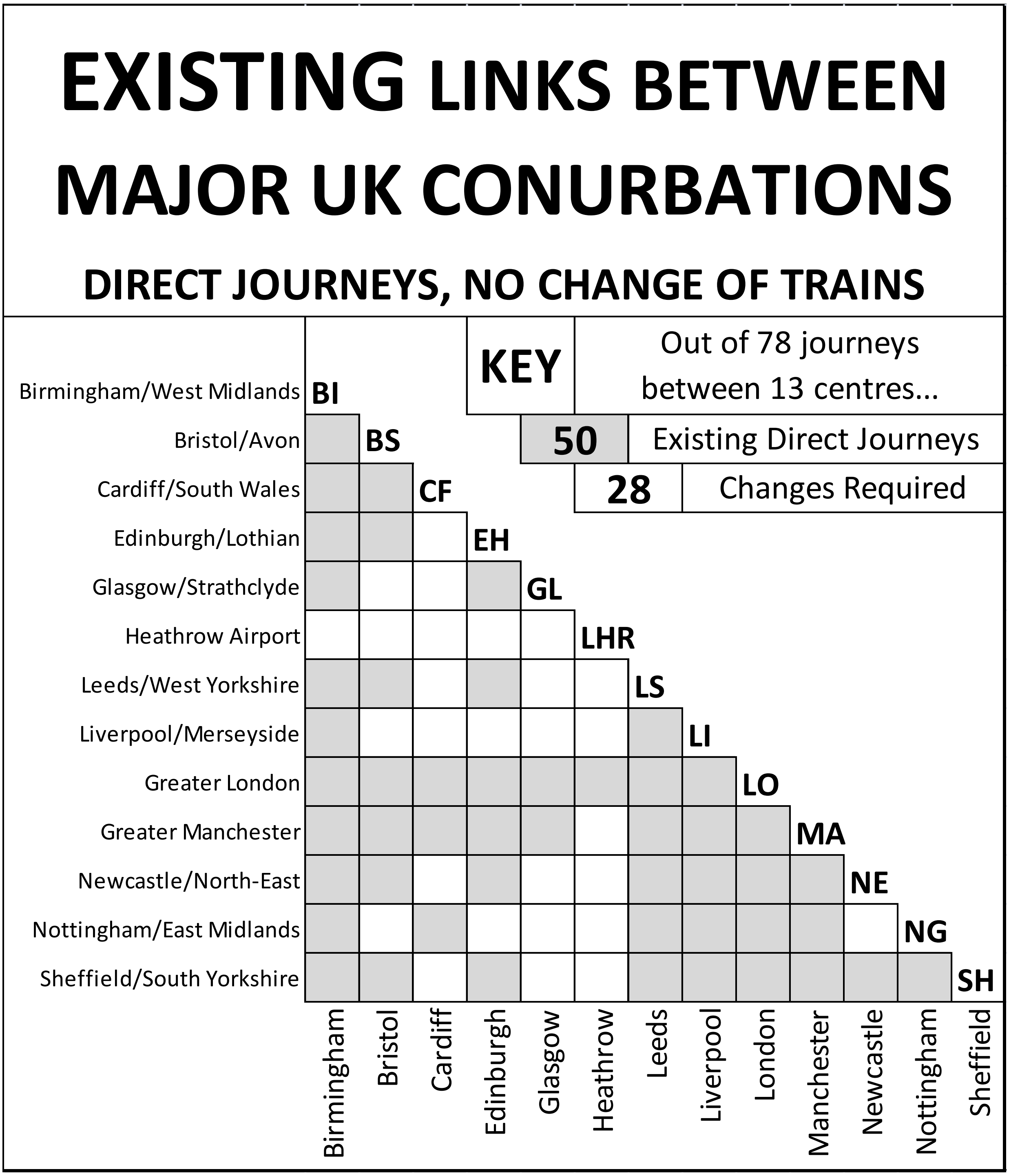


Figure 2.3 : Direct Interconurbation Links offered by existing UK rail network

If HS2 is to deliver on its promise of **"hugely enhanced…connectivity"** between the UK's major conurbations, its starting point must be the connectivity of the existing intercity rail network. The existing network's greatest connectivity deficiency is its inability to offer direct services between regional cities. Figure 2.2 shows that out of the 210 possible journeys between 21 centres, only 52% (109) are direct; the remainder requires one or more changes of train.

Within this global statistic, there are major variances between the 21 centres under consideration, as depicted on Figure 2.1. Whilst communities such as Northampton and Glasgow enjoy very few direct links, and each centre is on average directly connected to 10 other centres, London alone is directly connected to all 20 other centres. This is a very clear example of the existing network's London-centricity which is both a cause and an effect of the UK's highly London-centric economy.

It is also significant to note that Heathrow Airport only has direct rail links to London via the Heathrow Express service to Paddington. Passengers en route to the key regional cities of the Midlands, the North and Scotland must endure a highly inconvenient Tube transfer to continue their northward journeys from either Euston, St Pancras or Kings Cross stations. This leaves most regional communities with very poor links to the intercontinental connections that amongst UK airports are only available at Heathrow. Again, this is a major contributor to the economic disparities between London and the UK regions.

If HS2 were to succeed in its aim of **"hugely enhanced…connectivity"** by enabling all major UK centres, including Heathrow and other principal airports, to be directly interconnected, this would do much to rebalance the UK's economy.

2.3 The Capacity Imperative

Most of the justifications that have been offered in support of HS2 have focussed upon the **"hugely enhanced capacity"** that it is predicted to deliver for the UK rail network.

There is undoubtedly a major problem that must be addressed. Construction of the UK rail network began in early Victorian times and rail passenger journeys rose year on year to reach a peak of 1,543 million journeys by 1914. Since that time, the number of journeys declined to reach an all-time low of 625 million journeys in 1983. At that point rail's fortunes changed and almost every year since then has seen an increase in patronage with no less than 1,685 million journeys being made in 2015, a 170% increase over the 32 years since 1983.

Faced with this unprecedented change in the fortunes of rail transport in Britain the Government realised that it had a major problem on its hands; there simply was not enough capacity in the existing rail network to cope with projected growth in demand. With no realistic prospect either of upgrading the existing network or restoring lines that were closed in the Beeching cuts of the 1960's, the Government decided that its only option was to build new high speed lines to relieve the pressure on the existing network.

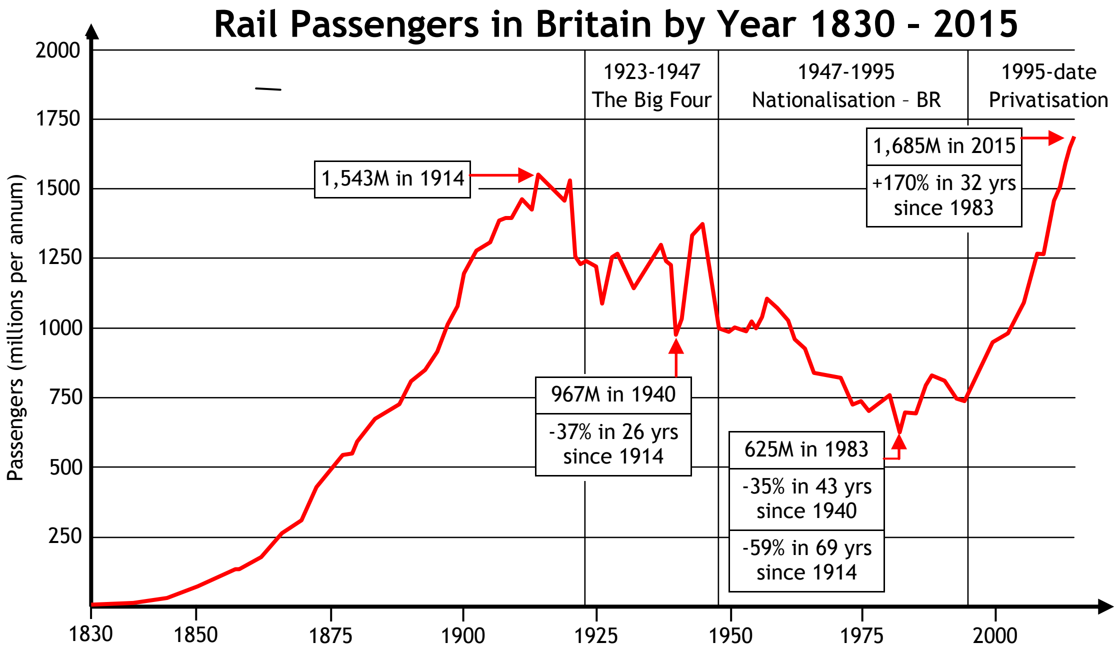


Figure 2.4 : Historical Growth in Passenger Volumes on UK Rail Network

Info in Figure 2.4 redrawn from diagram in
https://en.wikipedia.org/wiki/Rail_transport_in_Great_Britain#/media/File:GBR_rail_passengers_by_year_1830-2015.png

Whilst the decision to build new high speed lines is welcome, it has been taken largely on a 'business as usual' basis, reacting to the congestion issues of the UK's highly London-centric economy. Little or no account has been taken of factors such as the need to redress regional economic imbalances, or to tackle global warming.

There is a clear risk that if the mission of the UK high speed rail project is taken to be simply the provision of new capacity on critical London-centric routes such as the West Coast Main Line, the result will be to exacerbate existing economic disparities. There is an additional risk that the provision of this new capacity may fail to address the parallel need for improved direct links from the UK regions to Heathrow Airport. All this dictates that – just as with connectivity – a national strategy must be adopted in the enhancement of capacity.

This national strategy is essential to ensure that high speed rail delivers a 'local capacity dividend' of improved local services in all the locations of major congestion identified in Figure 2.1. These nationwide capacity enhancements are necessary not only to justify the huge public investment in new high speed intercity railways, but also to enable the existing rail network to play its part in delivering the **"hugely enhanced capacity and connectivity"** that is HS2's fundamental aim. It is simply not practicable to build new high speed lines to improve all the journeys between the UK's many regional cities – note that there are 496 possible journeys between the 32 centres highlighted in Figure 2.6.

The aim of the UK high speed rail project for transformed capacity and connectivity will only be met if all these journeys can be improved. This demands that congestion problems in all parts of the existing network are resolved with transformational interventions on a similar scale to that of building a new high speed line.

The issue of climate change sets a new dimension to the capacity challenge. The legally-binding target of the 2008 Climate Change Act has committed all Governments to achieve an 80% reduction in the emission of CO_2 by 2050, and the major part of that reduction must come from modal shift from car journeys and road haulage to trains. This would cause a growth in the demand for rail travel far beyond current projections.

2.4 Assessment of Direct Connectivity

The primary purpose of this study is to test HS2 Ltd's claims that its proposals will deliver **"hugely enhanced capacity and connectivity"** between the UK's major conurbations. Whilst detailed information concerning journey times, station locations, route alignments and connections to the existing network is confined to the 'Zone of Influence' of the HS2 'Y', the available information on proposed HS2 services allows a more qualitative assessment of HS2's performance as a national network encompassing cities as far north as Scotland.

This assessment focuses upon the simple issue of whether a direct link – either by high speed rail or by the existing network – exists between any given pair of cities. This will give a good overview of the performance of HS2 – and of the High Speed UK alternative – in addressing the connectivity deficiencies of the existing rail system.

2.4.1 Direct Connectivity Assessment between 21 Centres within HS2 'Zone of Influence' (21-centre Test)

In this assessment, the following 20 towns and cities plus Heathrow Airport (ie 21 centres in all) are considered, all as shown in Figure 2.1:

Primary Cities (population > 500,000):
London, Birmingham, Nottingham, Sheffield, Manchester, Liverpool, Leeds, Newcastle, Edinburgh and Glasgow.

Second-tier Towns/Cities (population 150,000 - 500,000):
Oxford, Milton Keynes, Northampton, Wolverhampton, Leicester, Derby, Stoke, Stockport, York and Darlington (for Teesside).

Airport:
Heathrow

2.4.2 Direct Connectivity Assessment between UK Primary Cities representing the UK 'Major Conurbations' (13-centre Test)

A further assessment has been undertaken, considering only the 12 UK primary cities (as listed above, plus Bristol and Cardiff) and Heathrow Airport. Each of these primary cities represents a 'major conurbation' (see Table 2.5 below), and the link to Heathrow represents the aspiration of each regional conurbation for improved links to international markets. In simplistic terms, this assessment provides the test most closely matched to HS2 Ltd's ambition for **"hugely enhanced capacity and connectivity"** between the UK's major conurbations.

Primary City	Conurbation
Birmingham	West Midlands
Bristol	Avon
Cardiff	South Wales
Edinburgh	Lothian
Glasgow	Strathclyde
Leeds	West Yorkshire
Liverpool	Merseyside
London	Greater London
Manchester	Greater Manchester
Newcastle	North-East
Nottingham	East Midlands
Sheffield	South Yorkshire

Table 2.5 : UK Primary Cities and Corresponding 'Major Conurbations'

2.5 Quantified Journey Time Assessment (32-centre Test)

The primary measure employed in the Quantified Journey Time Assessment is the improvement in journey times across the national rail network that will be achieved by the interventions of HS2 and High Speed UK.

It is freely acknowledged that the UK high speed rail project must be about more than the simplistic attainment of accelerated journey times between a few key centres; the goal of a better-connected and higher capacity network has far greater strategic importance. It is also acknowledged that the precise financial value of each minute shaved from an existing journey time is highly debatable.

However, it remains the case that the relative magnitude and the geographic distribution of improved journey times provide the simplest measure by which the effectiveness of HS2 or any other new railway intervention can be evaluated. New rail capacity is of little use unless it can be utilised in an efficient and inclusive manner.

If a new railway intervention such as HS2 could only improve intercity journey times between London and Birmingham, and it lacked the capacity, the correct routeing and the necessary connections to the existing network to deliver similar journey time improvements for Milton Keynes, Northampton, Leicester, Coventry, Walsall and Wolverhampton (either to London or between these communities), then it could be argued that the new railway was neither an efficient design nor a worthwhile project on which to expend large sums of public money.

As noted previously, the UK high speed rail project will meet its core objective of an inclusive and enhanced national rail network only if it can bring about step-change improvements across the entire UK network. The demonstration of comprehensive journey time improvements through the development of a timetable provides the strongest possible indicator of how effective the proposed intervention will be.

2.6 Geographic Scope of Quantified Journey Time Assessment

To assess how HS2 will function as a network, its journey time performance between 32 key centres has been quantified. Unlike the 21 centres considered in the Direct Connectivity Assessment (see Item 2.4.1), the 32 centres (29 towns/cities and 3 airports) shown on Figure 2.6 as 'considered in journey time assessment' are closely representative of the immediate 'Zone of Influence' of the HS2 'Y' ie a high speed rail system extending northwards from London via the West and East Midlands to the key Northern conurbations ie Merseyside, Greater Manchester, South Yorkshire, West Yorkshire and Humberside.

The centres considered are as follows:

Primary Cities (population > 500,000):
London, Birmingham, Nottingham, Sheffield, Manchester, Liverpool and Leeds.

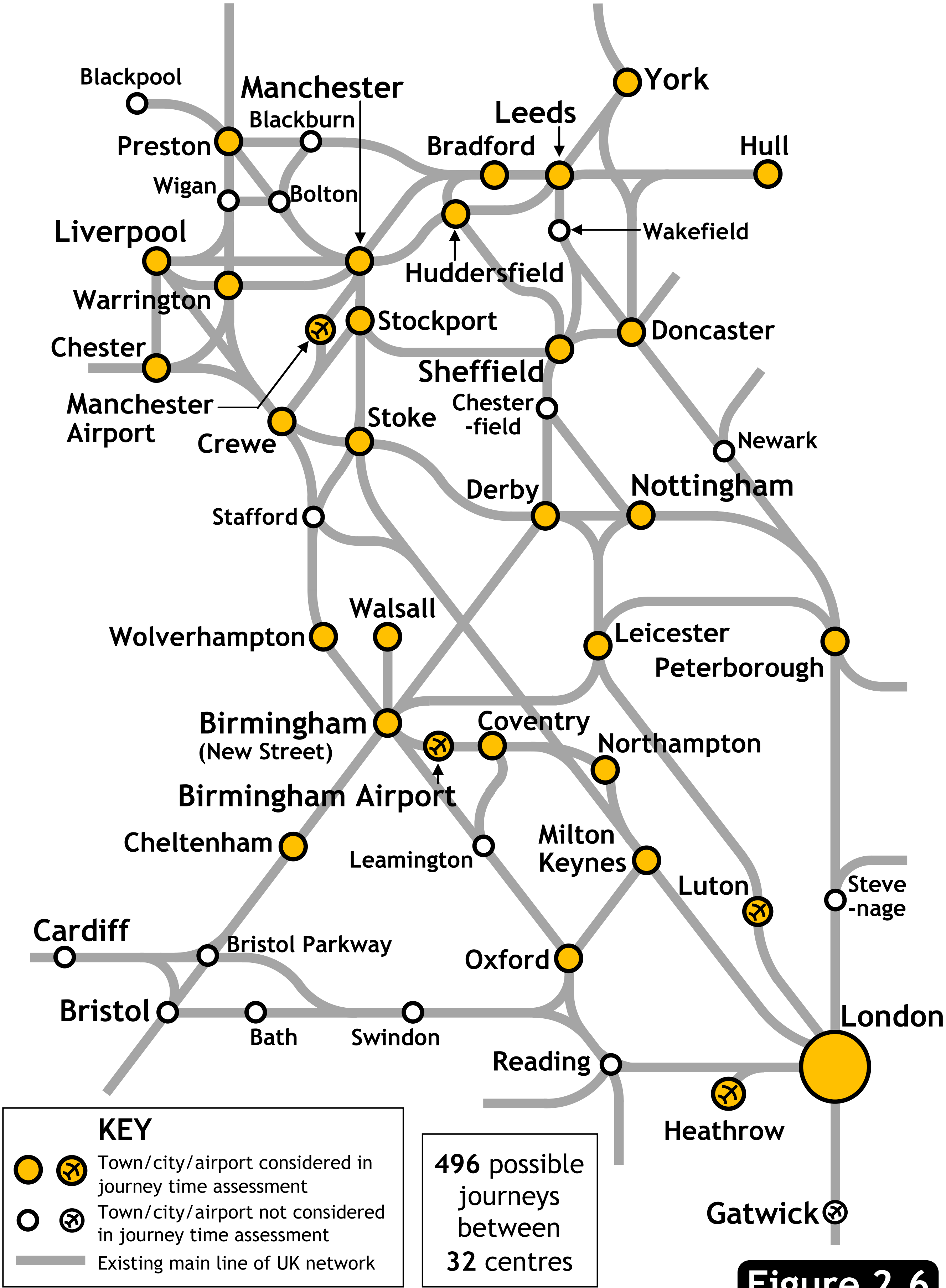
Second-tier Towns/Cities (population 150,000 - 500,000):
Luton, Milton Keynes, Northampton, Coventry, Walsall, Wolverhampton, Leicester, Derby, Stoke, Crewe, Warrington, Stockport, Huddersfield, Bradford, Doncaster and Hull.

Gateway Towns/Cities (population 80,000 - 300,000, also representative of onward routes outside immediate Zone of Influence):
Oxford (*for Thames Valley & South Coast*)
Cheltenham (*for West Country & South Wales*)
Peterborough (*for East Anglia*)
Chester (*for North Wales Coast*)
Preston (*for Cumbria and Scotland*)
York (*for North-East & Scotland*)

Airports:
Heathrow, Birmingham, Manchester

CENTRES CONSIDERED IN JOURNEY TIME ASSESSMENT

Figure 2.6



496 possible journeys between 32 centres

Figure 2.6

There are 496 possible journeys in a network linking these 32 centres, and all of these journeys must be considered in a full assessment of network performance. With the journeys to the 'gateway' centres representative of journeys to all major cities and regions outside the immediate 'Zone of Influence' of the HS2 'Y', this assessment becomes effectively national in its scope and extent.

2.7 Qualitative Capacity Assessment

Figure 2.1 also highlights 8 zones of critical network congestion, listed as follows:

- Central Belt of Scotland (Zone C1), *between Edinburgh and Glasgow*.
- West Yorkshire (Zone C2), *focussed upon Leeds station*.
- Transpennine lines (Zone C3), *between Manchester and Leeds/Sheffield*.
- Greater Manchester (Zone C4), *focussed upon Manchester Piccadilly*.
- West Midlands (Zone C5), *focussed upon Birmingham New Street*.
- West Coast Main Line (Zone C6), *between London and Rugby*.
- Greater London (Zone C7), *all 4 quadrants ie NW, NE, SW, SE*.
- Great Western Main Line (Zone C8), *between London and Severn Tunnel*.

Whilst it would appear to be impracticable for any high speed rail scheme to increase capacity in all of these areas, HS2's ability to achieve its aim of "**hugely enhanced capacity and connectivity**" can be measured by the number of different geographical areas in which it does achieve the necessary step change increase in capacity.

2.8 Scenarios to be considered : HS2, High Speed UK & Existing Network

An assessment of the benefits of HS2 can be accomplished by considering its journey times and network performance against the existing condition i.e. the existing network operated by Network Rail. However, assessment against an existing condition gives little indication of whether a new scheme has been properly optimised to give the best possible performance and value for money. This can only be accomplished by comparing HS2 with an exemplar alternative of broadly equivalent cost and functionality.

HS2 has so far been presented to public and politicians as a 'single option' scheme, and its primary justification has been against the alternative of upgrading the existing congested network. No explanation has been provided showing how HS2 will enhance overall network performance by operating in harmony with the existing network, or why HS2 is the optimum 'new build' scheme to achieve this aim.

Consequently, there is currently no assurance that HS2 has been developed with the necessary impartiality, professionalism and technical expertise to result in the best possible proposal, worthy of the expenditure of over £55 billion of public money.

The release in November 2016 of definitive proposals for Phase 2 of HS2 has now provided sufficient detail (see Appendices A2 and A3) to allow HS2's journey time and wider connectivity performance to be defined across the 'full network' of 32 centres considered in this study. This then allows detailed comparisons with the performance of the existing network, from which the magnitude and the distribution of HS2's improvements can be determined.

At the same time, comparison with the 'exemplar alternative' High Speed UK (HSUK) scheme enables a proper judgement upon to be made upon whether HS2 performs efficiently as a national network, and whether it constitutes the optimised proposal that its proponents claim.

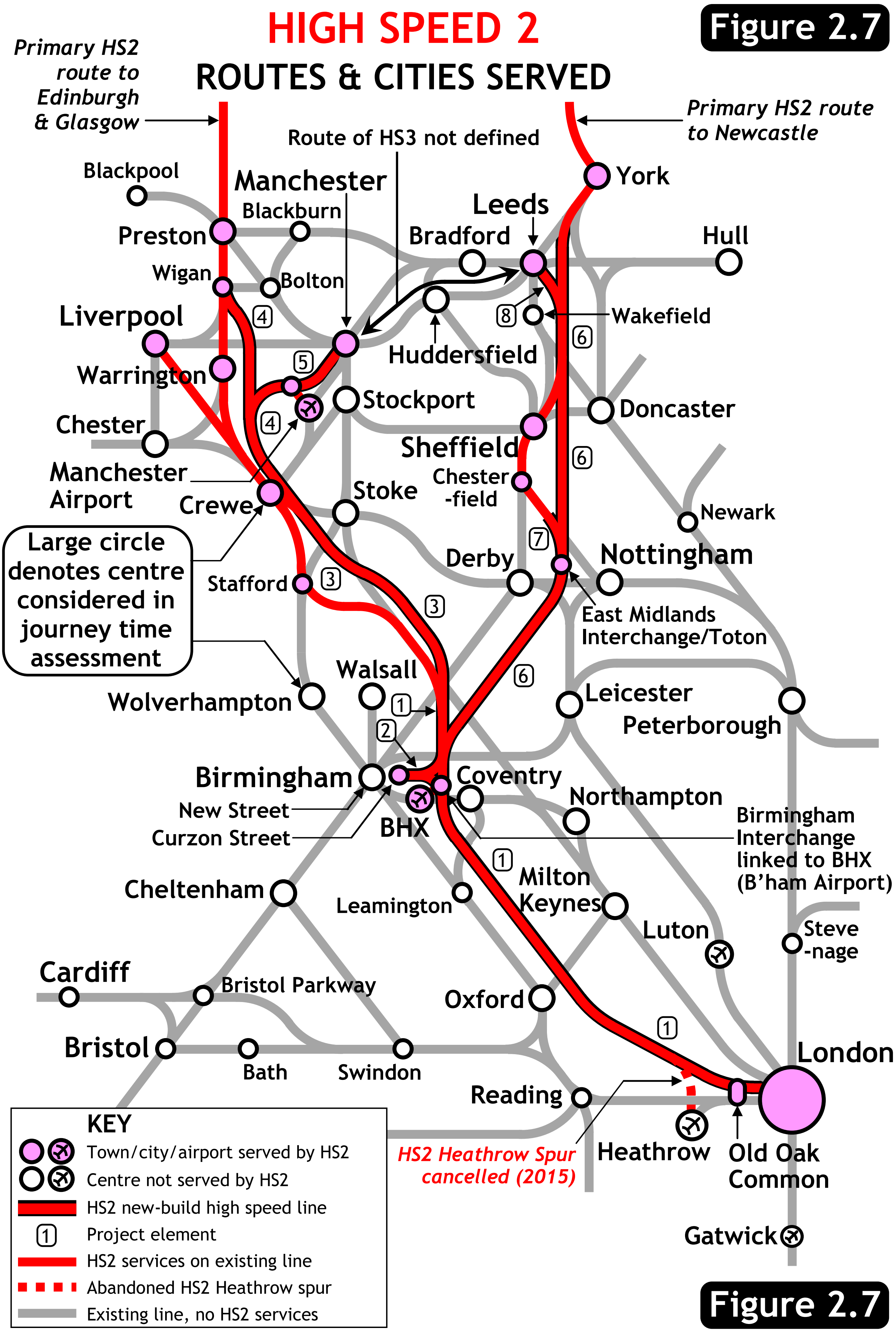
2.9 HS2 : A Brief Overview

The HS2 project was launched in 2009, with an initial remit (see Appendix A5) to develop proposals for a new high speed line from London to the West Midlands. Although the objectives of HS2 have at times been unclear, its fundamental mission is summarised by the following statement, given in evidence to the House of Commons HS2 Select Committee on 30th November 2015 by former HS2 Ltd Technical Director Andrew McNaughton:

> **"The aim of the HS2 project is to deliver hugely enhanced capacity and connectivity between our major conurbations"**

The HS2 proposals considered in this study comprise the following elements:

1. A new line from Euston Station in London via Old Oak Common and Water Orton (near Birmingham) to the West Coast Main Line (WCML) near Lichfield (Phase 1);
2. A spur from Water Orton to Curzon Street station in central Birmingham (Phase 1);
3. A continuation of the HS2 main line to Crewe (Phase 2a);
4. A continuation of the HS2 main line to the West Coast Main Line near Wigan (Phase 2b);
5. A spur to Manchester Piccadilly station (Phase 2b);
6. A new line from Water Orton via Toton to the East Coast Main Line (ECML) near York (Phase 2b);
7. A spur to the Midland Main Line (MML) to access Sheffield (Phase 2b);
8. A spur to Leeds (Phase 2b);
9. New stations at Euston (London), Old Oak Common, Birmingham Interchange, Curzon Street (Birmingham), Crewe, Manchester Airport, Manchester Piccadilly, Toton (aka East Midlands Interchange), Leeds;
10. Connections to the existing network at Handsacre (WCML), Crewe (WCML), Bamfurlong (for Preston and WCML), Alfreton (for Sheffield), Thurnscoe (for Sheffield) and Church Fenton (for York and ECML).



HIGH SPEED 2
ROUTES & CITIES SERVED
Figure 2.7
Primary HS2 route to Edinburgh & Glasgow
Primary HS2 route to Newcastle
Route of HS3 not defined
Blackpool
Preston
Manchester
Blackburn
Wigan
Bolton
Leeds
Bradford
York
Hull
Liverpool
Warrington
Huddersfield
Wakefield
Stockport
Chester
Doncaster
Sheffield
Manchester Airport
Crewe
Stoke
Chester -field
Newark
Large circle denotes centre considered in journey time assessment
Stafford
Derby
Nottingham
East Midlands Interchange/Toton
Walsall
Wolverhampton
Leicester
Peterborough
Birmingham
New Street
Curzon Street
BHX
Coventry
Northampton
Birmingham Interchange linked to BHX (B'ham Airport)
Milton Keynes
Cheltenham
Leamington
Luton
Steve -nage
Cardiff
Bristol Parkway
Oxford
Bristol
Bath
Swindon
London
Reading
Heathrow
Old Oak Common
HS2 Heathrow Spur cancelled (2015)
Gatwick
KEY
Town/city/airport served by HS2
Centre not served by HS2
HS2 new-build high speed line
1 Project element
HS2 services on existing line
Abandoned HS2 Heathrow spur
Existing line, no HS2 services
Figure 2.7

The items listed above – all illustrated in Figure 2.7 – collectively form the HS2 'Y'. Where practicable, HS2's new lines have been designed to operate at 360 km/h (225 MPH), with allowance for a future maximum speed of 400 km/h (250 MPH). At either 360 km/h or 400 km/h, HS2 would be the fastest railway in the world.

It should be noted that plans for a spur from HS2 to Heathrow were abandoned in 2015. This precludes any possibility of direct services from regional cities to Heathrow. Passengers will be compelled instead to change at Old Oak Common onto Heathrow Express services.

As yet, no detailed proposals have emerged for the works necessary to improve links between local communities and HS2's stations which are typically poorly integrated with local rail and other public transport networks.

Projected HS2 journey times are listed in Appendix A2 and projected HS2 services are listed in Appendix A3. With HS2 services generally handling traffic between the primary cities e.g. London to Manchester, London to Birmingham and Manchester to Birmingham, it has been necessary to consider the future of existing intercity services to intermediate cities such as Milton Keynes, Coventry and Stoke. Revisions to existing intercity patterns – generally reductions in service frequency with additional stops and sometimes more circuitous routeing – are also listed in Appendix A3.

Further work on developing proposals for services that might run on the existing network, given the reductions in intercity traffic noted above, has been undertaken by Network Rail. *Better Connections: Options for the integration of High Speed 2*[1] lists 25 potential new services. These services are listed in Appendix A4.

It is believed that the 25 services postulated by Network Rail, which are listed as serving approximately 100 existing stations, form the basis of the claim that 100 stations on the existing rail network will enjoy improved services as a result of the introduction of HS2.

2.10 Consideration of HS3 / Northern Powerhouse Rail

Other than the Leeds-Sheffield connection which can be improved through the intervention of HS2, this study takes makes no attempt to estimate precise journey times for prospective HS3/ Northern Powerhouse links between Northern cities. No detail, in terms of either route, stations or timescale, has yet emerged to define how HS3/Northern Powerhouse Rail will improve east-west transpennine links to a standard equivalent to what is proposed for the improvement of north-south links by means of HS2.

[1] *Better Connections: Options for the integration of High Speed 2*, Network Rail, July 2013.

However a specification[2] for both journey times and train frequency between the major cities of the North has been developed by Transport for the North. This specification is set out in Figure 2.8 below.

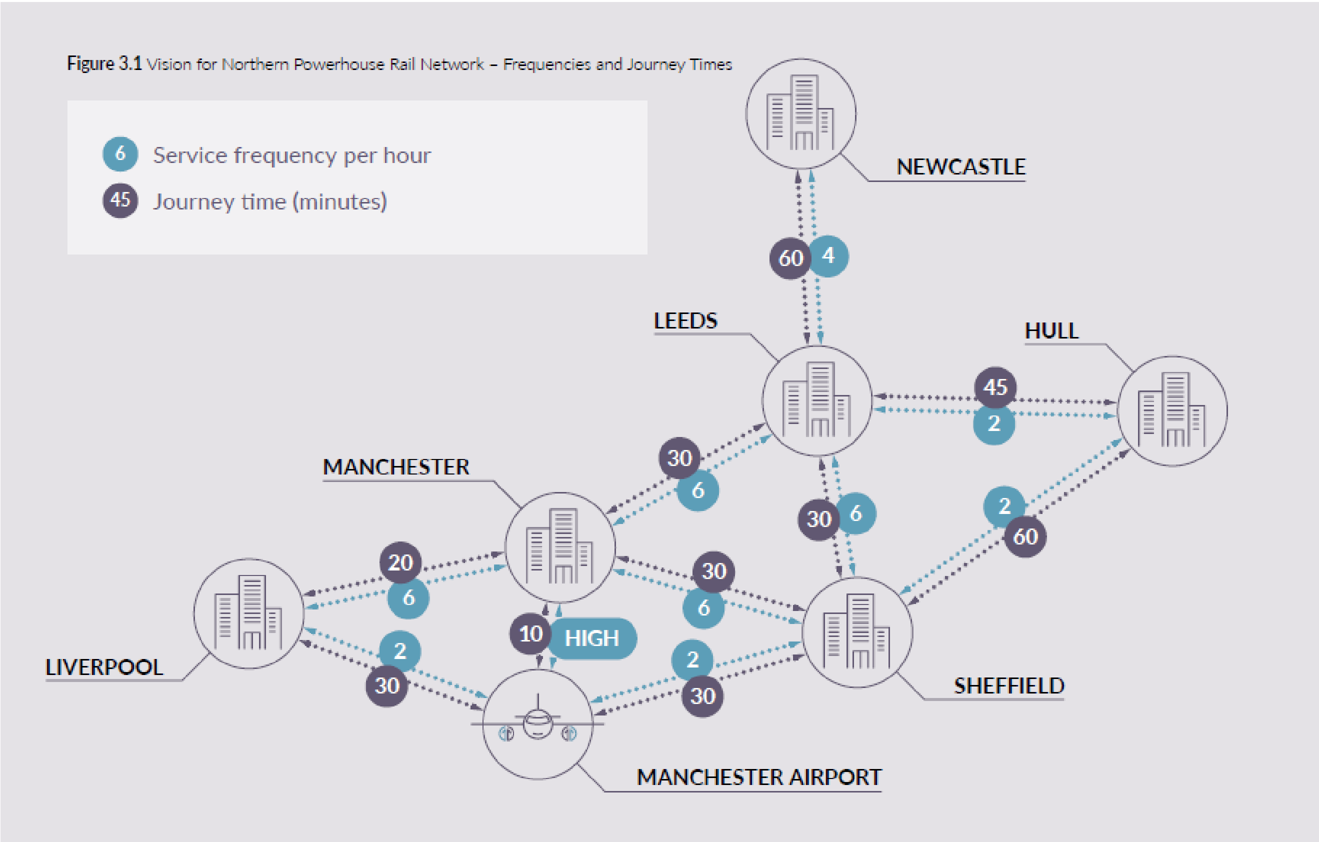


Figure 2.8 : Northern Powerhouse Rail specification for journey time & train frequency (from *The Northern Transport Strategy: Spring 2016 Report,* Transport for the North, 2016)

It should be noted that for the purposes of comparison between HS2 and High Speed UK, the new-build elements of the HS2 'Y' listed in Section 2.9 have an estimated construction cost similar to that required for the building of HSUK's new-build high speed lines and all associated route upgrades and restorations. Whilst the elements of HS2 include no 'HS3' element of transpennine connectivity (as detailed in Figure 2.8), HSUK's estimated cost includes the transpennine link via Woodhead and all other works necessary to interlink the 32 centres considered in the HSUK timetable.

The HS3 works necessary to interlink Liverpool, Manchester, Sheffield and Leeds are estimated to cost a further £14 billion, which has yet to be declared in the bill for HS2.

[2] The requirement for improved links (passenger and freight) between all principal cities of the North, and from these cities to Manchester Airport, was originally set out in *One North : A Proposition for an Interconnected North*, One North, July 2014. Note particularly the route diagram and journey time specification on pages 26 and 27 of the *One North* document. These are replicated in this study in Figures 2.8 and 5.39. The requirements for train frequency have subsequently been developed by Transport for the North.

2.11 High Speed UK : A Brief Overview

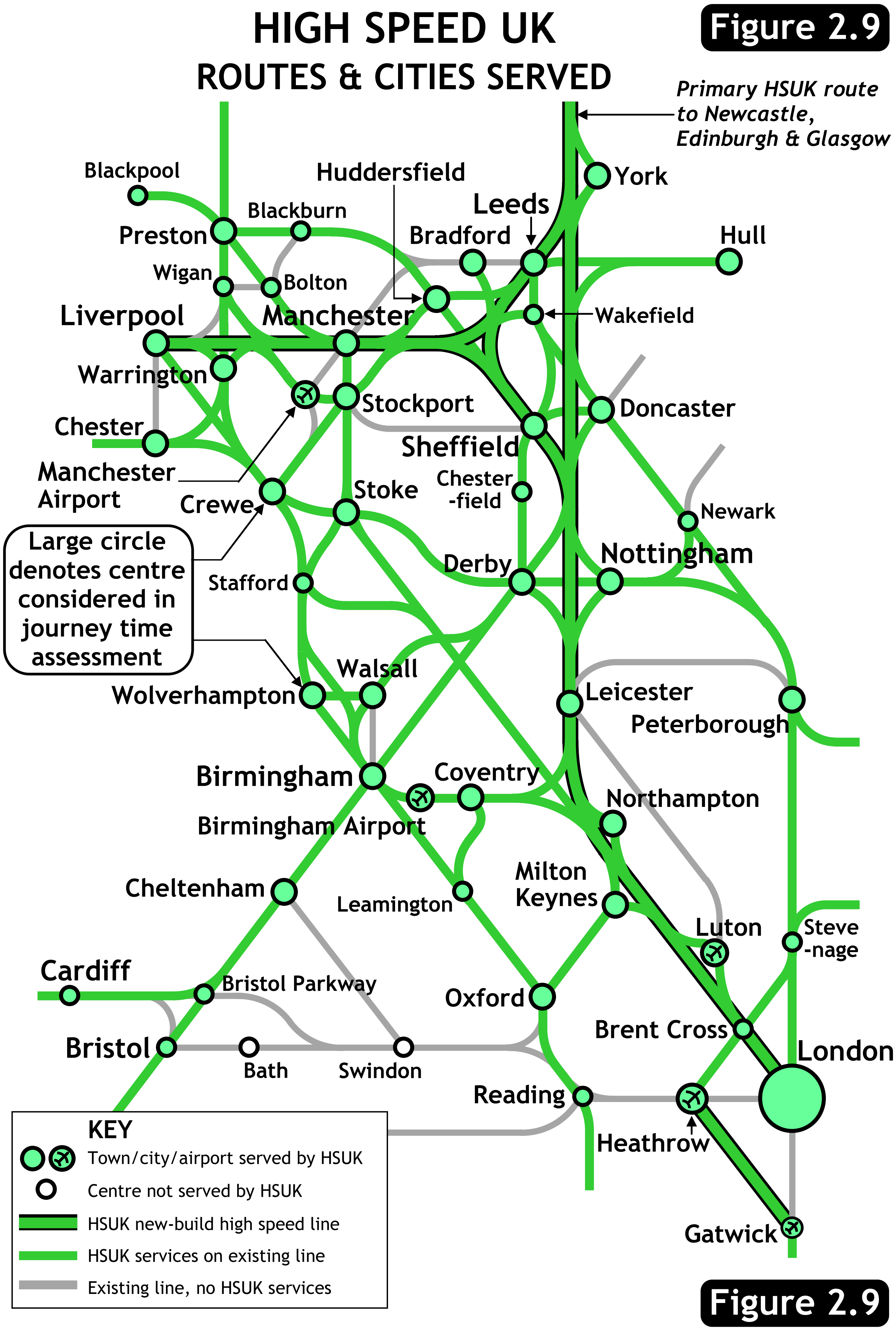
High Speed UK (HSUK) has been designed to a radically different philosophy to that which has driven the development of HS2. Whereas HS2 has been remitted as a stand-alone high speed line, with no stated requirement to perform as a network, HSUK has been designed from the outset to be fully integrated with the existing network with the aim of directly interconnecting all of the UK's many regional centres. The principal routes of the HSUK network are shown in Figure 2.9, and proposed interventions of new high speed line and upgraded or restored routes are shown in Figure 2.10.

In terms of its historical development, HSUK predates HS2, having been launched into the public domain in the summer of 2008 as 'High Speed North'. At the time, High Speed North was supported by the 2M Group of London and South-East Councils opposed to Heathrow expansion, on account of its efficient performance as a UK-wide network of high speed rail lines able to offer radically reduced journey times. This would give High Speed North the potential to attract passengers away from the short-haul flights currently dominating the longer distance intercity travel market, and thereby reduce pressure to expand Heathrow.

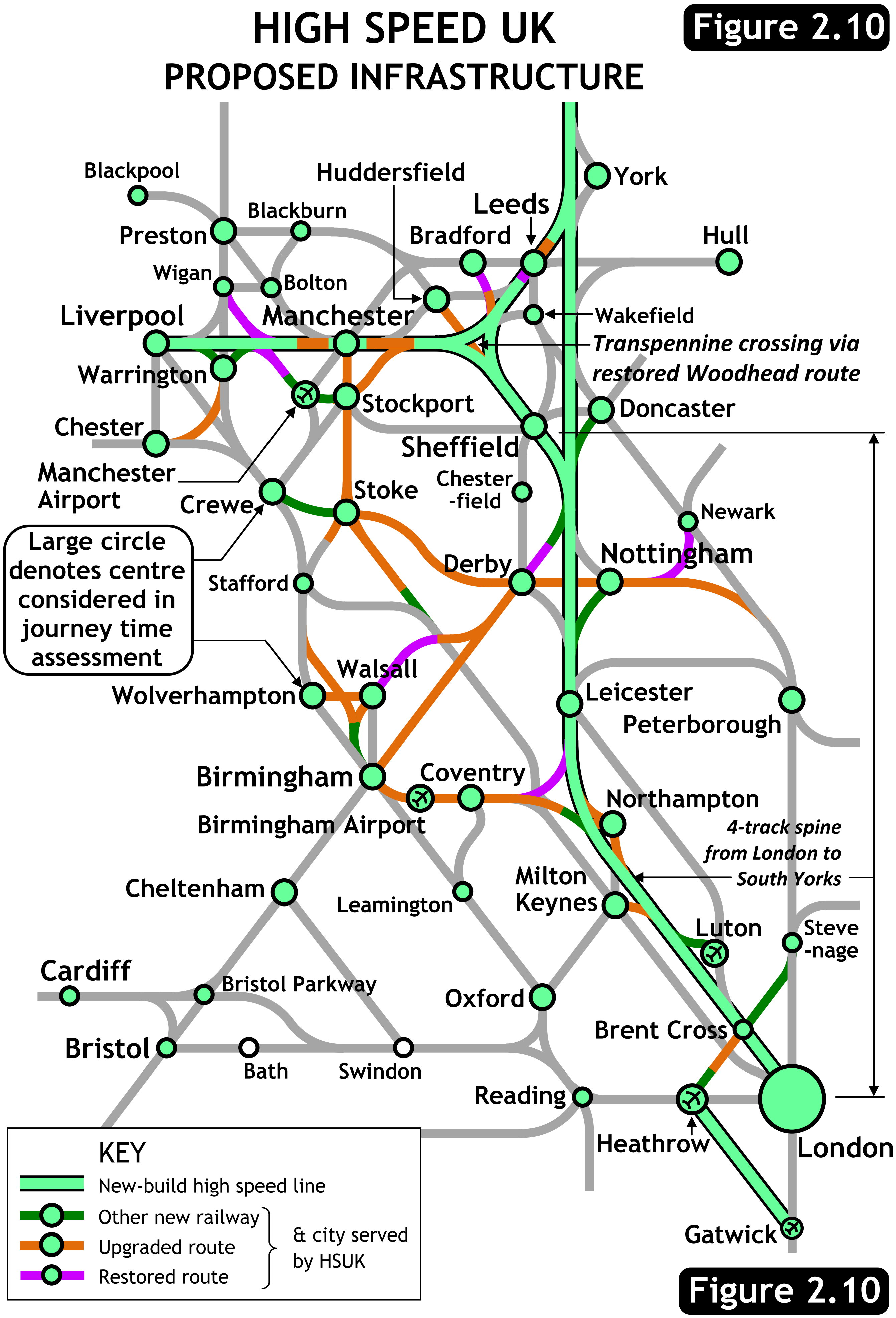
In 2013 High Speed North was relaunched as High Speed UK to reflect its national scope and ambition to create an enhanced intercity network extending across the entire nation.

In terms of geographic coverage, HSUK's proposed interventions of new lines, supplemented with upgrades and restorations of existing routes, are broadly equivalent to those of HS2, extending northwards from Greater London and Heathrow Airport to the West and East Midlands, and to Merseyside, Greater Manchester, South Yorkshire and West Yorkshire. New stations will be provided at Brent Cross, Sheffield Victoria, Manchester Piccadilly and Bradford Central but in all other cities, HSUK will operate from the existing central station served by the present intercity network.

HSUK's new routes have been designed to operate at a maximum speed of 360 km/h, with a generally much lower specification applied for upgraded routes. Route design has been undertaken at 1:25,000 scale, with all straights, transitions and circular curves defined, and with complementary vertical alignments also prepared. HSUK's designs allow detailed comparative costings to be drawn with the HS2 proposals (showing HSUK to cost £21 billion less on a like-for-like comparison) and they also allow the development of a 'demonstrator timetable' of the accelerated intercity services that could operate across the fully integrated HSUK network.



HIGH SPEED UK
ROUTES & CITIES SERVED
Figure 2.9
Primary HSUK route to Newcastle, Edinburgh & Glasgow
Blackpool
Preston
Blackburn
Huddersfield
Leeds
Bradford
York
Hull
Wigan
Bolton
Liverpool
Manchester
Wakefield
Warrington
Stockport
Doncaster
Chester
Sheffield
Manchester Airport
Crewe
Stoke
Chester -field
Newark
Large circle denotes centre considered in journey time assessment
Derby
Nottingham
Stafford
Walsall
Wolverhampton
Leicester
Peterborough
Birmingham
Coventry
Northampton
Birmingham Airport
Milton Keynes
Cheltenham
Leamington
Luton
Steve -nage
Cardiff
Bristol Parkway
Oxford
Brent Cross
Bristol
Bath
Swindon
London
Reading
Heathrow
Gatwick
KEY
Town/city/airport served by HSUK
Centre not served by HSUK
HSUK new-build high speed line
HSUK services on existing line
Existing line, no HSUK services
Figure 2.9


HIGH SPEED UK
PROPOSED INFRASTRUCTURE
Figure 2.10
Blackpool
Huddersfield
York
Leeds
Blackburn
Preston
Bradford
Hull
Wigan
Bolton
Liverpool
Manchester
Wakefield
Transpennine crossing via restored Woodhead route
Warrington
Stockport
Doncaster
Chester
Sheffield
Manchester Airport
Crewe
Stoke
Chester -field
Newark
Large circle denotes centre considered in journey time assessment
Nottingham
Derby
Stafford
Walsall
Wolverhampton
Leicester
Peterborough
Birmingham
Coventry
Northampton
Birmingham Airport
4-track spine from London to South Yorks
Milton Keynes
Cheltenham
Leamington
Luton
Steve -nage
Cardiff
Bristol Parkway
Oxford
Brent Cross
Bristol
Bath
Swindon
Reading
Heathrow
London
Gatwick
KEY
New-build high speed line
Other new railway
Upgraded route
Restored route
& city served by HSUK
Figure 2.10

The HSUK timetable – which is summarised in the proposed services listed in Appendix A1 – demonstrates the following:

- the improved journey times that can be achieved across the network;
- the opportunity for new intercity and airport services;
- the capacity requirements for this new network;
- the feasibility and benefits of full integration between new lines and existing network.

HSUK's route extending northwards from Yorkshire to the North-East and to Scotland is also fully defined to the same standards (1:25,000 scale horizontal alignment and complementary vertical alignment) as the design for its routes from London to the Midlands and the North. It is intended to extend the HSUK design to the enhancement of routes from London and the West Midlands to South Wales and the West Country, to create a truly national high speed network.

More detail of the HSUK proposals, including regional integration strategies, complementary freight strategy and detailed mapping setting out all proposed new build, upgrade and restoration interventions necessary to comprise a fully integrated national network, can be found on www.highspeeduk.co.uk.

2.12 The Network Imperative

If the UK high speed rail project is to fulfil its mission statement of **"hugely enhanced capacity and connectivity"** between the UK's major conurbations, it is clear, from any consideration of balance and inclusivity, that these improvements must be achieved between all conurbations, and indeed between all the principal cities that these conurbations represent.

Considered on the basis of the UK's 12 primary cities/conurbations and their links to the nation's principal international gateway at Heathrow (see Item 2.5.1), 78 connections between these 13 centres must be assessed, and developed to the common "hugely enhanced" standard. Considered on the basis of the 32 centres on which this study's Quantified Journey Time Assessment is based, there are 496 journeys that must be assessed, and developed as necessary.

It is immediately apparent that the intervention of one or even two high speed lines (as the HS2 'Y' might be characterised) is not capable of achieving the widespread and comprehensive improvements demanded by the project's mission statement. These improvements can only practicably be achieved if the new lines can be fully integrated with, and physically connected to, the existing rail system, to form an enhanced national network capable of meeting the needs of all major communities.

If the logical aim of the UK high speed rail project is an enhanced national railway network, it is equally logical to expect that the network as a whole must be designed to a balanced and rigorous specification to achieve this aim. Yet any such aim or even ambition is conspicuous by its absence in the HS2 project. This can be seen clearly from the briefest review of the HS2 remit (see Appendix A5), and overall there is no evidence that HS2 Ltd has undertaken any process to design HS2 to optimise the connectivity and capacity of the national railway network.

HS2 Ltd's near-exclusive focus on issues of 'line' rather than 'network' is essentially an extension of the historic transport planners' approach by which a specific transport corridor targeted for improvement would be rigorously studied to enable the necessary enhancements to be optimally designed. Typically, limited budgets have dictated that these enhancements comprise no more than upgrades of existing routes, and even the largest projects such as the West Coast Route Modernisation (1998-2008) have had little effect on the performance of the overall national rail system, and no effect on its fundamental shape.

However, for a new-build project of HS2's nationwide scope, the transport planners' corridor-specific approach is no longer appropriate. Every aspect of HS2's design – its route, the location of its stations and its provision of connections to the existing network – will have far-reaching effects upon how the overall national rail system will perform. Yet it would appear that HS2 Ltd has not considered any of the 'externalities' of wider network performance, and there is a self-evident risk that in the absence of this consideration, HS2 may actually have the effect of degrading overall network performance.

In any responsible and competent process of network design, the intervention of the new high speed line must be combined with parallel interventions of upgrades of existing routes and restorations of abandoned routes to bring about the greatest possible enhancement of overall network performance. This process should not consider merely the highest-volume, most profitable intercity flows that the transport planners have historically favoured. In the more holistic and engineered 'network design' approach, in which the integrity and the performance of the network are the most important factors, all possible connections should be considered, regardless of the magnitude of individual city-to-city flows.

This network design approach is based upon the simple axiom, that "the whole should be greater than the sum of the parts". This accords strongly with public policy considerations of inclusivity and regional rebalancing. One of this study's primary aims is to demonstrate that this axiom of holistic thinking also holds true in the world of high speed rail and intercity transport.

3 Methodology of Study

3.1 Definition of Station Locations

For the Quantified Journey Time Assessment (involving 32 centres) all intercity journey times for either the **Existing Network**, **HS2** or **HSUK** scenarios (see Section 2.8) are measured to primary city centre stations. In the majority of cities there is a single unambiguous location (e.g. York Station in York or Doncaster Station in Doncaster) but where multiple stations exist the 'primary' station is as listed in Table 3.1:

Location	*Primary Station*
Birmingham	Birmingham New Street station (**Existing** & **HSUK**) Birmingham Curzon Street station (**HS2**)
Birmingham Airport	Birmingham International station (**Existing**, **HS2** & **HSUK**) – *extra 8 minute allowance is made for shuttle connections to Birmingham International from HS2's Birmingham Interchange station*
Bradford	Bradford Interchange station (**Existing** & **HS2**) Bradford Central station (**HSUK**) – *through station located adjacent to present Bradford Interchange terminus*
Crewe	Crewe station (**Existing** & **HSUK**); Crewe Hub station (**HS2**)
Derby	Derby Midland station (**Existing**, **HS2** & **HSUK**) – *HS2's East Midlands Interchange at Toton (14km from Derby) is not accepted as an intercity station for Derby; a 15 minute journey time from Derby to Toton plus times for transfer to HS2 at Toton are allowed in all journeys to Derby via HS2.*
Heathrow	Terminal 5 station, Heathrow Express system (**Existing**, **HS2** & **HSUK**)
Leeds	Leeds City station (**Existing**, **HS2** & **HSUK**) – *extra 5 minute allowance is made for transfer from HS2 terminus platforms to remainder of station.*
Liverpool	Liverpool Lime Street station (**Existing**, **HS2** & **HSUK**)
London	Variously Kings Cross, St Pancras, Euston or Paddington, dependent upon regional city under consideration (**Existing**) Euston Station (**HS2** & **HSUK**)
Luton	Luton Airport Parkway (**Existing**, **HS2** & **HSUK**)
Manchester	Manchester Piccadilly or Manchester Victoria station (**Existing**), Manchester Piccadilly (**HS2** & **HSUK**)
Manchester Airport	Manchester Airport station (**Existing**, **HS2** & **HSUK**) – *An extra transfer time of 8 minutes is applied for journeys routed via HS2's Manchester Airport station.*
Nottingham	Nottingham Midland station (**Existing**, **HS2** & **HSUK**) – *HS2's East Midlands Interchange at Toton (9km from Nottingham) is not accepted as an intercity station for Nottingham; a 12 minute journey time from Nottingham to Toton plus times for transfer to HS2 at Toton are allowed in all journeys to Nottingham via HS2.*
Sheffield	Sheffield Midland station (**Existing** & **HS2**) Sheffield Victoria station (or Sheffield Midland for certain HSUK journeys continuing to operate via existing route) (**HSUK**)
Warrington	Warrington Bank Quay or Warrington Central (**Existing** & **HSUK**) Warrington Bank Quay station (**HS2**)

Table 3.1 : Definitions of Station Locations for Quantified Journey Time Assessment

For the 13-centre and 21-centre Direct Connectivity Assessments the definitions in Table 3.1 also apply for stations in Birmingham, Derby, Heathrow, Leeds, Liverpool, Manchester, Nottingham and Sheffield. Table 3.2 below also lists assumed station locations for Bristol, Cardiff, Darlington, Newcastle, Edinburgh and Glasgow.

Location	*Primary Station*
Bristol	Bristol Temple Meads (**Existing**, **HS2** & **HSUK**)
Cardiff	Cardiff Central (**Existing**, **HS2** & **HSUK**)
Darlington	Darlington station (**Existing**, **HS2** & **HSUK**)
Edinburgh	Edinburgh Waverley (**Existing**, **HS2** & **HSUK**)
Glasgow	Glasgow Central (**Existing**, **HS2** & **HSUK**)
Newcastle	Newcastle Central (**Existing**, **HS2**) Platforms on new Northumbria Bridge with travelator connection to adjacent Newcastle Central (**HSUK**)

Table 3.2 : Additional Stations considered in Direct Connectivity Assessment

3.2 Direct Connectivity Assessment

The following commentary relates to the Direct Connectivity Assessment undertaken upon 210 journeys between the 21 centres within the HS2 'Zone of Influence', as described in Item 2.4.1. Exactly the same methodology is applied in the Direct Connectivity Assessment undertaken upon 78 journeys between the 12 primary cities/major conurbations plus Heathrow Airport that are described in Item 2.4.2.

3.2.1 Direct Intercity Links achieved by Existing Network

All of the 210 journeys between the 21 centres covered in the Direct Connectivity Assessment – see Figure 2.1 – are reviewed on the National Rail website www.nationalrail.co.uk to determine whether they can be classified as a 'direct intercity link'. In general, journeys are classified as such if they operate at hourly or better frequency, regardless of the quality of rolling stock employed on that journey.

The only exceptions to this general rule are interregional journeys along the West Coast Main Line, from Manchester to Edinburgh or Glasgow, and from Milton Keynes/Birmingham/ Wolverhampton to Edinburgh or Glasgow. All these services operate at hourly frequency but – due to the split in the West Coast Main Line at Carstairs – they can only offer 2-hourly frequencies to Edinburgh or Glasgow. These services are accepted as 'direct intercity links' to simplify comparisons with HS2, which also can only offer 2-hourly frequency on journeys to Scotland from any originating point other than London.

3.2.2 Direct Intercity Links achieved by HS2

HS2's journeys between the same 21 centres are assessed in a similar manner, using data taken from *High Speed Two: Strategic Outline Business Case – Economic Case*[3] covering Phase 2 of HS2, published in November 2016. This data identifies most of the proposed direct HS2 services, either 'captive' or classic compatible. Data for HS2's London-Birmingham service is taken from *HS2 Regional Economic Impacts*[4], published in September 2013.

Data on proposed HS2 services is included in Appendices A2 and A3.

HS2 interregional services operating at 2-hourly frequency from Birmingham to Edinburgh/ Glasgow are classified as 'direct intercity links', to match the classification applied to the existing network. A similar 2-hourly service from Manchester to Edinburgh/Glasgow has also been assumed.

The HS2 data is combined with data relating to the existing network – duly modified to reflect service reductions proposed by HS2 Ltd in *HS2 Regional Economic Impacts* – to provide an assessment of overall network connectivity, with HS2 in place. All journeys deemed to be made worse by HS2, according to the criteria set out in Item 3.3.4, are highlighted.

3.2.3 Direct Intercity Links achieved by HSUK

Data on the direct journeys offered by HSUK is derived from the HSUK timetable, and the train service patterns are summarised in Appendix A1. All these services are planned to operate at hourly frequency (to give much greater frequency between many close-spaced pairs of cities) and thus, for the purposes of this study, qualify as 'direct intercity links'.

The HSUK data is combined with data relating to the existing network in the 2 instances (out of 210) where HSUK offers no service.

3.3 Quantified Journey Time Assessment

3.3.1 Derivation of Existing Journey Times

Existing journey times, for all of the 496 journeys between 32 centres covered in the Quantified Journey Time Assessment – see Figure 2.6 – are taken from the National Rail website www.nationalrail.co.uk. The number of changes of train necessary to complete each journey is also recorded. Data is taken for a weekday, at around 11h00. Where more than one journey is offered within a single hour, the shortest journey time is recorded.

[3] *High Speed Two: Strategic Outline Business Case – Economic Case*, DfT, 2016
[4] Table 23, pp91-92, *HS2 Regional Economic Impacts*, HS2 Ltd, September 2013

3.3.2 Calculation of HS2 Journey Times

HS2 journey times and train services are primarily taken from the DfT Command Paper[5] covering Phase 2 of HS2 and from supporting reports[6], all published in November 2016. This data identifies all proposed direct HS2 services, either 'captive' or 'classic compatible', and lists their journey times. Where necessary, other sources[7] are consulted. See Appendices A2 and A3. All of HS2's direct journeys are invariably quicker than those offered by the existing network.

Although HS2's stations are typically poorly located with respect to proximity to city centres, or connection with existing local services, it is still possible in certain instances to show that the introduction of HS2 will bring substantial journey time savings between city centre stations. These journey times are calculated by means of the following generic sum:

- Journey time by HS2; plus...
- Journey time by Network Rail local service; plus...
- Time to transfer between platforms; plus...
- Half of interval between local services (e.g. an allowance of 7.5 minutes is made for a service operating at 15 minute frequency).

This methodology assumes that HS2 services at an HS2 station such as the proposed East Midlands Interchange will be reasonably frequent, but not conforming to any regular interval pattern when both northbound and southbound directions arrivals are considered. It will therefore not be practicable to arrange the timetabling of local services to precisely coincide with the arrival (or departure) of HS2 services. Instead, local services will depart at regular 'clockface' intervals, for example at 15 minute frequency.

In the calculation it is assumed that on average, an HS2 service will arrive halfway through the service interval. This allows for the two extreme eventualities of a train arriving either just in time to make the connection (in which case none of the 'service interval' allowance would be required), or arriving just too late to make the connection (in which case the passenger would be forced to wait for the full service interval).

Where HS2 will bring no advantage to the journey, no HS2 journey time is recorded and instead the existing journey time and the relevant number of changes are recorded.

3.3.3 Consideration of Luton

It should be noted that Luton is effectively excluded from the detailed assessment of HS2's connectivity, with a null 'no improvement' result recorded for every journey. This is compelled by the routeing of most intercity journeys to Luton via central London, a situation

[5] Command Paper *High Speed Two: from Crewe to Manchester, the West Midlands to Leeds and beyond*, DfT, 2016
[6] *High Speed Two: Strategic Outline Business Case – Economic Case*, DfT, 2016
[7] Table 23, pp91-92, *HS2 Regional Economic Impacts*, HS2 Ltd, September 2013
. *HS2 – Building a Connected Britain* Article by Andrew McNaughton in European Rail Review, 2013

which will be replicated by HS2. Hence any 'improved' journey from a regional city to London would automatically translate into an improved journey to Luton.

Luton's near complete dependency upon London for its intercity connectivity is entirely inappropriate for a major community of over a quarter of a million population, located on the nation's primary 'M1' transport corridor. HS2 Ltd's failure to address this deficiency is totally at odds with the stated aim of the HS2 project, to deliver **"hugely enhanced capacity and connectivity"** between the UK's principal towns and cities. For this reason, no accelerated HS2 journey times have been recorded for Luton. By the same token, no journeys to Midland Main Line destinations have been recorded as 'made worse' by HS2 due to withdrawal of intercity services as noted in Item 3.3.4 below.

Despite these difficulties in undertaking a meaningful qualitative connectivity assessment for Luton, it is still possible to make qualitative comparisons between the outcomes that HS2 and HSUK deliver for Luton.

3.3.4 Journeys 'made worse' by HS2 intervention

It must be emphasised that many existing intercity journeys will be made worse by the intervention of HS2[8]. This typically occurs where the introduction of HS2 – for instance between London and Birmingham – will abstract a large proportion of those passengers currently travelling by the existing 'classic' West Coast services which run via Coventry. With fewer passengers from Coventry and other intermediate calling points to support the current 3 trains per hour service, it is proposed to reduce Coventry's intercity services to a single train per hour.

Predicted reductions of intercity service levels on existing main lines, together with proposed HS2 services, are given in the 2013 report *HS2 Regional Economic Impacts* (see Appendix A2). Although these predictions are not repeated in the latest HS2 Ltd documentation published in November 2016 in support of the HS2 Phase 2 scheme, it must be noted that:

- The proposed HS2 services listed alongside the predicted intercity service reductions are broadly similar to the currently proposed HS2 service patterns. Therefore it seems reasonable to assume that the predicted service reductions will also not have changed significantly since 2013.
- The predicted service reductions are entirely consistent with the transfer of 'primary city to primary city' traffic to HS2, and the requirement to create more capacity for improved commuter services on the West Coast Main Line entering London.

These service reductions primarily cover the axes of the West Coast Main Line, Midland Main Line and East Coast Main Line; here, journey times will remain broadly similar to what currently applies, but service frequency will be significantly reduced.

[8] Predicted reductions of intercity service levels on existing main lines, together with proposed HS2 services, are given in Table 23 on pages 91-92 of *HS2 Regional Economic Impacts*, published by HS2 Ltd, September 2013.

In the case of the CrossCountry Main Line, services from Sheffield to Derby will be diverted from the main line via Ambergate, and instead routed via the more circuitous and slower Erewash Valley route in order to serve the new HS2 East Midlands Interchange at Toton. With new local stops and the necessary reversal at Derby also taken into account, journey times are likely to increase by around 25 minutes. This will adversely affect every journey from Yorkshire and the North-East to Derby, Birmingham New Street and onward destinations including South Wales, the West Country and the South Coast.

Projected HS2 services to Birmingham will not remedy the connectivity that will be lost through the diversion of CrossCountry services via Toton. These HS2 services will not arrive at New Street, but instead at the proposed HS2 terminus at Curzon Street. They will be of no assistance to passengers who would have to make the 10 minute walking connection to continue their journeys from New Street.

A journey is deemed to have been 'made worse' in any of the 3 cases listed below:

- intercity journeys operating at reduced frequencies;
- journeys made significantly longer by the imposition of circuitous routeing;
- a new walking connection required.

Generally, the addition of up to 2 stops to an existing intercity service which remains on its established route is not counted as a journey 'made worse'.

All journeys 'made worse' by the intervention of HS2 are noted on the relevant journey time charts. So far no attempt has been made to quantify the adverse impact on journey times, and in the comparative analysis presented in this paper, the existing journey time and number of changes of train are conservatively assumed to continue to apply.

3.3.5 Calculation of High Speed UK Journey Times

All HSUK journey times are derived from a 'demonstrator timetable' which has been developed as an integral part of the HSUK design, through the following process:

- HSUK route designs have been prepared for all sections of new build, upgraded and restored railway. This includes detailed horizontal alignments at 1:25,000 scale with straights, transitions and circular curves all identified, plus complementary vertical alignments.
- The HSUK design has established 'route geography' ie longitudinal chainage[9] and speed profile for the full extent of the HSUK network. Where necessary additional data has been taken from the Network Rail Sectional Appendix.
- Published train performance data for the Alstom AV360 train has been reviewed and incorporated in the HSUK models. This data gives acceleration and deceleration performance throughout the speed range ie 0 km/h to 360 km/h.

[9] The term 'longitudinal chainage' means a distance measured along the sinuous line of route from a fixed datum which is generally a junction or a station. It is not a direct 'as the crow flies' distance.

- Using this route geography and train performance data, 'start-to-stop' timings between stations have been calculated.
- Using the calculated timings, with due allowance for dwell times[10] at intermediate stations, a schedule for an entire multi-stop train service has been created.
- The methodology to calculate these timings, including assumed rates of acceleration and deceleration, has been verified against published HS2 intercity timings and route data (i.e. longitudinal chainage and speed profile).
- Train service patterns have been developed along new/upgraded/restored/existing routes, with the primary aim of maximising interconnectivity between UK regional population centres.
- The train service patterns have been compiled and co-ordinated in a 'demonstrator timetable' covering al proposed HSUK services.
- Data has been extracted from the demonstrator timetable to give timings between all 32 centres considered in this study. Where journeys are not direct, the number of changes of trains has also been recorded.
- Where HSUK will bring no advantage to the journey, no HSUK journey time has been recorded and instead the existing journey time and the relevant number of changes have been recorded.

Proposed HSUK services and journey times are listed in Appendix A1. These new service patterns have been designed with the specific purpose of improving the national intercity network, with no intercity connections made worse. Effectively they supersede all existing intercity services along East Coast, Midland, West Coast, CrossCountry and TransPennine main lines.

3.3.6 Comparison of HS2, HSUK & Existing Network Journey Times

In the comparison between journey times offered by HS2, HSUK and the existing network, it is necessary also to take account of the number of changes of train necessary to complete the journey, and to apply a 'time penalty' for each change of trains. This reflects the strong preference on the part of passengers for direct journeys, without the inconvenience and uncertainty of changing trains.

The elimination wherever practicable of changes of trains should be a driving consideration in the design and development of the UK rail network. A national network in which all major regional centres are directly linked by trains of 'intercity quality' is clearly more conducive to the development of balanced and well-connected regional economies than one in which interregional journeys often require several changes of train, and high quality direct intercity services are typically only provided towards London. Such a network would also be more commercially viable, more capable of attracting passengers from road transport, and

[10] 'Dwell time' is the period that a train remains stationary at a station platform, between its arrival and its departure.

consequently more capable of bringing about major reductions in transport CO_2 emissions through step-change road-to-rail modal shift.

Generally, a **20 minute** 'penalty' is applied for each change of trains. This penalty is additional to the actual journey time, including the time spent waiting at a station between the passenger's arrival on one train and the passenger's departure on another.

In 3 specific cases, an enhanced **30 minute** 'penalty' is applied:

- **Case 1 – Change introduced through degradation of existing direct intercity link**. A prime example is the direct intercity link between Leeds and Derby, currently provided by an hourly CrossCountry service. As noted previously, this service will be diverted via the new HS2 East Midlands Interchange at Toton, with around 25 minutes added to journey times. As a result, the quickest route from Leeds to Derby would be via HS2, with a change of trains at Toton.
- **Case 2 – Change introduced through withdrawal of existing direct intercity link**. A prime example is the direct intercity link between London and Chester, currently provided by an hourly Virgin West Coast service. This direct service will no longer operate with HS2 in place, and instead passengers will be forced instead to change trains from a local service to an HS2 service at Crewe Hub.
- **Case 3 – Shuttle Transfer between Birmingham Interchange and Birmingham International** Under HS2 proposals, passengers will transfer between HS2 trunk services to Birmingham Interchange and local services from Birmingham International, by means of a 2.5km long shuttle connection. In simplistic terms, this transfer will involve 2 changes of train at separate stations, requiring a total penalty of 40 minutes. However, it is assumed that the shuttle transfer would be high frequency and relatively 'seamless'. Accordingly, a 30 minute penalty is applied to the entire transfer between HS2 services at Birmingham Interchange and local or intercity services at Birmingham International.

3.3.7 Calculation of Average Journey Time Reductions

For every individual HSUK and HS2 journey time, an acceleration factor can be calculated as follows:

$$\text{Acceleration Factor (AF)} = \frac{\text{Existing Journey Time}}{\text{HSUK (or HS2) Journey Time}}$$

Where no journey time reduction is achieved, the Acceleration Factor would be 1.00 (unity). This would include HS2 journeys deemed to be 'made worse' – see Item 3.3.4. In all other cases, a journey time reduced by HSUK or HS2 would result in an Acceleration Factor of greater than 1.00.

To determine the average Acceleration Factor for each of the 32 centres considered in the Quantified Journey Time Assessment, Acceleration Factors for each of the 31 journeys to the other 31 centres (or 30 journeys in the case, noting the exclusion of Luton – see Item 3.3.3) would be summated, and divided by the number of journeys (ie N = 31):

$$\text{Average Acceleration Factor (AAF)} = \frac{\sum(AF)}{N}$$

The Average Acceleration Factor is then transformed into an overall Journey Time Reduction score for each town, city or airport by the following calculation:

$$\text{Journey Time Reduction (JTR)} = \frac{(AAF-1)}{AAF} \times 100\%$$

In this calculation, no weighting is applied to any of the individual Acceleration Factors from which each centre's overall Journey Time Reduction score is developed. This accords with the holistic principle adopted in this study, that in a balanced intercity network designed to optimise connectivity between regional communities, all journeys should be accorded equal significance.

3.3.8 Consideration of 'Volume Weighting'

It is instructive also to consider the effects of applying 'volume weighting' in the calculation of overall Journey Time Reductions. This volume weighting would reflect the unarguable fact that flows between (say) Birmingham and London are far greater than between (say) Birmingham and Bradford. However, there is a clear risk that in according greater significance to the higher volume flows on the established high-quality Birmingham-London route (served by frequent and direct intercity trains), the greater need for improvements on the lower-quality Birmingham-Bradford route (served by less frequent, lower quality trains, and requiring a change at Leeds) might well be neglected.

Introduction of volume weighting as an additional consideration also introduces massive additional uncertainties. No reliable and comprehensive data exists for passenger flows on all of the 496 journeys between the 32 towns, cities and airports considered in this study's Quantified Journey Time Assessment. Moreover, even if such data did exist, it would be heavily conditioned by several factors:

- A general London-centric bias in intercity flows, reflecting the existing economic disparities between London and the UK regions.
- The difficulty (or in certain cases the near-impossibility) of accomplishing certain intercity journeys by rail, owing to the deficiencies of the existing network.
- The need to consider all other transport modes, including private car, coach and domestic aviation.
- The potential on any of the 496 journeys for modal shift to rail, given the improvements achieved by HSUK or HS2.

In the absence of more definitive and reliable data, intercity flows on all 496 journeys have been calculated by a simple 'gravitational' model, considering the following factors:

- Populations (P_A and P_B) of the two centres connected[11].
- The distance between the two centres (S_{AB})[12].

The flow between any 2 centres A and B is calculated as follows:

$$Q_{AB} = \frac{P_A \times P_B}{S_{AB}}$$

These flows are then used as the weighting factors in the following calculation:

$$\text{Weighted Average Acceleration Factor (WAAF)} = \frac{\sum(AF \times Q)}{\sum(Q)}$$

The Weighted Average Acceleration Factor is then transformed into an overall Journey Time Reduction score for each town, city or airport by the following calculation:

$$\text{Weighted Journey Time Reduction (WJTR)} = \frac{(WAAF-1)}{WAAF} \times 100\%$$

[11] City populations are generally as given in Appendices B1-Y1, with some adjustment of the figures for Birmingham, Manchester and Leeds to reflect the city's immediate hinterland rather than the entire conurbation. Heathrow Airport has been allocated a nominal 600,000 population in accordance with accepted transport planning practice, and 'populations' of Birmingham and Manchester Airports have been scaled using the relative passenger figures also noted in Appendices B2, H1 and M2.

[12] The procedure for calculating distances is described in Item 3.4. Notwithstanding the 'gravitational' nature of the model, the 2-dimensional nature of transport on the Earth's surface, as opposed to the 3-dimensional nature of interplanetary space, dictates that distances are considered as 'inverse linear' rather than 'inverse squared'.

3.4 Calculation of Average Journey Speeds

To enable a more accurate comparison of the connectivity enjoyed by different cities, than would be possible through simply comparing journey times, an average journey speed is calculated for each of the 32 centres considered in the Quantified Journey Time Assessment.

To calculate the speed, the distance between any 2 cities is divided by the time taken to complete the journey between these 2 cities. In this comparison, the journey time includes the appropriate 'penalty' (as described in the preceding sections) applied for every change of trains. Straight-line distances between all the 32 towns, cities and airports considered in this study are calculated by simple coordinate geometry, using the Ordnance Survey grid co-ordinates of the existing central station, as noted in Table 3.1.

The average speed across all 31 possible journeys is calculated as a mean average rather than a median average.

3.5 Calculation of Intercity Connectivity Index

An 'Intercity Connectivity Index' (ICCI) has also been developed to provide an alternative indicator of connectivity for each of the 32 centres considered in the Quantified Journey Time Assessment. The ICCI takes account of the availability of direct intercity links, and the quality of the trains providing these links. It assesses the total 'service offer' i.e. both existing network and high speed services provided by HS2 and HSUK.

The ICCI is calculated by considering only the direct connections available from each centre. A score from 1 to 5 is allocated for each direct connection in respect of the quality of rolling stock, as listed in Table 3.3. The addition of all individual scores gives the overall Intercity Connectivity Index for each town or city.

Score	**Rolling stock type** *(note DMU=diesel multiple unit, EMU=electric multiple unit)*
1	1980s vintage Class 141/142 'Pacer' units or single car DMUs
2	1980s vintage Class 150/155/156/158 'Sprinter' DMUs
3	Voyager CrossCountry units, Class 185 DMUs & other modern DMUs/EMUs
4	WCML Pendolinos, MML Meridian units, ECML '225' and HSTs
5	Modern high speed trains on either HS2 or HSUK systems

Table 3.3 : Scoring of Rolling Stock for Intercity Connectivity Index

The Intercity Connectivity Index is an empirical and somewhat arbitrary measure. However, it is a fair representation of the preference of intercity passengers to travel on trains formed of high quality rolling stock suitable for long distance city-to-city journeys, without the inconvenience of changing trains at intermediate stations.

3.6 Qualitative Capacity Assessment

The ambition of HS2 Ltd for **"hugely enhanced capacity and connectivity"** between the UK's major conurbations is only achievable if step-change capacity improvements can be implemented in most if not all areas of critical network congestion. For the purposes of this study, the following congestion zones have been defined (see Figure 2.1).

- Central Belt of Scotland (Zone C1), *between Edinburgh and Glasgow.*
- West Yorkshire (Zone C2), *focussed upon Leeds station.*
- Transpennine lines (Zone C3), *between Manchester and Leeds/Sheffield.*
- Greater Manchester (Zone C4), *focussed upon Manchester Piccadilly.*
- West Midlands (Zone C5), *focussed upon Birmingham New Street.*
- West Coast Main Line (Zone C6), *between London and Rugby (where main lines to Birmingham and Manchester/Liverpool/Glasgow divide).*
- Greater London (Zone C7), *all quadrants.*
- Great Western Main Line (Zone C8), *including Severn Tunnel.*

For all these zones, a qualitative assessment has been undertaken of how the respective interventions of HS2 and of HSUK will improve capacity. This assessment takes into account:

- proposed physical interventions of new and/or upgraded/restored routes;
- proposed new station locations;
- proposed service patterns for HS2 and HSUK;
- effects upon the existing network and locations of most critical congestion.

The results of these Qualitative Capacity Assessments are presented in Section 5.4.

3.7 Presentation of Results

Detailed connectivity assessments are presented in Appendices B1 (Birmingham) to Y1 (York) for each of the 32 centres considered in the Quantified Journey Time Assessment. Each Appendix is formatted in the following manner:

- A summary sheet records the principal outputs of this study for each town/city/ airport. These outputs for both HS2 and High Speed UK include:
  - average journey time reductions,
  - number of cities directly connected,
  - number of journeys made faster and
  - number of journeys made worse,.

  A written commentary is also provided.
- Colour-coded 'time line' representations indicate journey times, with appropriate allowance for change of trains, to each of the other 31 centres. Each timeline records the journey time with the intervention of either HS2 or HSUK in place; a journey time equal to the existing implies no change from the existing journey. All instances

where the intervention of HS2 makes an existing journey worse are recorded, but no attempt is made to quantify any additional journey times that will accrue.

- A plan indicating HS2 routes and services (if provided by HS2) from the town/city/airport in question, plus key connectivity data.
- A plan indicating HSUK routes, and services from the town/city/airport in question, plus key connectivity data.
- A comprehensive tabulation of journey times from the town/city/airport in question for HS2, HSUK and the existing network.

All averages are calculated as 'mean averages' rather than 'median averages'.

The results of the study are discussed in detail in Section 4 of this study, and are summarised on Summary Charts ES3-ES9.

3.7.1 Summary Charts ES3, ES4 & ES5

Summary Chart ES3 shows whether HSUK or HS2 offers shorter journey times for each of the 496 intercity journeys considered in this study.

Summary Chart ES4 shows HS2's network performance by cataloguing its effect upon each of the 496 intercity journeys considered in this study ie whether improved, no effect or .made worse'. As noted in Item 3.3.3, all HS2 journeys to Luton have been classified as a 'null' i.e. no improvement outcome indicated.

Summary Chart ES5 shows High Speed UK's network performance by cataloguing its effect upon each of the 496 intercity journeys considered in this study ie whether improved, no effect or made worse.

3.7.2 Summary Chart ES6

Summary Chart ES6 collates quantified results for each of the 32 cities (or airports) ie:

- average journey time reduction;
- number of cities connected by direct high speed services;
- number of journeys made faster; and
- numbers of journeys 'made worse'.

This data is taken from the detailed information for each of the 32 cities (or airports) given in Appendices B1 (Birmingham) to Y1 (York).

3.7.3 Summary Chart ES7

Summary Chart ES7 gives an alternative presentation of the comparative journey time data displayed in Summary Chart ES3. It shows in 'bar chart' format the outcomes for each of the 32 cities ie whether HSUK or HS2 delivers greater journey time reductions in that city's intercity links to each of the other 31 cities.

3.7.4 Summary Charts ES8 & ES9

Summary Charts ES8 & ES9 describe HSUK's and HS2's performance in achieving step-change capacity enhancements in 8 critical areas of the UK rail network. The scores allocated for each area are aggregated into a single overall score. The charts show:

- HS2 awarded a negative score of -5 out of 10 for its design of London-centric routes and stations for Sheffield, Leeds and Manchester, that will effectively prevent the establishment of efficient and higher capacity transpennine links.
- HS2 achieving a pitiful overall score of 8 out of 100; this can be attributed to its failure to achieve any significant capacity improvements outside its remitted West Coast Main Line corridor.
- HSUK achieving a far superior score of 82 out of 100; this can be attributed to its full integration with the existing network, its adherence to existing transport corridors and its design from the outset as a national network.

4 Summary of Findings

The following commentary provides a summary of the full findings of this study, documented in Section 5. Item 4.1 below corresponds to Section 5.1, Item 4.2 corresponds to Section 5.2, and so on.

4.1 Introduction

The basic purpose of this study is to test HS2 Ltd's promise, that HS2 will deliver **"hugely enhanced capacity and connectivity"** between the UK's major conurbations. Considered on their own merits, the findings of this study show clearly that HS2 will fail disastrously to meet the promise of step-change enhancements in rail network capacity and connectivity. However, HS2's failure is greatly illuminated by comparison with the alternative High Speed UK proposals, and in all sections of this study HS2's performance is contrasted with that of HSUK.

4.2 Direct Connectivity Assessment

The **Direct Connectivity Assessment** tests HS2's ability to provide a national intercity network in which all principal cities/major conurbations can be directly interconnected with high quality and frequent intercity services. At present the existing intercity service fails to offer direct, high quality or frequent services on many interregional routes, and HS2 must greatly improve this performance to meet the requirement for **"hugely enhanced… connectivity"**.

However, HS2 tends only to reinforce the failure of the existing network. HS2 only provides significant improvements on a small number of intercity connections, generally to London and to Birmingham; withdrawal of intercity services on existing routes will lead to more intercity connections being degraded than improved. Of particular concern is the loss of many intercity services to Scotland, and the fragmentation of the national network caused by the development of HS2's isolated Curzon Street terminus in Birmingham.

HSUK's design from the outset as a national network has required its new high speed lines to be fully connected to, and integrated with the existing network. This full integration is crucial to HSUK's unprecedented achievement of a national network in which all principal cities and major conurbations will be comprehensively interlinked with direct high speed intercity services.

4.3 Quantified Journey Time Assessment

The **Quantified Journey Time Assessment** tests HS2's ability to offer significantly improved intercity journey times, in line with HS2 Ltd's promise to deliver **"hugely enhanced… connectivity"**. The assessment is based upon HS2 Ltd's own published information which describes HS2's routes, station locations, connections to the existing network, proposed new high speed services and proposed reductions in intercity service levels on existing routes.

Using this information, journey times can be calculated for all 496 journeys between 32 principal towns, cities and airports that together represent the UK rail network. HS2 succeeds only in improving a small proportion (18%) of all journeys, and it has the effect of making more (20%) worse. Its overall effect is to reduce journey times by an average of 9%.

HSUK's detailed design of over 1,000km of new, upgraded and restored railway with over 60 connections to the existing network has allowed the compilation of a comprehensive 'demonstrator timetable'. This describes how the UK intercity network will operate, with HSUK in place. It shows that the intervention of HSUK will improve 93% of all journeys, make no journeys worse and reduce journey times by an average of 46%.

HSUK's superior performance is replicated across all 32 towns, cities and airports considered in the **Quantified Journey Time Assessment**.

4.4 Qualitative Capacity Assessment

The **Qualitative Capacity Assessment** tests HS2's ability to offer high speed services to all major cities served by the present intercity network. It also determines whether HS2 will provide the comprehensive improvements across the national network necessary to meet the test of **"hugely enhanced capacity"**.

HS2's capacity failures are exemplified by the inadequacies of its 2-track stem between London and the West Midlands. Its full 18 train per hour capacity is already allocated to serving only 11 of the 31 provincial towns cities and airports considered in the Quantified Journey Time Assessment; the other 20 cities will remain reliant on the existing network, on which intercity services are generally projected to be reduced.

Considered on a network-wide basis, HS2 succeeds only in providing improved capacity along the narrow corridor of the West Coast Main Line. It fails to offer any significant enhancements in the critically congested regional networks in the West

Midlands, Greater Manchester and West Yorkshire and overall it achieves a nationwide capacity score of just 8%.

HSUK's 4-track spine, extending from London to South Yorkshire, provides the new capacity necessary to allow high speed services to extend to all principal cities served by the present intercity network. This is only achievable through full connection to and integration with the existing network, and this in turn demands the development of radical solutions to address the congested 'bottlenecks' that exist at the major stations at the heart of the UK's regional networks. Together these enhancements will deliver step-change gains in capacity for national and local services, earning HSUK a nationwide capacity score of 82%.

4.5 HS2 : Remitted as a Stand-Alone High Speed Line but Failing to Perform as an Integrated National Network

Direct comparison of HS2's and HSUK's performance on each of the 496 journeys considered in the Quantified Journey Time Assessment reveals HS2's near-complete failure as a national network. However, it is instructive also to examine HS2's relative successes ie the few journeys on which it offers shorter journey times relative to HSUK allows the underlying priorities in each scheme to be identified.

Overall, HSUK offers shorter timings for 440 journeys while HS2 offers shorter journey times for 21 (the remaining 35 of the 496 are not improved by either HSUK or HS2). Of these 21 journeys, 20 are routed along the corridor of the West Coast Main Line. This clearly indicates HS2 Ltd's narrow focus on a single main line corridor, and a wider failure to meet HS2's objective of "hugely enhanced capacity and connectivity" between the UK's major conurbations.

HS2's best (or in reality 'least worst') performance is achieved for 3 cities (London, Birmingham and Preston) and for all 3 airports (Heathrow, Birmingham and Manchester) considered in this study. This demonstrates HS2's excessive focus on providing improved links to airports, to the detriment of its performance as an intercity network.

HSUK's best performance, in relative terms, is for 6 Midlands towns and cities (Derby, Northampton, Nottingham, Stoke, Walsall and Wolverhampton), all of which HS2 Ltd has chosen to bypass, and leave reliant on reduced services on the existing network. The transformed connectivity that HSUK will deliver for all of these cities is necessary if the Government's aspirations either for a Midlands Engine or for a better-connected Britain are ever to be met.

It should be emphasised that even for the cities and airports where HS2 achieves its best performance, HSUK still achieves far superior overall journey time reductions.

4.6 HS2 : Failing to Provide Transformed Direct Links to Principal UK Airports

These comparisons are based upon the fundamental precept, that any major airport should have direct rail links to all principal communities within its hinterland. For the 3 airports considered in this study (Heathrow, Birmingham and Manchester), Heathrow's hinterland extends across the entire island of Great Britain, while Birmingham's and Manchester's respective hinterlands extend across the Midlands and the North.

Although HS2's routeing strategy was prioritised upon Heathrow, Birmingham and Manchester airports, HS2 still fails to offer worthwhile rail links to any of these airports. Despite much initial promise, HS2 will offer no direct regional services to Heathrow, and the few links that it will offer to Birmingham and Manchester airports are all long-distance, outside the regional hinterland that each airport is intended to serve.

By contrast, HSUK achieves transformational improvements for all 3 airports. Its establishment of a 'Compass Point Network' around Heathrow will allow hourly services from all principal UK cities. HSUK will also offer direct links to Birmingham and Manchester airports from all principal regional centres in line with the requirements for the Midlands Engine and the Northern Powerhouse.

4.7 HS2 : Failing to Start the Midlands Engine

The remit of the HS2 project, to connect London and the West Midlands by means of a new high speed line, was written with the clear intention of delivering major connectivity gains for all West Midlands communities.

However, the briefest examination of HS2 Ltd's proposals shows clearly that HS2 will fail to meet this simple objective. HS2 will only serve new and generally disconnected stations in the Boroughs of Birmingham and Solihull; most other West Midlands communities will be left isolated from HS2, and thereby unable to gain direct benefit. HS2 also fails to offer any direct links between the principal cities of the West or the East Midlands, and it will do nothing whatsoever to stimulate the development of a 'Midlands Engine'.

HSUK's alternative strategy of full integration with the existing network will generate far greater gains for the entire West Midlands. The required gains in capacity and connectivity are achieved not through the physical expansion of Birmingham New Street. Instead they are achieved by 4-tracking of key radial routes, and by the full inclusion of outlying centres such as Coventry, Walsall and Wolverhampton into the HSUK network.

The many initiatives in both West and East Midlands, that are necessary to create HSUK's transformed national network, will combine to create a 'Midlands Ring'. This will for the first time efficiently interconnect all the principal communities of the Midlands and also provide comprehensive links to Birmingham Airport. Unlike HS2, HSUK will deliver all of the connectivity objectives of the Midlands Engine.

4.8 HS2 : Unwittingly Sabotaging the Northern Powerhouse

The failure of HS2 Ltd to include any transpennine link between Northern cities in its initial proposals (in 2010) for the HS2 'Y' led ultimately to the belated launch (in 2014) of proposals for 'HS3' transpennine links as part of a wider 'Northern Powerhouse' strategy. The HS3 initiative is underpinned by a detailed specification for improved journey times between the principal cities of the North, and from these cities to Manchester Airport.

Detailed examination of the timelines for both HS2 and HS3 projects raises serious concerns that the Government's greater commitment to HS2 will lead to increased London-centricity in the national transport system. This can only be to the detriment of Northern economies. The apparent 'dilution' of the new-build HS3 project into the 'Northern Powerhouse Rail' concept for upgraded transpennine routes gives further cause for concern.

However, the greatest cause for concern lies with the fact that HS2's routes and stations – which were designed with no thought for improved transpennine connectivity – will form the basis for Transport for the North's Northern Powerhouse Rail plans for improved 'HS3' transpennine links. This fundamental 'logic gap' will leave the Northern economy crippled by a dysfunctional and inefficient transport system:

- Two separate new transpennine routes required;
- No transpennine freight strategy;

- Terminus station in Manchester unable to cope with through flows;
- Circuitous and slow route from Manchester to Liverpool;
- No relief to existing congestion at Leeds station;
- Unsuitable station in Sheffield located on 66km long loop
- Many Northern cities bypassed by HS3;
- York bypassed by future HS3 line to Newcastle.

By basing HS3 upon the established HS2 proposals, HS3 will never deliver the efficient transpennine rail links demanded by the Northern Powerhouse specification.

All of these problems are avoided in the High Speed UK scheme. HSUK has been designed from the outset with a transpennine route to Manchester and Liverpool that will be fully integrated with the HSUK north-south spine and fully integrated with the existing network. As a result, HSUK will meet all the requirements of the Northern Powerhouse specification.

4.9 HS2 : Concentrating Connectivity and Economic Benefits on London and Other Economically-Advantaged Areas

There is a self-evident contradiction between the clear focus of the HS2 ‘Y’ upon London, and repeated official predictions that HS2 will deliver step-change economic benefits to the UK regions. This accounts for much of the public scepticism that has persistently accompanied the HS2 project; yet HS2 Ltd has remained firm in its forecasts of transformed regional economies. The detailed connectivity analysis undertaken for this study now allows HS2 Ltd’s predictions to be put to the test.

Two measures of connectivity have been adopted. The first measure is the **Average Journey Speed** for each of the 29 towns and cities under 3 scenarios i.e. the existing national network, and future national networks with HS2 and HSUK in place. The second measure is an empirical ‘**Intercity Connectivity Index**’ (ICCI) based upon the availability of direct journeys with no change of trains, and the quality of rolling stock on offer. For each town/city, **Average Journey Speed** and **Intercity Connectivity Index** are plotted against the average **Gross Disposable Household Income** as an indicator of community prosperity.

The following conclusions can be drawn from review of the plots:

- For the existing network, there is a clear linkage between connectivity and community prosperity. London, by far the best connected city, is also the most prosperous.
- HS2's greatest connectivity gains are achieved for London and for other well-connected and prosperous communities. It generally achieves little or no gains for economically-disadvantaged communities.
- It therefore follows that HS2 will tend to reinforce, rather than redress existing economic disparities.
- By contrast, HSUK's achievement of greatest connectivity gains in the most disadvantaged communities suggests strongly that (unlike HS2) it should be effective in bringing major economic benefit to the UK regions and in so doing redress the North-South Divide.

4.10 HS2 : Implications for Transport CO_2 Emission Reductions

Given the 'green' credentials of rail transport, the implementation of HS2, the largest single intervention in UK surface transport for perhaps half a century, should provide a historic opportunity to achieve massive reductions in CO_2 emissions across the entire transport sector. However, HS2 Ltd's own figures show HS2 to be no better than carbon-neutral, completely at odds with the target of the **2008 Climate Change Act** for an 80% reduction in national CO_2 emissions by 2050.

HS2's failure can be very simply explained by the multiple capacity and connectivity failures documented in this study. With HS2 unable to meet its promise of **"hugely enhanced capacity and connectivity"** it cannot achieve the step-change modal shift from high-emitting road transport to lower-emitting rail transport necessary to achieve the radical target of the **2008 Climate Change Act**.

With HSUK's far greater capacity and connectivity, achieved on a national scale, CO_2 reductions in line with the **2008 Climate Change Act** appear to be feasible. HSUK's studies demonstrate potential CO_2 reductions of around 600 million tonnes.

4.11 HS2 : Extreme Design Speed Totally Counter-Productive to Efficient Performance of National Railway Network

HS2 has been designed to be the fastest railway in the world, with a proposed operating speed of 360km/h (225MPH) and allowance for future operation at 400km/h (250MPH). High economic value has been ascribed to every minute shaved off already-fast journeys to London, with little account apparently given to the adverse effects of extreme speed. These adverse effects include increased energy consumption and CO_2 emissions, increased maintenance costs and technical risk, and greater construction cost and impact on rural landscapes through adoption of ultra-straight alignments.

HSUK's achievement of far greater journey time reductions, despite its design for a lower ultimate speed of 360km/h and its greater focus on upgrading/ restoration of existing routes, indicates clearly that increased speed cannot be the uniformly positive factor that HS2 Ltd's designers have assumed it to be. Instead, integration with the existing network appears to be a far more powerful factor in achieving step-change journey time reductions across the national network.

Detailed analysis shows that HSUK's average journey time reduction of 46% would reduce to a slightly lower figure of 39%, if the entire network were operated at the existing maximum speed of 200km/h. This is more than 4 times the 9% average journey time reduction that HS2 could achieve, operating at 400km/h.

There is no indication that HS2 Ltd has ever undertaken the research necessary to establish the relationship between the speed for which a new railway intervention is designed, and the speed at which the entire national rail system can operate.

There is equally no indication HS2 Ltd has undertaken any sort of network performance study, to determine how the national rail network will perform, with HS2 in place. Together, these two omissions represent a catastrophic design failure, and they stand testament to the wider design failure of the entire HS2 project.

5 Findings of *HS2 : High Speed to Nowhere*

5.1 Introduction

The basic purpose of this study is to test HS2 Ltd's promise, that HS2 will deliver **"hugely enhanced capacity and connectivity"** between the UK's major conurbations. Considered on their own merits, the findings of this study show clearly that HS2 will fail disastrously to meet the promise of step-change enhancements in rail network capacity and connectivity. However, HS2's failure is greatly illuminated by comparison with the alternative High Speed UK proposals, and in all sections of this study HS2's performance is contrasted with that of HSUK.

5.1.1 3 Core Tests

The findings of this study are based upon 3 core tests:

- Direct Connectivity Assessment (see Section 2.4).
- Quantified Journey Time Assessment (see Sections 2.5 and 2.6).
- Qualitative Capacity Assessment (see Section 2.7).

The findings from these 3 assessments are set out in Sections 5.2-5.4. Further implications arising from these assessments are discussed in Sections 5.5-5.11 as follows:

- Section 5.5 – National Network issues.
- Section 5.6 – Direct Links to Principal UK Airports.
- Section 5.7 – Midlands Engine issues.
- Section 5.8 – Northern Powerhouse issues.
- Section 5.9 – Relationship between Connectivity and Economic Benefit
- Section 5.10 – Implications for Transport CO_2 Emission Reductions
- Section 5.11 – Design Speed issues

5.1.2 Interpretation of Findings

The findings of this study should be interpreted in 2 different ways.

- HS2 – consideration on its own merits.
- HS2 – consideration by comparison with an 'exemplar alternative'.

5.1.3 Consideration of HS2 'on its own merits'

HS2 must be considered as a new railway intervention designed to provide benefits commensurate with the investment of over £55 billion of public money. It must accord fully with all the public policy goals defined in Item 2.1, and most importantly it must meet the its own objective of **"hugely enhanced capacity and connectivity"** between the UK's major conurbations. This objective can only be met through the improvement of the network as a whole, and this study has established the necessary models to allow the effect of HS2 upon the national network to be comprehensively assessed.

5.1.4 Consideration of Intercity Service Reductions caused by Introduction of HS2

Whilst it might be difficult to make a judgment in isolation as to whether HS2 achieves sufficient overall journey time reductions or provides sufficient extra capacity, no such difficulty exists in the case of the major reductions to intercity services that have been set out in HS2 Ltd's own documentation – see Appendix A2.

These reductions, which are discussed in Item 3.3.4, will bring about major reductions in intercity services across the national network. They will particularly affect second-tier cities such as Milton Keynes, Coventry, Leicester, Derby and Stoke which are bypassed by HS2's new routes connecting the primary cities, for instance London, Birmingham, Manchester, Sheffield and Leeds. All of these cities will lose premium intercity services, which will at best be substituted by slower and lower-quality services. Whilst some capacity might be gained, this will only be at the expense of greater losses in connectivity.

This creates a huge constituency of communities that will lose connectivity – and therefore economic prosperity – from the introduction of HS2. This flies in the face of the public policy requirement for inclusivity (as set out in Item 2.1.4) by which the 'winners' from any public project must vastly outnumber the 'losers'.

In the forthcoming sections 5.2 and 5.3, and in Appendices B1-Y1 covering all 32 centres considered in the Quantified Journey Time Assessment, all journeys deemed to have been 'made worse' by the intervention of HS2 have been identified.

5.1.5 Consideration of New Services proposed by Network Rail

The potential new services proposed by Network Rail in *Better Connections : Options for the integration of High Speed 2* have been qualitatively reviewed, but they have not so far been given detailed assessment. It should be noted that:

- Network Rail's service proposals are heavily caveated, assuming a level of integration between high speed and classic services that HS2 is unlikely to be able to provide.
- Many proposals are in fact mutually exclusive alternatives and therefore cannot be considered together.
- Stopping patterns, frequencies and journey times have yet to be defined.
- 11 of the 25 services proposed by Network Rail are classified as 'suburban' or 'interurban' ie slow speed stopping or commuter services not relevant to this study's consideration of intercity connectivity.

In general, it is considered that even if all the proposed services were to operate, this would do little to mitigate the overall loss in connectivity that will afflict the many second-tier cities that will be bypassed by HS2.

The uncertainties surrounding the Network Rail proposals also make it impossible to make an accurate assessment of the performance of the overall HS2 system comprising:

- HS2 services as set out in Appendix A2;
- Reduced intercity services as set out in Appendix A2;
- Additional services projected by Network Rail, as set out in Appendix A4;

However, from the outcomes of this study set out in Sections 5.2 and 5.3 and Appendices B1-Y1 it can be stated with confidence that such a disjointed system would still be vastly outperformed by HSUK's fully integrated network.

5.1.6 Consideration of HS2 against the HSUK 'exemplar alternative'

HS2 can only be taken forward if it can be shown to be a fully optimised scheme, delivering the greatest possible improvements in capacity and connectivity to the greatest possible proportion of the UK population, for the least cost and environmental impact. This requirement for technical optimisation should apply to any publicly-funded project, but it is especially pertinent in the case of HS2, given the huge sums at stake.

The degree to which HS2 has been technically optimised can be demonstrated very simply through comparing HS2's performance with that of the exemplar alternative of High Speed UK. These comparisons are set out in the following sections of this study.

5.2 Direct Connectivity Assessment

The **Direct Connectivity Assessment** tests HS2's ability to provide a national intercity network in which all principal cities/major conurbations can be directly interconnected with high quality and frequent intercity services. At present the existing intercity service fails to offer direct, high quality or frequent services on many interregional routes, and HS2 must greatly improve this performance to meet the requirement for **"hugely enhanced... connectivity"**.

However, HS2 tends only to reinforce the failure of the existing network. HS2 only provides significant improvements on a small number of intercity connections, generally to London and to Birmingham; withdrawal of intercity services on existing routes will lead to more intercity connections being degraded than improved. Of particular concern is the loss of many intercity services to Scotland, and the fragmentation of the national network caused by the development of HS2's isolated Curzon Street terminus in Birmingham.

HSUK's design from the outset as a national network has required its new high speed lines to be fully connected to, and integrated with the existing network. This full integration is crucial to HSUK's unprecedented achievement of a national network in which all principal cities and major conurbations will be comprehensively interlinked with direct high speed intercity services.

5.2.1 Direct Connectivity Assessment of HS2 (21-centre Test)

HS2's connectivity performance has been established by its ability to offer direct journeys between 21 key centres of the national network, as illustrated in Figure 2.1. It would seem reasonable to expect a project aimed at delivering **"hugely enhanced...connectivity"** between the UK's major conurbations to provide direct connections for a large proportion of the 210 possible journeys between 21 key hubs of the UK rail network.

However, HS2 fails spectacularly in its aim, and this is demonstrated in Figure 5.1:

- HS2 offers direct 'high speed' journeys on only 24 out of 210 possible journeys; the remainder (89% of the total) will remain reliant on existing network services.
- HS2 offers no direct regional connections to Heathrow. Instead, passengers will be compelled to make an inconvenient change at Old Oak Common to join Heathrow Express services.
- The intervention of HS2 will have the effect of degrading 60 journeys (29% of the total), either through reduction in frequency, diversion onto slower routes, or through withdrawal of existing through services.

- HS2 fails to create any new direct journey opportunities.
- On the contrary, its introduction will see the withdrawal of 7 existing through services, with the result that a national network that offered 109 direct services out of 210 (52%) will now offer only 102 direct services out of 210 (49%).

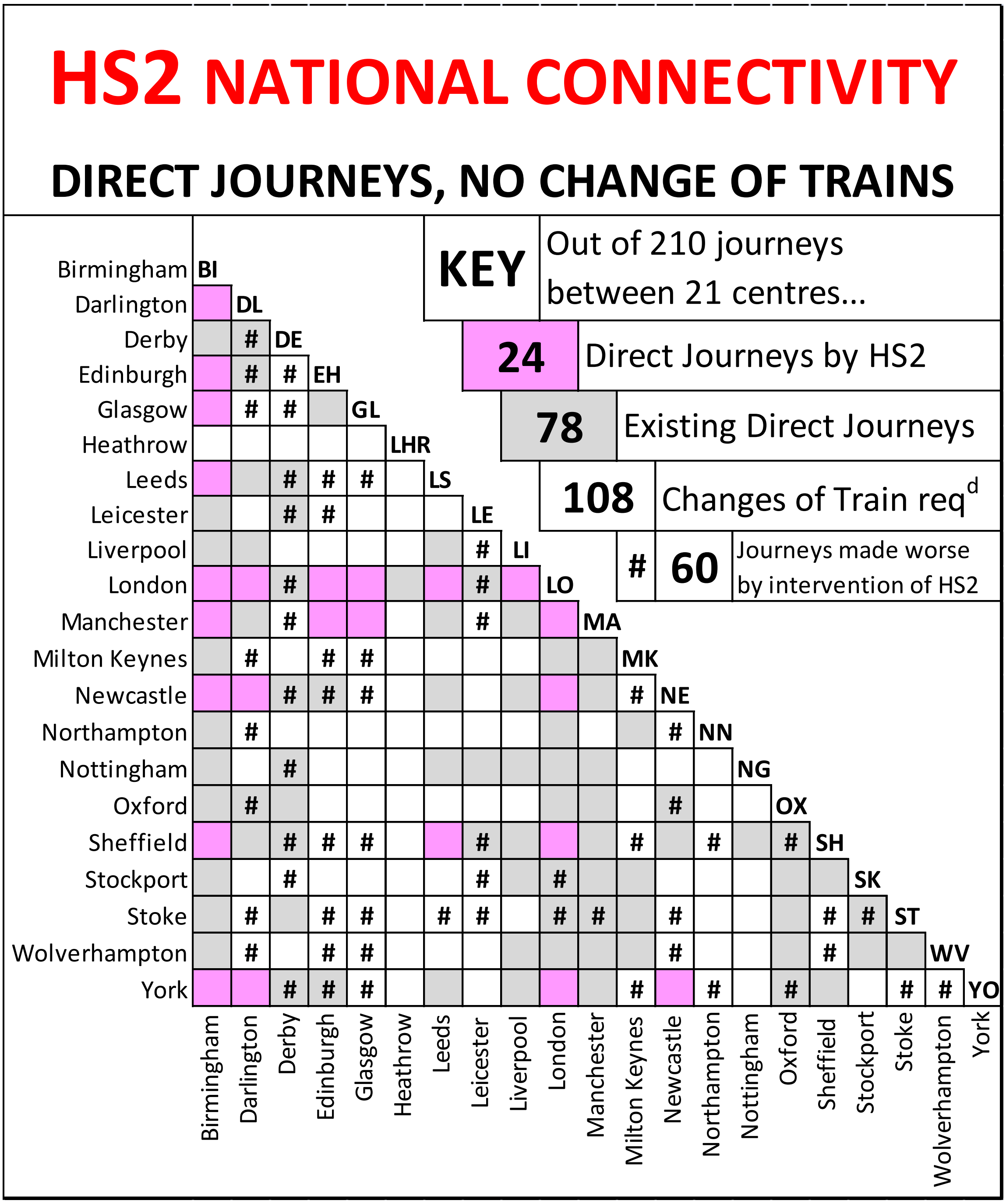


Figure 5.1 : Assessment of Direct Intercity Connectivity with HS2 in place

5.2.2 Degradation of Intercity Links to Scotland caused by HS2

From all of these statistics, it seems clear that HS2 will have a regressive overall effect on the national network. It is particularly concerning that all of the 7 direct services that will be lost are to Scotland. Scotland, and especially Glasgow, is already poorly connected to the remainder of the United Kingdom, and HS2 will have the effect of making this poor connectivity even worse. This analysis shows Edinburgh and Glasgow collectively enjoying 16 direct links to English cities; under HS2, this will reduce almost by one half, to 9 direct links.

So far, this analysis has ignored the Plymouth-Edinburgh CrossCountry (XC) services, a proportion of which continue to Glasgow, generally at 2-hourly frequency. Inclusion of these services, operating at 2-hourly frequency, would give 6 extra direct intercity links, from Glasgow to Newcastle, Darlington, York, Leeds, Sheffield and Derby. Under current predictions for reduced intercity services (as given in Table 23 of *HS2 Regional Economic Impacts*) the withdrawal of the current hourly CrossCountry service to Edinburgh would of course also affect journeys to Glasgow.

Figure 5.2 summarises the effect of HS2 upon direct intercity links from English cities to Edinburgh and Glasgow. This fully demonstrates the disastrous effect that HS2 will have on connectivity between UK cities.

Direct Intercity Links from	Existing, including WCML journeys @ 2-hourly frequency	Existing, including WCML & XC journeys @ 2-hourly frequency	Direct Intercity Links proposed under HS2 scheme
Edinburgh	**11**	**11**	**6**
Glasgow	**5**	**11**	**3**
Total	**16**	**22**	**9**
Possible links	**40**	**40**	**40**
Success rate	**40%**	**55%**	**22.5%**
%age Connectivity **Loss** under HS2	**43%**	**59%**	
%age Connectivity **Gain** under HSUK	**150%**	**82%**	

Table 5.2 : Losses in Direct Intercity Connectivity to Scotland with HS2 in place

5.2.3 Testing HS2 Ltd's Claim of "Hugely Enhanced Capacity and Connectivity" between the UK's Major Conurbations (13-centre Test)

In order to test HS2 Ltd's claim that HS2 will deliver "hugely enhanced capacity and connectivity" between the UK's major conurbations, a separate Direct Connectivity Assessment has been undertaken. Bristol and Cardiff have been included in this assessment so that all 12 UK primary cities – each representative of its own 'major conurbation', as listed in Table 2.5 – can be considered, along with the links from all cities to Heathrow Airport.

The results of this assessment, as set out in Figure 5.3, are broadly similar to the 21-centre assessment discussed in Items 5.2.1 and 5.2.4. The same picture can be seen of a divided, 2-tier national rail system, in which a small proportion (17 out of 78) links will be improved, but the remainder will be left either unimproved or made worse.

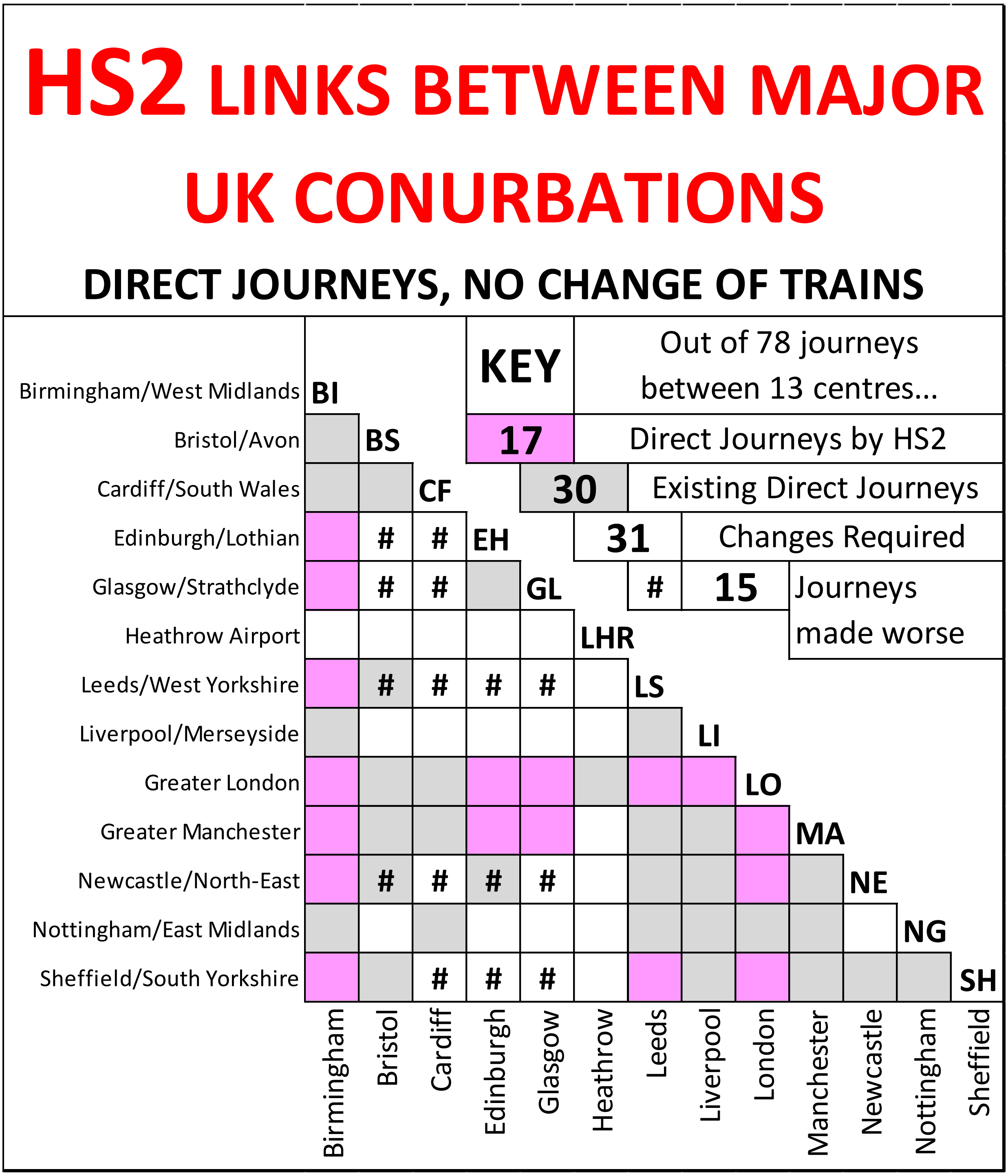


Figure 5.3 : Direct Interconurbation Links offered by HS2

HS2 Ltd's 'cherry-picking' of certain lucrative flows (mostly London-centric) whilst an almost equal number are made worse will inevitably lead to a degraded and damaged national rail network that is incapable of efficiently connecting the nation and bringing about economic benefit commensurate with the massive public investment that is proposed for HS2. Overall, it is clear that there can be no justification for HS2 Ltd's oft-repeated claim, that HS2 will deliver **"hugely enhanced capacity and connectivity"** between the UK's major conurbations.

Inclusion of Bristol and Cardiff in the connectivity assessment allows the disastrous effects of HS2's proposed Birmingham Curzon Street terminus to be properly identified. With HS2 trains from Northern and Scottish cities arriving at Curzon Street, but trains for Bristol and Cardiff continuing to depart from Birmingham New Street, passengers will be forced to make a walking transfer between the two stations. This will effectively cut the existing CrossCountry routes in half at Birmingham.

With Birmingham located at the fulcrum of the national rail network , HS2 Ltd's ill-considered proposals for a new terminus station in Birmingham will have calamitous consequences for the entire system. Figure 5.3 shows clearly that HS2 Ltd's proposals for Birmingham Curzon Street will have the effect of fracturing the integrity of the entire national network.

5.2.4 Direct Connectivity Assessment of High Speed UK (21-centre Test)

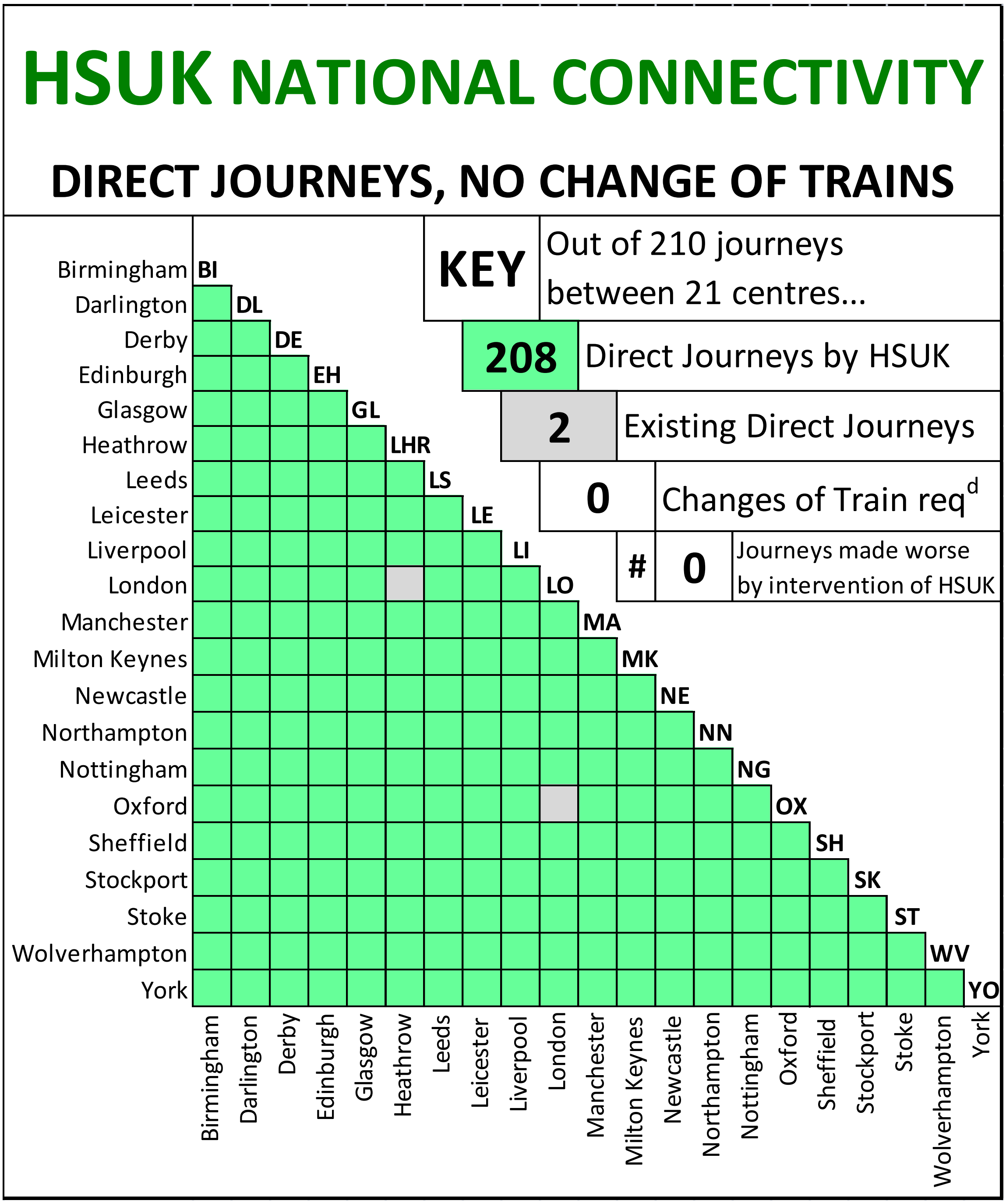


Figure 5.4 : Assessment of Direct Intercity Connectivity with HSUK in place

HSUK's connectivity performance has been established by its ability to offer direct journeys between 21 key centres of the national network, as illustrated in Figure 2.1. HSUK's design from the outset as an optimised and integrated national network achieves a level of performance, illustrated in Figure 5.4, that completely outclasses HS2:

- HSUK offers direct 'high speed' journeys on 208 out of 210 possible journeys.
- The remaining 2 journeys (Oxford to London and Heathrow to London) are geographically outside the scope of the UK high speed rail project, and both enjoy high quality and frequent services.
- The intervention of HSUK will not make any existing journeys worse.
- HSUK's achievement of comprehensive (ie 100%) direct connectivity between every one of the 21 centres represents a huge improvement over the 52% proportion of direct journeys offered by the existing network.
- Many of the new direct journeys offered by HSUK represent a transformation of existing connectivity, offering new intercity links that currently require highly circuitous and inconvenient journeys.

HSUK's transformations are particularly marked on journeys to Heathrow and to the M1 corridor communities of Milton Keynes and Northampton. As Table 5.5 demonstrates, HSUK also achieves massive improvements in links to Scotland, in complete contrast to the damaged and fractured links that HS2 will bring about.

5.2.5 Improvement of Intercity Links to Scotland achieved by HSUK

Unlike HS2 and unlike the existing national network, High Speed UK will allow both Edinburgh and Glasgow to be fully integrated into a fully-connected UK intercity rail network.

Direct Intercity Links from	Existing, including WCML journeys @ 2-hourly frequency	Existing, including WCML & XC journeys @ 2-hourly frequency	Direct Intercity Links proposed by HSUK (all hourly frequency)
Edinburgh	**11**	**11**	**20**
Glasgow	**5**	**11**	**20**
Total	**16**	**22**	**40**
Possible links	**40**	**40**	**40**
Success rate	**40%**	**55%**	**100%**
%age Connectivity **Gain** under HSUK	**150%**	**82%**	
%age Connectivity **Loss** under HS2	**43%**	**59%**	

Table 5.5 : Gains in Direct Intercity Connectivity to Scotland with HSUK in place

By concentrating upon a single primary east-sided route to Scotland, Glasgow and Edinburgh (and Newcastle and Darlington) will be placed on a single line of route, and it becomes feasible to offer hourly services from Glasgow and Edinburgh to all principal UK cities.

5.2.6 HSUK Achievement of Full Interconnectivity between the UK's Major Conurbations (13-centre Test)

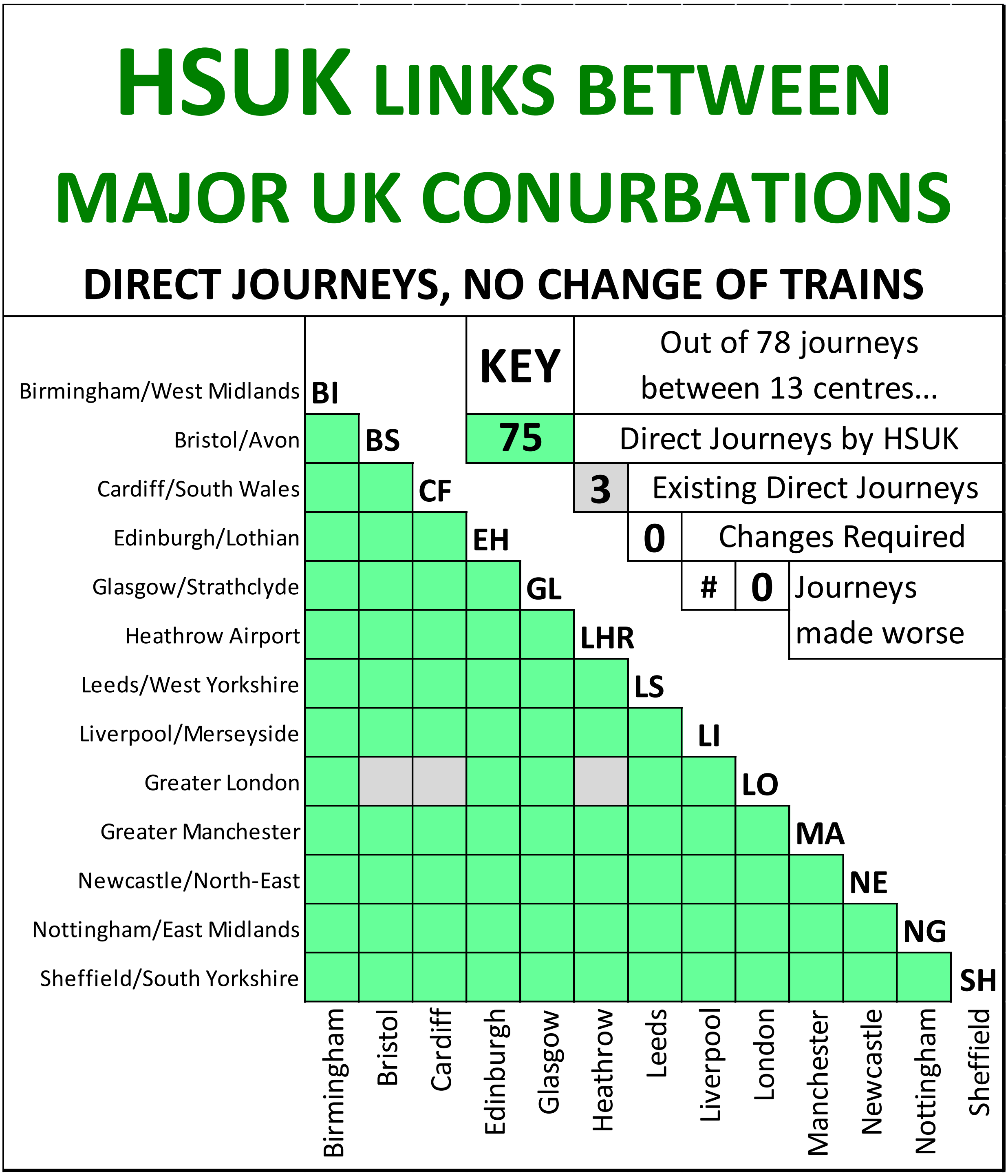


Figure 5.6 : Direct Interconurbation Links achieved by HSUK

The extent of HS2 Ltd's failure to fulfil its own mission statement, of delivering **"hugely enhanced capacity and connectivity"** between the UK's major conurbations, can only be truly appreciated by comparison with HSUK's comprehensive success in this quest, as illustrated in Figure 5.6. The only gaps in the HSUK service offering, from London to

Heathrow, Bristol and Cardiff, are along the Great Western axis and well outside HSUK's scope of intervention; all of these journeys are well served either by Heathrow Express or Great Western trains.

HSUK's achievement of full interconnectivity between the United Kingdom's principal regional conurbations, as illustrated on Figure 5.6, is without precedent in a historically London-centric national rail system that has always lacked efficient interregional links.

5.3 Quantified Journey Time Assessment

The **Quantified Journey Time Assessment** tests HS2's ability to offer significantly improved intercity journey times, in line with HS2 Ltd's promise to deliver **"hugely enhanced... connectivity"**. The assessment is based upon HS2 Ltd's own published information which describes HS2's routes, station locations, connections to the existing network, proposed new high speed services and proposed reductions in intercity service levels on existing routes.

Using this information, journey times can be calculated for all 496 journeys between 32 principal towns, cities and airports that together represent the UK rail network. HS2 succeeds only in improving a small proportion (18%) of all journeys, and it has the effect of making more (20%) worse. Its overall effect is to reduce journey times by an average of 9%.

HSUK's detailed design of over 1,000km of new, upgraded and restored railway with over 60 connections to the existing network has allowed the compilation of a comprehensive 'demonstrator timetable'. This describes how the UK intercity network will operate, with HSUK in place. It shows that the intervention of HSUK will improve 93% of all journeys, make no journeys worse and reduce journey times by an average of 46%.

HSUK's superior performance is replicated across all 32 towns, cities and airports considered in the **Quantified Journey Time Assessment**.

5.3.1 Average Journey Time Reductions and Volume-Weighting

The performance of HS2 and HSUK in achieving network-wide journey time reductions is presented as an average journey time reduction for each of the towns, cities and airports considered (32 considered for HSUK, or 31 for HS2 noting the exclusion of Luton, see Item 3.3.3). Two different methodologies have been applied in the calculation of these averages:

- An 'unweighted' methodology, with all journeys accorded equal significance, regardless of the volume of flow on each journey. See Item 3.3.7.
- A 'volume-weighted' methodology, to reflect the greater volumes of flow between more populous centres. See Item 3.3.8.

Average journey time reductions for all 32 centres, calculated by 'unweighted' and 'volume weighted' methodologies, are set out in Table 5.7. The following conclusions can be drawn from a review of this data:

- On whichever methodology – unweighted or volume-weighted – HSUK offers greater journey time reductions for every one of the 32 centres considered.

Northern Powerhouse city/airport	Midlands Engine city/airport	Average journey time reductions			
		calculated with no volume weighting	calculated with volume weighting	calculated with no volume weighting	calculated with volume weighting
		HIGH SPEED UK		HS2	
Birmingham		36%	36%	23%	28%
B'ham Airport		43%	37%	20%	13%
Bradford		50%	42%	13%	10%
Cheltenham		28%	17%	0%	0%
Chester		42%	40%	2%	1%
Coventry		48%	46%	9%	6%
Crewe		32%	30%	6%	12%
Derby		47%	43%	2%	1%
Doncaster		37%	29%	1%	0%
Heathrow		50%	17%	33%	8%
Huddersfield		40%	32%	8%	9%
Hull		32%	25%	3%	2%
Leeds		50%	45%	20%	20%
Leicester		62%	57%	6%	3%
Liverpool		43%	42%	4%	9%
London		31%	28%	19%	20%
Luton		62%	41%	Journey times not assessed for Luton	
Manchester		42%	39%	13%	18%
M'ch'r Airport		43%	42%	18%	15%
Milton Keynes		46%	39%	1%	0%
Northampton		60%	59%	5%	2%
Nottingham		56%	55%	10%	8%
Oxford		38%	25%	2%	1%
Peterborough		32%	23%	0%	0%
Preston		35%	30%	12%	13%
Sheffield		53%	54%	8%	16%
Stockport		45%	35%	2%	0%
Stoke		46%	41%	1%	0%
Walsall		59%	65%	0%	0%
Warrington		43%	46%	4%	5%
Wolverhampton		47%	59%	2%	1%
York		42%	39%	9%	13%
Average		46%	40%	9%	14%

Table 5.7 : Average Journey Time Reductions calculated by Alternate Methodologies

- Notwithstanding the exclusion of Luton from analysis of HS2, it can safely be assumed that HS2 – which bypasses Luton and offers no specific interventions for Luton – cannot possibly achieve the 62%/41% performance offered by HSUK.

- HS2's concentration upon higher-volume intercity flows between primary cities such as London, Birmingham, Manchester and Leeds gives a greater network-wide performance when volume-weighting is taken into account.
- By contrast, HSUK's greatly superior performance, in which the greatest gains are achieved for the smaller, poorer-connected cities, tends to reduce with volume-weighting is taken into account.
- Under either methodology, HSUK still massively outperforms HS2.
- With volume-weighting, HSUK achieves an average journey time reduction of 40% – almost 3 times greater than HS2's average journey time reduction of 14%.
- With no volume-weighting, HSUK achieves an average journey time reduction of 46% – over 5 times greater than HS2's average journey time reduction of 9%.

From the commentary set out above, it is plain that adoption of either unweighted or volume-weighted methodologies makes no fundamental difference to the fundamental findings of this study. HS2 is massively outperformed by the alternative High Speed UK scheme, and from this it can be reasonably concluded that the necessary process of technical optimisation has been completely absent in the development of HS2.

For the purposes of this study, journey time reductions in subsequent sections will continue to be quoted in line with the 'unweighted' methodology. This accords more closely with this study's underlying ethos of balanced network development in which all intercity flows are of equal significance, and with the more holistic philosophy summarised by the simple axiom that the whole must be greater than the sum of the parts.

5.3.2 HS2 Network Performance – Nationwide

HS2 Overall Network Performance					
Average journey time reduction	Proportion of journeys made faster	Proportion of journeys accelerated by > 35%	Proportion of journeys not improved	Proportion of journeys made worse	Proportion of direct journeys without change of trains
9%	18%	8%	62%	20%	41%

Table 5.8 : HS2 Overall Network Performance

The results of the Quantified Journey Time Assessment are summarised in Table 5.8 above, and set out in 'S-curve' format in Figure 5.9.

HS2 NETWORK PERFORMANCE

REPRESENTED BY JOURNEY TIME REDUCTIONS ACROSS NATIONAL NETWORK

Interpreting this diagram *The diagram below charts the performance of HS2 in achieving journey time reductions across the full range of the 465 journeys between the 31 towns, cities and airports considered in this study's analysis of the UK rail network (note that Luton is excluded from analysis of HS2's performance, see Item 3.3.3). HS2's poor performance - shown by the red line - is characterised by a significant percentage of journeys made worse, a high percentage showing no improvement, and only a low percentage achieving major journey time reductions.*

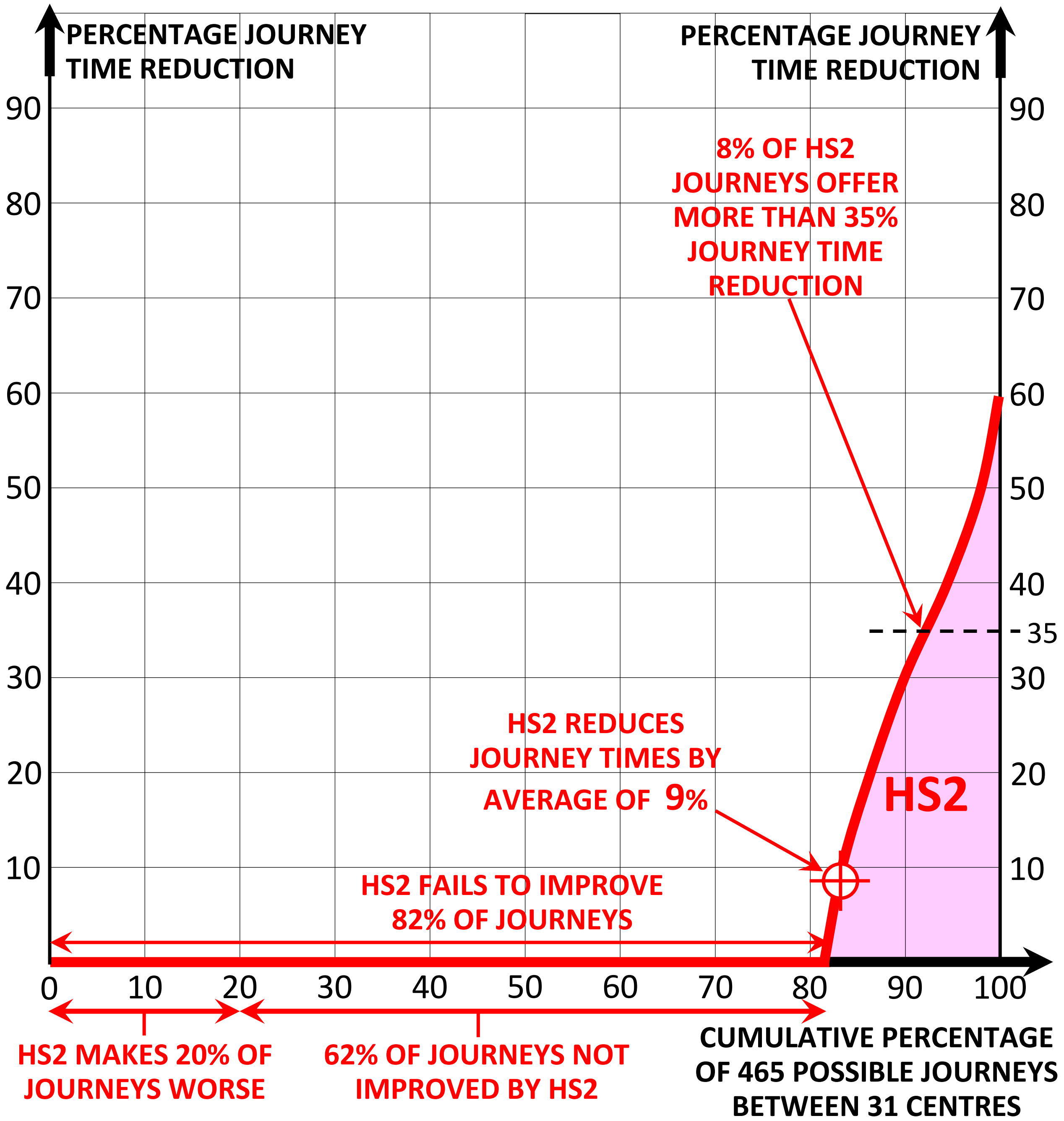


Figure 5.9 : HS2 Network Performance

Table 5.8 and Figure 5.9 capture HS2's performance as a national system, and demonstrate clearly that HS2 fails to meet any of its capacity and connectivity objectives:

- HS2's average journey time reduction, considered across the total of 465 journeys between 31 centres, is only 9%.
- This figure would reduce to a significantly lower percentage if the effective journey time increase associated with the 20% of journeys made worse were taken into account.
- HS2 improves only 18% of journeys, with only 8% achieving a journey time reduction of 35% or more.
- The remaining 82% will either see no direct improvement, or will be made significantly worse through the reduction in speed and frequency of intercity services on the existing main line network, that will be caused by the intervention of HS2.
- In terms of the direct journeys that it offers as opposed to those requiring a change of trains, HS2 represents no improvement compared with the existing network; HS2 offers no new direct intercity journeys so it can do nothing to improve the performance of the existing network, on which only 41% of journeys which are direct.

5.3.3 HS2 Network Performance – City by City

HS2's network performance, considered on a city-by-city basis, is summarised in Table 5.10. , 4 separate measurements of connectivity are applied for each town/city/airport:

- Average journey time reduction, considering journeys to all other 30 centres (note exclusion of Luton as discussed in Item 3.3.3).
- Number of cities linked by direct HS2 services.
- Number of journeys made faster by intervention of HS2.
- Number of journeys made worse, according to the criteria set out in Item 3.3.4.

Against all of these criteria, HS2 offers extremely poor performance:

- The majority of HS2's improvements will be on journeys to a very selective range of destinations, with London, Heathrow Airport, Birmingham and Birmingham Airport seeing the majority of gains.
- Many key regional centres – for instance Derby, Doncaster, Stoke and Warrington – will see more intercity journeys made worse than are improved, and as a whole seem likely to experience significant loss of connectivity under the HS2 scheme.
- For all 32 towns, cities and airports considered in the Quantified Journey Time Assessment, HS2 is outperformed by High Speed UK on all 4 criteria of Average Journey Time Reduction, Number of cities directly linked, Number of journeys made faster and Number of journeys made worse. The only exception is at Peterborough, where neither HS2 nor HSUK are judged to make any journeys worse
- Expressed as a rugby score, HS2, **0** : HSUK, **127**.

Northern Powerhouse city/airport / Midlands Engine city/airport	HIGH SPEED 2				Comparison with HSUK	
	Average journey time reduction (JTR)	Cities directly linked by HS2 services	Journeys made faster (out of 30)	Journeys made worse (out of 30)	Detailed HS2 and HSUK journey time results and connectivity analysis for each town/city/airport presented in Appendices as follows...	HSUK or HS2 superior on all 4 criteria?
Birmingham	23%	8	12	2	**See Appendix B1**	**HSUK**
B'ham Airport	20%	6	9	4	**See Appendix B2**	**HSUK**
Bradford	13%	0	12	4	**See Appendix B3**	**HSUK**
Cheltenham	0%	0	0	8	**See Appendix C1**	**HSUK**
Chester	2%	0	1	4	**See Appendix C2**	**HSUK**
Coventry	9%	0	9	5	**See Appendix C3**	**HSUK**
Crewe	6%	4	2	1	**See Appendix C4**	**HSUK**
Derby	2%	0	4	12	**See Appendix D1**	**HSUK**
Doncaster	1%	0	1	16	**See Appendix D2**	**HSUK**
Heathrow	33%	0	23	1	**See Appendix H1**	**HSUK**
Huddersfield	8%	0	8	2	**See Appendix H2**	**HSUK**
Hull	3%	0	5	8	**See Appendix H3**	**HSUK**
Leeds	20%	4	12	5	**See Appendix L1**	**HSUK**
Leicester	6%	0	5	12	**See Appendix L2**	**HSUK**
Liverpool	4%	2	2	1	**See Appendix L3**	**HSUK**
London	19%	11	13	8	**See Appendix L4**	**HSUK**
Luton	HS2 performance not assessed for Luton				**See Appendix L5**	**HSUK**
Manchester	13%	4	6	3	**See Appendix M1**	**HSUK**
M'ch'r Airport	18%	4	7	2	**See Appendix M2**	**HSUK**
Milton Keynes	1%	0	2	8	**See Appendix M3**	**HSUK**
Northampton	5%	0	6	5	**See Appendix N1**	**HSUK**
Nottingham	10%	0	9	1	**See Appendix N2**	**HSUK**
Oxford	2%	0	4	5	**See Appendix O1**	**HSUK**
Peterborough	0%	0	0	0	**See Appendix P1**	**HSUK**
Preston	12%	5	7	7	**See Appendix P2**	**HSUK**
Sheffield	8%	3	5	11	**See Appendix S1**	**HSUK**
Stockport	2%	0	1	4	**See Appendix S2**	**HSUK**
Stoke	1%	0	1	11	**See Appendix S3**	**HSUK**
Walsall	0%	0	0	10	**See Appendix W1**	**HSUK**
Warrington	4%	3	2	12	**See Appendix W2**	**HSUK**
Wolverhampton	2%	0	3	6	**See Appendix W3**	**HSUK**
York	9%	2	5	10	**See Appendix Y1**	**HSUK**
Average	9%	1.8	5.5	5.9		

Table 5.10 : HS2 City-by-City Connectivity Performance

5.3.4 HS2 Network Performance – Conclusions

Overall, HS2 conveys the impression of a highly limited intervention, capable of delivering only very limited direct benefits to a select group of primary cities. No structured consideration appears to have been given to how its benefits might 'trickle down' to a wider group of communities. Instead it seems simply to have been assumed that this beneficial outcome will happen as a natural consequence of building a new railway, despite a self-evident absence of the connections and the correct routeing strategy necessary for a wider distribution of benefits.

All the results of this study indicate strongly that HS2's isolation and lack of integration is such that this 'trickledown' cannot happen. This makes it simply unacceptable to spend huge sums of public money on a transport intervention from which only a very small proportion of the UK public can benefit, either directly or indirectly.

5.3.5 High Speed UK Network Performance – Nationwide

High Speed UK Overall Network Performance					
Average journey time reduction	Proportion of journeys made faster	Proportion of journeys accelerated by > 35%	Proportion of journeys not improved	Proportion of journeys made worse	Proportion of direct journeys without change of trains
46%	**93%**	**58%**	**7%**	**0%**	**73%**

Table 5.11 : HSUK Overall Network Performance

The results of the Quantified Journey Time Assessment are summarised in Table 5.11 above, and set out in 'S-curve' format in Figure 5.12. These statistics capture HSUK's performance as a national system, and demonstrate clearly that HSUK offers national performance far superior to that of HS2:

- HSUK will offer 46% average journey time reductions, calculated across the total of 496 journeys between 32 centres.
- HSUK improves 92% of journeys, with 59% achieving a journey time reduction of 35% or more.
- The remaining 8% generally comprise peripheral routes or local direct journeys (e.g. Peterborough-Doncaster, Chester-Liverpool or Leeds-Bradford) not capable of improvement through the intervention of a north-south high speed line such as either HSUK or HS2.
- No journeys will be made worse.
- HSUK's achievement of 73% direct journeys out of a total of 496 journeys represents a transformational improvement compared with the existing network's offering of 41% direct journeys.

HSUK & HS2 NETWORK PERFORMANCE

REPRESENTED BY JOURNEY TIME REDUCTIONS ACROSS NATIONAL NETWORK

Interpreting this diagram *The diagram below charts the performance of High Speed UK in achieving journey time reductions across the full range of the 496 journeys between the 32 towns, cities and airports considered in this study's analysis of the UK rail network. HSUK's good performance - shown by the green line - is characterised by only a small percentage showing no improvement, and a high percentage achieving major journey time reductions. HS2's poor performance (measured between 31 centres, with Luton excluded as noted in Item 3.3.3, and shown by the red line) is characterised by a significant percentage of journeys made worse, a high percentage with no improvement, and only a low percentage achieving major journey time reductions.*

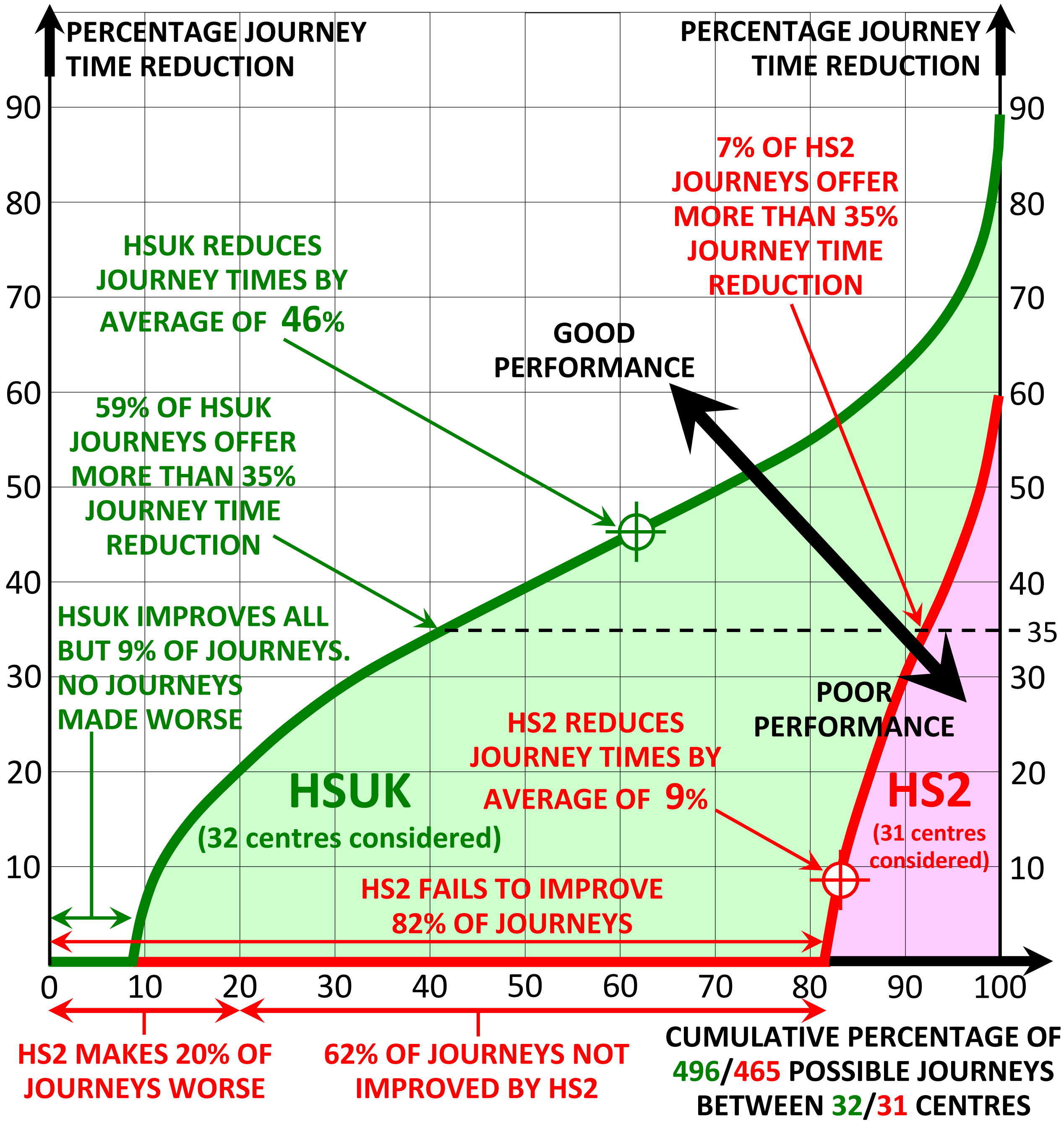


Figure 5.12 : HSUK & HS2 Network Performance

Northern Powerhouse city/airport / Midlands Engine city/airport	HIGH SPEED UK				Comparison with HS2	
	Average journey time reduction (JTR)	Cities directly linked by HSUK services	Journeys made faster (out of 31)	Journeys made worse (out of 31)	Detailed HS2 and HSUK journey time results and connectivity analysis for each town/city/airport presented in Appendices B1-Y1...	HSUK or HS2 superior on all 4 criteria?
Birmingham	36%	29	28	0	See Appendix B1	HSUK
B'ham Airport	43%	24	29	0	See Appendix B2	HSUK
Bradford	50%	12	25	0	See Appendix B3	HSUK
Cheltenham	28%	17	29	0	See Appendix C1	HSUK
Chester	42%	12	29	0	See Appendix C2	HSUK
Coventry	48%	24	29	0	See Appendix C3	HSUK
Crewe	32%	20	25	0	See Appendix C4	HSUK
Derby	47%	27	29	0	See Appendix D1	HSUK
Doncaster	37%	16	25	0	See Appendix D2	HSUK
Heathrow	50%	22	30	0	See Appendix H1	HSUK
Huddersfield	40%	17	26	0	See Appendix H2	HSUK
Hull	32%	16	26	0	See Appendix H3	HSUK
Leeds	50%	30	26	0	See Appendix L1	HSUK
Leicester	62%	27	29	0	See Appendix L2	HSUK
Liverpool	43%	27	28	0	See Appendix L3	HSUK
London	31%	27	25	0	See Appendix L4	HSUK
Luton	62%	17	30	0	See Appendix L5	HSUK
Manchester	42%	29	28	0	See Appendix M1	HSUK
M'ch'r Airport	43%	13	29	0	See Appendix M2	HSUK
Milton Keynes	46%	22	28	0	See Appendix M3	HSUK
Northampton	60%	18	31	0	See Appendix N1	HSUK
Nottingham	56%	27	31	0	See Appendix N2	HSUK
Oxford	38%	21	27	0	See Appendix O1	HSUK
Peterborough	32%	14	26	0	See Appendix P1	HSUK
Preston	35%	19	27	0	See Appendix P2	HSUK
Sheffield	53%	31	30	0	See Appendix S1	HSUK
Stockport	45%	28	29	0	See Appendix S2	HSUK
Stoke	46%	26	31	0	See Appendix S3	HSUK
Walsall	59%	18	31	0	See Appendix W1	HSUK
Warrington	43%	23	29	0	See Appendix W2	HSUK
Wolverhampton	47%	27	31	0	See Appendix W3	HSUK
York	42%	25	28	0	See Appendix Y1	HSUK
Average	46%	22	28	0		

Table 5.13 : HSUK City-by-City Connectivity Performance

5.3.6 HSUK Network Performance – City by City

HS2's network performance, considered on a city-by-city basis, is summarised in Table 5.13.

- HSUK's greatest improvements achieved are concentrated upon communities such as Bradford, Leicester, Luton, Northampton, Nottingham and Walsall which currently have very poor connectivity, with few if any intercity links and slow journey times. All will see a transformation, with effective journey time reductions of 50% or greater.
- HSUK will also achieve transformational improvements for the better connected primary cities. All will be fully interconnected with direct high speed services, operating at hourly or better frequencies. This interregional connectivity represents a step-change improvement on the London-centricity of the existing intercity network.
- HSUK outperforms HS2 on all 4 criteria for all 32 towns, cities and airports considered in the Quantified Journey Time Assessment. The only exception is at Peterborough, where neither HS2 nor HSUK are judged to make any journeys worse.
- Expressed as a rugby score, HSUK, **127** : HS2, **0**.

5.3.7 HSUK Network Performance – Conclusions

HSUK's superior performance as a national network stems from the fundamental difference in design philosophy between HS2 and HSUK. Whereas HS2 has been remitted only as a high speed line, with no requirement to perform as a network, HSUK has been designed from the outset as a national network. To design as a national network leads naturally to an ambition that all principal UK cities and airports should be directly interconnected. This ambition cannot be achieved by building high speed lines in isolation; it can only be achieved through full integration with the existing network, and this inclusive approach also enables much superior performance on a local scale.

5.4 Qualitative Capacity Assessment

The **Qualitative Capacity Assessment** tests HS2's ability to offer high speed services to all major cities served by the present intercity network. It also determines whether HS2 will provide the comprehensive improvements across the national network necessary to meet the test of **"hugely enhanced capacity"**.

HS2's capacity failures are exemplified by the inadequacies of its 2-track stem between London and the West Midlands. Its full 18 train per hour capacity is already allocated to serving only 11 of the 31 provincial towns cities and airports considered in the Quantified Journey Time Assessment; the other 20 cities will remain reliant on the existing network, on which intercity services are generally projected to be reduced.

Considered on a network-wide basis, HS2 succeeds only in providing improved capacity along the narrow corridor of the West Coast Main Line. It fails to offer any significant enhancements in the critically congested regional networks in the West Midlands, Greater Manchester and West Yorkshire and overall it achieves a nationwide capacity score of just 8%.

HSUK's 4-track spine, extending from London to South Yorkshire, provides the new capacity necessary to allow high speed services to extend to all principal cities served by the present intercity network. This is only achievable through full connection to and integration with the existing network, and this in turn demands the development of radical solutions to address the congested 'bottlenecks' that exist at the major stations at the heart of the UK's regional networks. Together these enhancements will deliver step-change gains in capacity for national and local services, earning HSUK a nationwide capacity score of 82%.

5.4.1 HS2 Capacity Problems

In recent years, the Government has sought to down-play HS2's journey time benefits, and instead to emphasise the capacity benefits that HS2 will bring. This study exposes for the first time how limited these capacity benefits will be, and how great HS2's capacity problems will be.

The maximum capacity of a 2-track high speed railway is generally accepted to be 18 trains per hour. For HS2's 2-track route from London to the West Midlands, the full capacity is already allocated[13], mostly to trains from London to the primary cities of Birmingham, Liverpool, Manchester, Sheffield, Leeds, Newcastle, Edinburgh and Glasgow. This leaves no

[13] Table 23, pp91-92, *HS2 Regional Economic Impacts*, HS2 Ltd, September 2013

capacity for equivalent improvement in services to most other regional cities, which will remain reliant on the existing main line network where intercity city services are generally projected to be reduced in speed and frequency. Equally serious, HS2's 2 tracks also lack the capacity to allow direct services from regional cities to Heathrow Airport.

High speed links to London via:	Average journey time reduction	Cities directly linked by HSUK services	Cities directly linked by existing I/C services	Journeys made faster (out of 25)	Journeys made worse (out of 25)
2-track HS2	**19%**	**11**	**26**	**13**	**8**

Table 5.14 : HS2 high speed links to London

As Table 5.14 indicates, HS2 will offer direct high speed services from London to only 11 of the 31 other centres under consideration. If Heathrow, Birmingham and Manchester Airports are excluded, and also Cheltenham, Oxford and Peterborough for being geographically 'out of scope', then HS2 will improve only 10 of 25 possible intercity links – a score of 40%.

If the capacity of HS2's new 2-track railway is fully consumed in delivering improved direct links to only 40% of communities, there is a clear capacity problem in providing high speed intercity services for the other 60% of major communities which might reasonably expect to be included in the Government's high speed rail project. This of course demands not only a greater number of tracks, but also appropriate routeing and connections to the existing network, to allow these communities to be included.

On a simplistic level, it can be argued that HS2 is equivalent to building a new motorway with a single lane in each direction, and no interchanges. It possesses neither the capacity nor the connectivity to constitute the holistic integrated transport solution that the UK clearly needs; and as such it will fail every regional community that depends upon an effective national rail network.

From the wider perspective of HS2 as a national system, capacity for more services might exist in the western and eastern arms north of Birmingham. However, the configuration of the HS2 'Y' is highly inefficient, generally only permitting single pairs of cities to be linked, and this has tended to govern the services that are offered. For example Manchester to Birmingham is deemed a sufficiently strong 'city pair' to justify a 2 train per hour service, but Liverpool to Birmingham – also possible on new HS2 infrastructure – is not. This problem of 'single city pair' interregional routes is greatly exacerbated by the terminus stations that are proposed in the key primary cities ie Birmingham, Manchester and Leeds. Given also HS2's inappropriate routeing and lack of connections, it becomes difficult to see where the present HS2 design might assist in a significantly greater number of journeys.

HS2 NATIONWIDE CAPACITY ASSESSMENT

Ref	Location	Congestion relief/Capacity improvement achieved	Score
C1	**Scottish Central Belt** *between Edinburgh and Glasgow*	HS2's west-sided approach to Scotland, with separate routes to Glasgow and Edinburgh splitting at Carstairs, is poorly aligned with the Scottish aspiration for a new high speed intercity route directly linking Glasgow-Edinburgh Airport-Edinburgh. Any Glasgow-Edinburgh high speed route based on current HS2 proposals will offer poor journey times and will probably fail to include Edinburgh Airport.	1/10
C2	**West Yorkshire** *local network focussed on Leeds*	Although new terminus platforms will be built for HS2 trains at Leeds, HS2 will do nothing to relieve present congestion in the existing platforms. Instead, congestion at Leeds seems likely to increase given the inability of HS2's proposed layout to accommodate through services from London to Bradford, Harrogate and the Aire Valley.	0/10
C3	**Transpennine lines** *Manchester to Leeds & Sheffield*	HS2 does nothing to improve the capacity of any transpennine route. Instead, proposed HS2 routes to and stations in Leeds, Sheffield and Manchester, all developed to London-centric priorities, will compromise future delivery of efficient HS3 transpennine links. Hence a negative score has been awarded.	-5/10
C4	**Greater Manchester** *local network focussed on Manchester Piccadilly*	Although new terminus platforms will be built for HS2 trains at Manchester Piccadilly, HS2 will do nothing to relieve present congestion either in the station or on its primary approach route via Stockport. Current 'Northern Hub' strategies are only incremental and will not deliver the required step-change in capacity; moreover, the entire Greater Manchester network will remain critically dependent upon the existing 2-track railway from Manchester Piccadilly (Platforms 13/14) via Oxford Road to Deansgate.	0/10
C5	**West Midlands** *local network focussed on Birmingham New Street*	The selection of Curzon Street as HS2's Birmingham station will achieve only minimal congestion relief at New Street. However, any new capacity at New Street will be compromised by the disconnection between local/regional services at New Street, and high speed services at Curzon Street.	1/10
C6	**West Coast Main Line** *from Euston to Rugby*	HS2's congestion relief to the WCML is greatly compromised by its lack of interconnection with the WCML, and the political need to maintain express intercity services to bypassed cities such as Coventry and Stoke. Moreover, with only 2 tracks, it lacks the capacity to serve all major cities within its 'Zone of Influence', or to provide direct regional links to Heathrow.	8/20
C7	**Greater London** *all quadrants, NW,NE,SW,SE*	Any capacity relief that HS2 will deliver for Greater London will naturally be confined to the north-west quadrant. The extra capacity that it will bring to the WCML is compromised by the continued need for commuters to transfer to the Tube or Crossrail 2 at Euston, and by the huge disruption associated with the proposed expansion and reconstruction of Euston Station.	3/20
C8	**Great Western Main Line** *incl. Severn Tunnel*	HS2's general north-south orientation prevents it from providing significant capacity relief to the GWML. Additionally, HS2's design with a terminus station in Birmingham effectively prevents HS2 services extending to Bristol, Cardiff etc.	0/10
	Nationwide Capacity Score (out of 100)		**8**

Table 5.15 : HS2 Nationwide Capacity Assessment

It is therefore reasonable to assert that the inadequate capacity of HS2's 2-track stem, combined with an associated failure of routeing strategy and lack of capacity on existing intercity routes, renders HS2 incapable of improving significantly more than the 18% of journeys identified in this study. With the remaining vast majority (ie 82%) of journeys left unimproved by the intervention of HS2, it is unreasonable for the Government and HS2 Ltd to assert that HS2 will achieve improvements in network capacity commensurate with a publicly-financed investment in a project of HS2's national scope.

HS2's failure to address the national need for greater rail capacity is conclusively established by the Nationwide Connectivity Assessment set out in Table 5.15. This is a qualitative assessment of the effectiveness of the proposed HS2 interventions to provide step-change capacity enhancements in any of the 8 identified areas of critical network congestion. The huge limitations of the current HS2 scheme are highlighted by the facts that:

- HS2 only provides useful capacity relief to 2 of the 8 identified congestion zones;
- HS2 provides no useful capacity gains in any of the regional conurbations that it serves;
- HS2's routes to, and stations in Sheffield, Leeds and Manchester have been developed to a largely London-centric agenda, and as described in Section 5.8 of this study, their configuration is greatly counter-productive to the establishment of efficient high-capacity transpennine links. Accordingly, a score of minus 5 out of 10 has been applied to this element of the Nationwide Capacity Score.

This results in HS2 having an overall Nationwide Capacity Score of 8 out of 100. This would appear to be somewhat at odds with HS2 Ltd's ambition for **"hugely enhanced capacity"**, and compares extremely poorly with High Speed UK's score of 82 out of 100 (see Table 5.17).

5.4.2 High Speed UK Capacity Enhancements

HSUK's greatly improved network performance is only possible with greatly increased capacity on all routes. This generally demands that major routes are enhanced to 4 tracks (new and existing), to enable the separation of higher speed express passenger traffic from lower speed local passenger and freight traffic.

But any high speed route running northwards from London must enhance 3 major existing routes – the West Coast Main Line, the Midland Main Line and the East Coast Main Line. Dependent upon where the cross-section is taken, these 3 main lines collectively comprise between 8 and 12 tracks. The intervention of HS2's 2 tracks is clearly insufficient to enhance these 3 main lines. HS2 will be just as ineffective at replicating the intercity functionality of these 3 lines in the 21st century as a single lane M1 would have been in the 20th century at superseding the A5, the A6 and the A1.

High speed links to London via:	Average journey time reduction	Cities directly linked by HSUK/ HS2 services	Cities directly linked by existing I/C services	Journeys made faster	Journeys made worse
4-track HSUK	**31%**	**27**	**23**	**25**	**0**
2-track HS2	**19%**	**11**	**23**	**13**	**8**

Table 5.16 : HSUK & HS2 high speed links to London

As noted previously, the restricted capacity and inappropriate routeing of HS2's 2 tracks offer only 11 direct intercity links from London, and very limited overall network benefits. HS2's 2 tracks also lack the capacity to allow direct services from Heathrow to any UK regional city.

To enable High Speed UK to provide the direct links to London and to Heathrow that all regional communities expect, 4 tracks are essential; and to provide the network benefits set out on Table 5.16, full integration with and frequent connection to the existing network are also essential.

For this latter requirement, HS2's disconnected route through the Chilterns is simply inappropriate; integration and interconnection are only possible with routes following existing transport corridors such as the West Coast Main Line. HSUK's route following the M1 is the only practicable option to meet the twin requirements of a 4-track route and full integration with the existing network.

HSUK's success in addressing the national need for greater rail capacity is conclusively established by the Nationwide Capacity Assessment set out in Table 5.17. This is a qualitative assessment of the effectiveness of the proposed HSUK interventions to provide step-change capacity enhancements in the 8 identified areas of critical network congestion.

HSUK's widespread success in achieving step-change capacity improvements in most of the identified areas is attributable to 4 primary factors:

- HSUK's full integration with the existing railway network;
- HSUK's adherence to established transport corridors;
- HSUK's efficient 'spine & spur' network configuration;
- HSUK's transformation of the local networks in all principal regional cities, bringing huge benefits for local and high speed services.

HSUK's primary limitation is geographical, in that its north-westerly orientation from London prevents it from offering significant benefits either to London's eastern quadrants, or to the corridor of the Great Western Main Line.

HSUK's huge outperformance of HS2 is reflected in its vastly superior Nationwide Capacity Score of 82 out of 100, far exceeding the HS2 score of 8 out of 100 (see Table 5.14).

HSUK NATIONWIDE CAPACITY ASSESSMENT			
Ref	Location	Congestion relief/Capacity improvement achieved	Score
C1	**Scottish Central Belt** *between Edinburgh and Glasgow*	HSUK's east-sided approach to Scotland creates a unified high speed route to Edinburgh and Glasgow. This allows direct high speed services from Edinburgh and Glasgow to most principal UK cities. HSUK's proposals also align with Scottish aspirations for a new high speed intercity route directly linking Glasgow-Edinburgh Airport-Edinburgh, and provide 2 new tracks between the 2 cities.	10/10
C2	**West Yorkshire** *local network focussed on Leeds*	HSUK's strategy to create a dedicated route for high speed services through Leeds, achieved through 4-tracking of approach route, will greatly increase capacity for local services. Construction of a new Stourton-Neville Hill link will allow many terminating services to be converted to through services. Together these 2 measures will allow capacity for local services to be approximately doubled.	10/10
C3	**Transpennine lines** *Manchester to Leeds & Sheffield*	HSUK's 'spine & spur' configuration incorporates a transpennine link (via the restored Woodhead corridor) as an integral part of network development. This will relieve congestion on all existing transpennine routes, and also creates the opportunity for a new transpennine freight route and a Sheffield-Manchester lorry shuttle	10/10
C4	**Greater Manchester** *local network focussed on Manchester Piccadilly*	HSUK's transpennine spur, serving both Manchester and Liverpool, demands a new east-west cross-Manchester tunnel with underground platforms at Manchester Piccadilly. This new facility - linking to Huddersfield, Sheffield and Stockport in the south and east, and to Liverpool and Bolton in the north and west, will also provide major new capacity for local services. This will greatly augment and reinforce current 'Northern Hub' strategies, and also offer a much more resilient local network.	10/10
C5	**West Midlands** *local network focussed on Birmingham New Street*	HSUK's strategy of 4-tracking key approach routes into Birmingham New Street (from Coventry, Derby and Wolverhampton/Walsall) enables local services to be segregated from express intercity services. This creates a step-change in capacity, and with the additional benefit of new routeing options created by HSUK, it is no longer necessary to terminate or reverse services at New Street; comprehensive 'through' operation will hugely increase platform capacity and allow much more frequent local services.	10/10
C6	**West Coast Main Line** *from Euston to Rugby*	HSUK's 4 tracks and its frequent interconnection with the WCML will deliver much greater congestion relief and resilience than HS2. With 4 tracks, HSUK has sufficient capacity to serve all major cities within its 'Zone of Influence' (including Coventry and Stoke) and also to provide direct links from all these cities to Heathrow.	20/20
C7	**Greater London** *all quadrants, NW,NE,SW,SE*	HSUK will deliver capacity relief for Greater London in both the north-west quadrant and – on account of its transformation of Heathrow's rail links – in the south-west quadrant also. Unlike HS2, its strategy to transfer commuter flows to Crossrail, or to a future 'Westlink' tunnelled route linking Euston and Charing Cross, will have massive beneficial effects upon current WCML commuter flows, eliminating the need to transfer to Tube lines at Euston.	10/20
C8	**Great Western Main Line** *incl. Severn Tunnel*	HSUK's general north-south orientation prevents it from providing significant capacity relief to the GWML. A complementary 'High Speed West' scheme is currently under development. Proposed HSUK services via Birmingham New St will ensure full connection of Cardiff, South Wales, Bristol & West Country to national network.	2/10
	Nationwide Capacity Score (out of 100)		**82**

Table 5.17 : HSUK Nationwide Capacity Assessment

5.5 HS2 : Remitted as a Stand-Alone High Speed Line but Failing to Perform as an Integrated National Network

Direct comparison of HS2's and HSUK's performance on each of the 496 journeys considered in the **Quantified Journey Time Assessment** reveals HS2's near-complete failure as a national network. However, it is instructive also to examine HS2's relative successes ie the few journeys on which it offers shorter journey times relative to HSUK allows the underlying priorities in each scheme to be identified.

Overall, HSUK offers shorter timings for 440 journeys while HS2 offers shorter journey times for 21 (the remaining 35 of the 496 are not improved by either HSUK or HS2). Of these 21 journeys, 20 are routed along the corridor of the West Coast Main Line. This clearly indicates HS2 Ltd's narrow focus on a single main line corridor, and a wider failure to meet HS2's objective of "hugely enhanced capacity and connectivity" between the UK's major conurbations.

HS2's best (or in reality 'least worst') performance is achieved for 3 cities (London, Birmingham and Preston) and for all 3 airports (Heathrow, Birmingham and Manchester) considered in this study. This demonstrates HS2's excessive focus on providing improved links to airports, to the detriment of its performance as an intercity network.

HSUK's best performance, in relative terms, is for 6 Midlands towns and cities (Derby, Northampton, Nottingham, Stoke, Walsall and Wolverhampton), all of which HS2 Ltd has chosen to bypass, and leave reliant on reduced services on the existing network. The transformed connectivity that HSUK will deliver for all of these cities is necessary if the Government's aspirations either for a Midlands Engine or for a better-connected Britain are ever to be met.

It should be emphasised that even for the cities and airports where HS2 achieves its best performance, HSUK still achieves far superior overall journey time reductions.

5.5.1 HS2's Inadequate Performance for Cities

The comparative connectivity data presented in Appendices B1-Y1 and in Summary Charts ES3 - ES7, and set out in abbreviated form below in Figure 5.18, tell a consistent story of HSUK's comprehensive network-wide outperformance of HS2:

- For every one of the 32 towns, cities and airports considered in this study, HSUK delivers greater average journey time reductions and more direct connections than HS2 can offer.

- Even for the cities supposedly benefited by HS2 (such as London and Birmingham), HSUK delivers quicker journey times for a vast majority of the 31 connections to the other cities considered in this study.
- For 19 of the 32 towns, cities and airports, HS2 fails to offer even a single journey that is quicker than that offered by HSUK.
- Out of the total of 496 journeys between the 32 centres, HS2 'wins' on only 21 journeys, while HSUK 'wins' on 440.
- Put another way, for every HS2 winner there are over 20 HSUK winners.

It should be noted that the remaining 35 journeys (out of 496) classified as 'no difference' are all instances (e.g. Bradford to Leeds or Doncaster to Peterborough) where neither HS2 nor HSUK are capable of offering a positive intervention to reduce the existing journey time. Where a particular journey (e.g. Leeds to Doncaster) is 'made worse' by the intervention of HS2, but is unchanged by HSUK, HSUK is recorded as the winner.

It is instructive to contrast the 6 centres where HSUK offers the best performance with the 6 centres where HS2 achieves best performance, as set out in Table 5.18.

HS2 Best Performance				HSUK Best Performance			
Journeys from...	Number of journeys (out of 31)..			Journeys from...	Number of journeys (out of 31)..		
	Quickest by HS2	No Difference	Quickest by HSUK		Quickest by HS2	No Difference	Quickest by HSUK
London	7	6	18	Derby	0	0	31
Heathrow	6	1	24	Northampton	0	0	31
Birmingham	5	2	24	Nottingham	0	0	31
M'ch'r Airport	5	2	24	Stoke	0	0	31
Preston	4	3	24	Walsall	0	0	31
B'ham Airport	4	0	27	Wolverhampton	0	0	31

Table 5.18 : HS2 and HSUK Best Performers

The HSUK best performers are all Midlands cities which will be bypassed by HS2 (even Nottingham, whose HS2 station will be the disconnected Toton, 9km from the city centre). These are all major population centres which must be efficiently and directly interconnected if the HS2 project is to deliver its aim of "hugely enhanced capacity and connectivity" between the UK's major conurbations. Without these enhancements, the UK will never have the 'Regional Powerhouse' economies that the Government has championed.

5.5.2 HS2 Focus upon West Coast Corridor

The narrow focus of the HS2 project can be seen clearly from the fact that all of the 6 centres where HS2 achieves best (or in reality 'least worst') performance are located along the corridor of the West Coast Main Line. Equally significantly, 20 of the 21 journeys where HS2 offers shorter timings are routed along this corridor.

The concentration of HS2's few benefits along the corridor of the UK's busiest main line would appear to be a logical consequence of the remit of HS2's first phase (see Appendix A5). This remit called for a high speed line from London to the West Midlands, but it never specified the balanced development of the national network necessary to bring about the overriding objective of **"hugely enhanced capacity and connectivity"** between the UK's major conurbations.

Instead, the remitted requirement for a high speed line from London to the West Midlands has followed through into a project whose benefits will mostly be concentrated along the corridor of the West Coast Main Line. These benefits are limited, and they plainly fail to meet the wider objective of **"hugely enhanced capacity and connectivity"**.

There is a clear misalignment between the HS2 project's remit and its objectives. In a well-regulated public project, this mismatch would have been recognised at an early stage, and the necessary action would have been taken, to bring the project back on track. Regrettably, this crucial deficiency has gone unrecognised, and this will leave HS2 unable ever to deliver the promised gains in capacity and connectivity.

5.5.3 HS2 Focus upon Airports

3 of the 6 centres where HS2 achieves best performance are not cities, but airports. This shows the extent to which HS2's routeing has been influenced by a political requirement to deliver high speed links to airports. This has been positively counter-productive to the achievement of improved connections between the UK's many regional cities.

The disastrous effects of HS2's excessive focus upon airports can be seen most clearly in the 'gravitational pull' that Heathrow has exerted over HS2. This has led directly to its route through the Chilterns and its bypassing of all the key population centres (Luton, Milton Keynes, Northampton and Leicester) along the M1 corridor. Ultimately it has led to the adoption of HS2's 'Y' configuration and its singular inability to interlink UK cities. Yet the cancellation in 2015 of all proposals for a direct spur from HS2 to Heathrow offers the plainest possible demonstration of the failure of HS2 Ltd's airport-focussed routeing strategy.

It is also significant to note that the entire HS2 'Y' is focussed upon Birmingham Interchange (the HS2 station serving Birmingham Airport), a station at which the majority of proposed HS2 services will not stop. Also, routeing of HS2 via Manchester Airport has precluded any possibility of HS2 serving Stockport.

5.5.4 Priority upon Intercity Flows

All this indicates a worrying lack of focus in the development of HS2. Whilst rail links to airports are desirable, they typically fail to generate the high volume intercity flows that constitute the primary rationale for developing new high speed lines. This must dictate that new high speed lines are primarily focussed upon intercity, rather than city-to-airport or inter-airport flows.

This is the principle that has guided the development of High Speed UK from the outset, and its benefits can be seen in every aspect of HSUK's vastly superior performance as an intercity network. However, adherence to the principle of the primacy of intercity flows has an unexpected side-effect. As demonstrated in the following section, it also allows the creation of far superior city-to-airport connections.

5.6 HS2 : Failing to Provide Transformed Direct Links to Principal UK Airports

These comparisons are based upon the fundamental precept, that any major airport should have direct rail links to all principal communities within its hinterland. For the 3 airports considered in this study (Heathrow, Birmingham and Manchester), Heathrow's hinterland extends across the entire island of Great Britain, while Birmingham's and Manchester's respective hinterlands extend across the Midlands and the North.

Although HS2's routeing strategy was prioritised upon Heathrow, Birmingham and Manchester airports, HS2 still fails to offer worthwhile rail links to any of these airports. Despite much initial promise, HS2 will offer no direct regional services to Heathrow, and the few links that it will offer to Birmingham and Manchester airports are all long-distance, outside the regional hinterland that each airport is intended to serve.

By contrast, HSUK achieves transformational improvements for all 3 airports. Its establishment of a 'Compass Point Network' around Heathrow will allow hourly services from all principal UK cities. HSUK will also offer direct links to Birmingham and Manchester airports from all principal regional centres in line with the requirements for the Midlands Engine and the Northern Powerhouse.

5.6.1 Need for Effective Surface Access between Airport and Hinterland

The excessive focus of HS2's routeing strategy upon Heathrow, Birmingham and Manchester airports noted in preceding paragraphs can be attributed to a strong political desire that new high speed rail lines should improve the connectivity of regional communities to international markets. Indeed, the promise of improved links from regional cities to Heathrow Airport was one of the key factors in securing regional support for the HS2 project.

This promise accords well with the fundamental principle that all airports should have efficient public transport links to their respective hinterlands. In the case of Heathrow, this hinterland extends across the entire UK, and there is a clear case for a network of rail routes extending across the island of Great Britain to provide rail 'spokes' to the international hub at Heathrow. In the case of Birmingham and Manchester airports, the hinterlands extend across their respective regions ie the West and East Midlands and the entire North of England.

This section reviews the success of both HS2 and HSUK in achieving efficient surface access to Heathrow, Birmingham and Manchester airports.

5.6.2 High Speed Links to Heathrow Airport

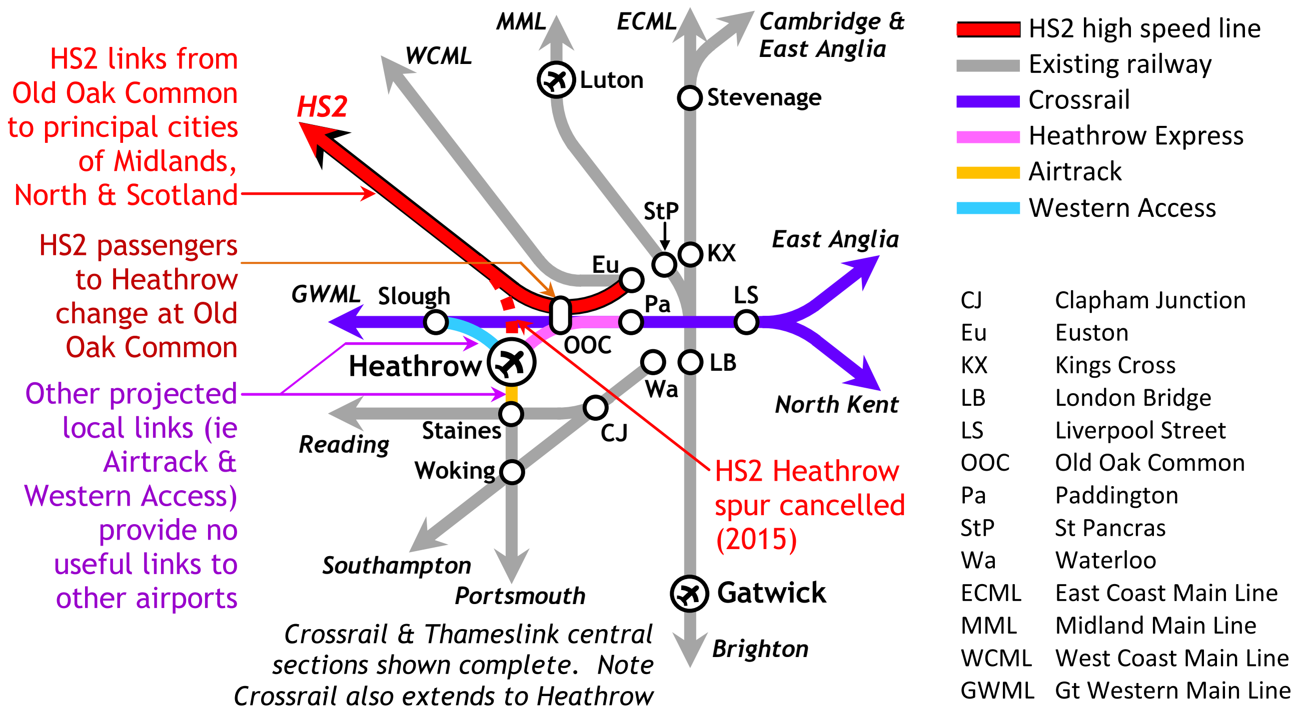


Figure 5.19 : HS2 Links to Heathrow via Old Oak Common

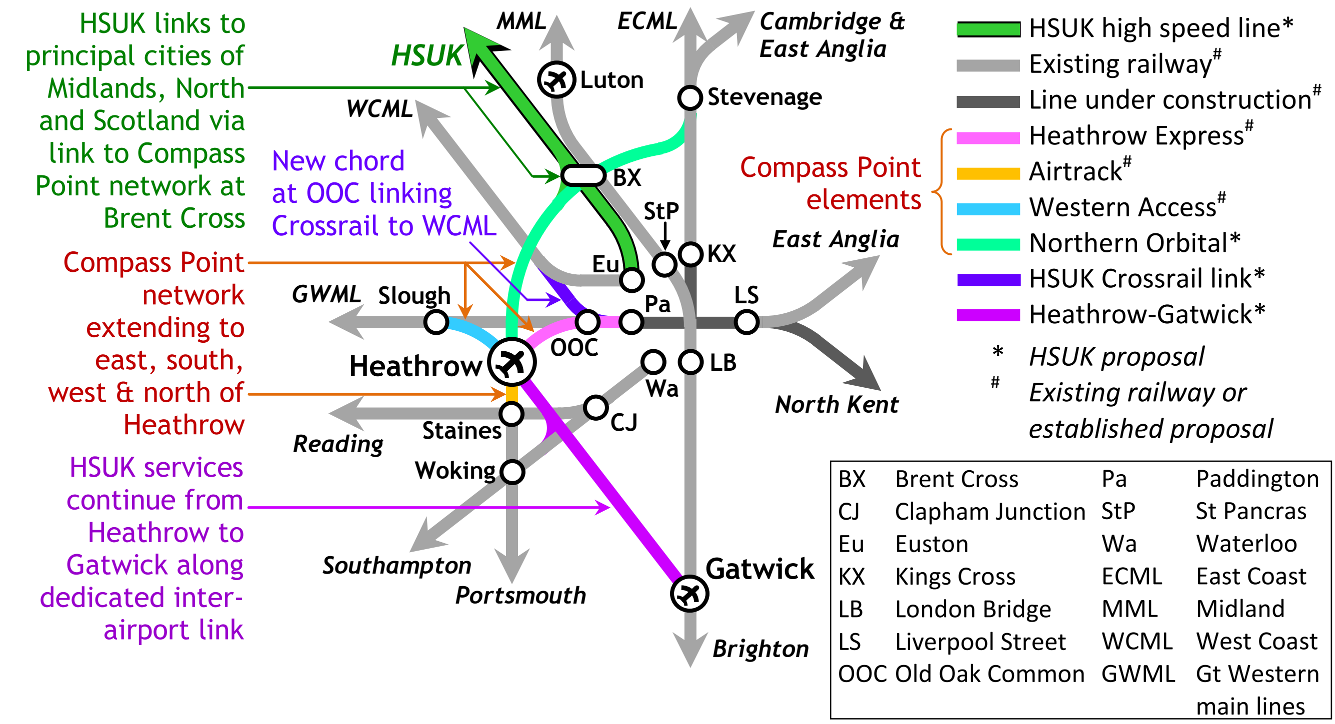
With the cancellation in 2015 of the proposed HS2 spur to Heathrow, any prospect of direct services from Heathrow to UK regional cities has been lost. Instead passengers will be compelled to change at Old Oak Common (see Figure 5.19) and then travel to an extremely restricted range of regional destinations.

It is fair to comment that the HS2 proposals for direct high speed services from Heathrow to UK regional cities were never viable, for 3 reasons:

- Lack of capacity on HS2's 2-track stem, between London and the West Midlands.
- Inefficient configuration of HS2 'Y', with separate services required to each primary regional city.
- High cost of dedicated Heathrow spur, used by very few services.

With no direct links to Heathrow, and only limited coverage of regional communities, HS2's potential to enhance the UK regions' international connectivity is similarly restricted. HS2 is also in no position to provide any worthwhile relief to the congestion that currently afflicts Heathrow.

HSUK has adopted an alternative strategy of developing a 'Compass Point' network to enable Heathrow to be fully connected to its entire hinterland, to east, south, west and north. The Compass Point network will be based upon the existing Heathrow Express infrastructure, and the established proposals for a new 'Airtrack' route linking Heathrow to the south and a 'Western Access' route linking Heathrow to the west. There will be no need for major construction within the confines of the airport.



BX	Brent Cross	Pa	Paddington
CJ	Clapham Junction	StP	St Pancras
Eu	Euston	Wa	Waterloo
KX	Kings Cross	ECML	East Coast
LB	London Bridge	MML	Midland
LS	Liverpool Street	WCML	West Coast
OOC	Old Oak Common	GWML	Gt Western main lines

Figure 5.20 : High Speed UK and Heathrow Compass Point Network

The additional capacity for the extra HSUK services will be achieved through the transformation of the Heathrow Express system from a terminating spur into a 'through' railway. This will link to the Southern network via the established 'Airtrack' proposals, and to the Great Western network via the established 'Western Access' scheme.

Most importantly, the Compass Point network will include a northern arm, linking both to the existing main lines and also to High Speed UK. Collectively, this will enable direct services from Heathrow to extend to all principal communities in the immediate regional hinterland to the north of the Thames, and also to all primary cities of the Midlands, the North and Scotland.

Whilst HS2's multiple design failures (listed previously) have combined to preclude any possibility of direct regional services to Heathrow, HSUK's fully integrated design for a national network of high speed lines takes full account of the desire of regional communities for direct services to Heathrow:

- HSUK's 4-track spine has the capacity for high speed services from regional communities both to London and to Heathrow.
- The efficient configuration of HSUK's 'spine and spur' network enables all primary regional cities and many other second-tier communities to be linked to Heathrow by only 4 trains (HSUK91/92/93/94, as listed in Appendix A1), each operating at hourly frequency.
- HSUK's proposed new links to Heathrow will cost far less than the previously proposed HS2 spur, and will be used by far more services.

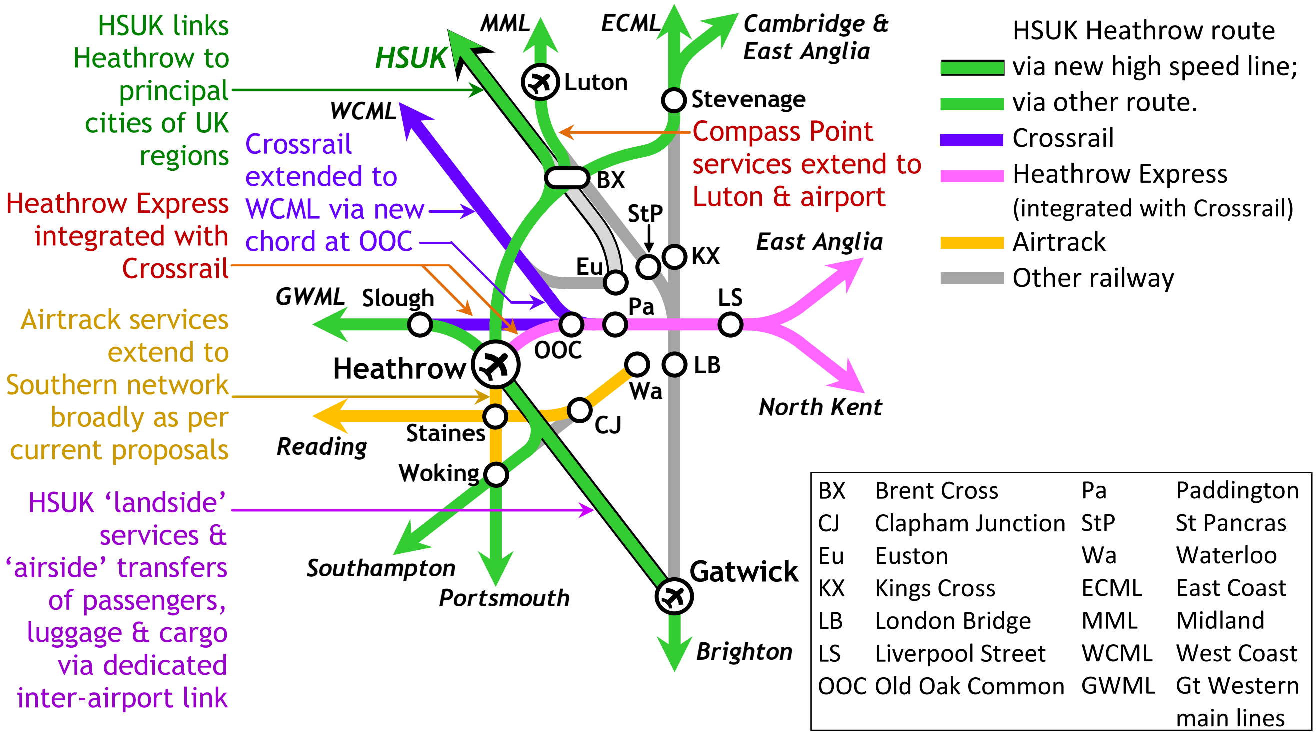


Figure 5.21 : High Speed UK links to Heathrow via Compass Point Network

The establishment of rail services from most principal cities of the Midlands, the North and Scotland to Heathrow opens up the possibility of a south-eastwards extension to Gatwick. A dedicated link between Heathrow and Gatwick (illustrated on Figures 5.20 and 5.21) would allow:

- 'landside' connections from both airports to the entire mainland UK hinterland;
- 'airside' connections between Heathrow and Gatwick for the transfer of transit passengers, and of luggage and freight.

This Heathrow-Gatwick connection would allow the two airports to be operated as a single multi-site aviation hub. Detailed plans already exist for a second runway at Gatwick, involving far less environmental damage than the proposed third runway at Heathrow; the resulting 4-runway hub airport would be in a far better position to compete with continental hubs such as Amsterdam Schiphol or Paris Charles de Gaulle.

HS2 to Heathrow Airport				HSUK to Heathrow Airport			
Number of direct links to Heathrow Airport from		Number of cities	Success rate	Number of direct links to Heathrow Airport from		Number of cities	Success rate
Southern cities	0	4#	0%	Southern cities	3	4#	75%
Midlands cities	0	10	0%	Midlands cities	9	10	90%
Northern cities	0	14	0%	Northern cities	10	14	71%

Existing Heathrow Express link to central London excluded from comparison

Table 5.22 : HS2 and HSUK Direct High Speed Links to Heathrow Airport

In summary, the HSUK scheme to access Heathrow comprehensively outperforms HS2, and unlike HS2 it also directly addresses the congestion pressures which are driving the present destructive plans to expand the airport into surrounding communities.

The numbers of regional cities enjoying direct HS2 and HSUK links to Heathrow Airport are listed in Table 5.22..

5.6.3 High Speed Links to Birmingham Airport

HS2's failure to achieve worthwhile improvements in links to Birmingham Airport is exemplified by the fact that London, Birmingham, Manchester, Leeds and Preston will be the only UK cities directly connected by HS2. HS2 fails completely to improve Birmingham Airport's connectivity to any city within its own Midlands hinterland; its only direct link, from Birmingham Interchange to Birmingham Curzon Street, represents no improvement over the existing link from Birmingham International to Birmingham New Street. HS2's almost complete inability to provide direct links from Birmingham Airport to other Midlands communities is illustrated in Figure 5.23.

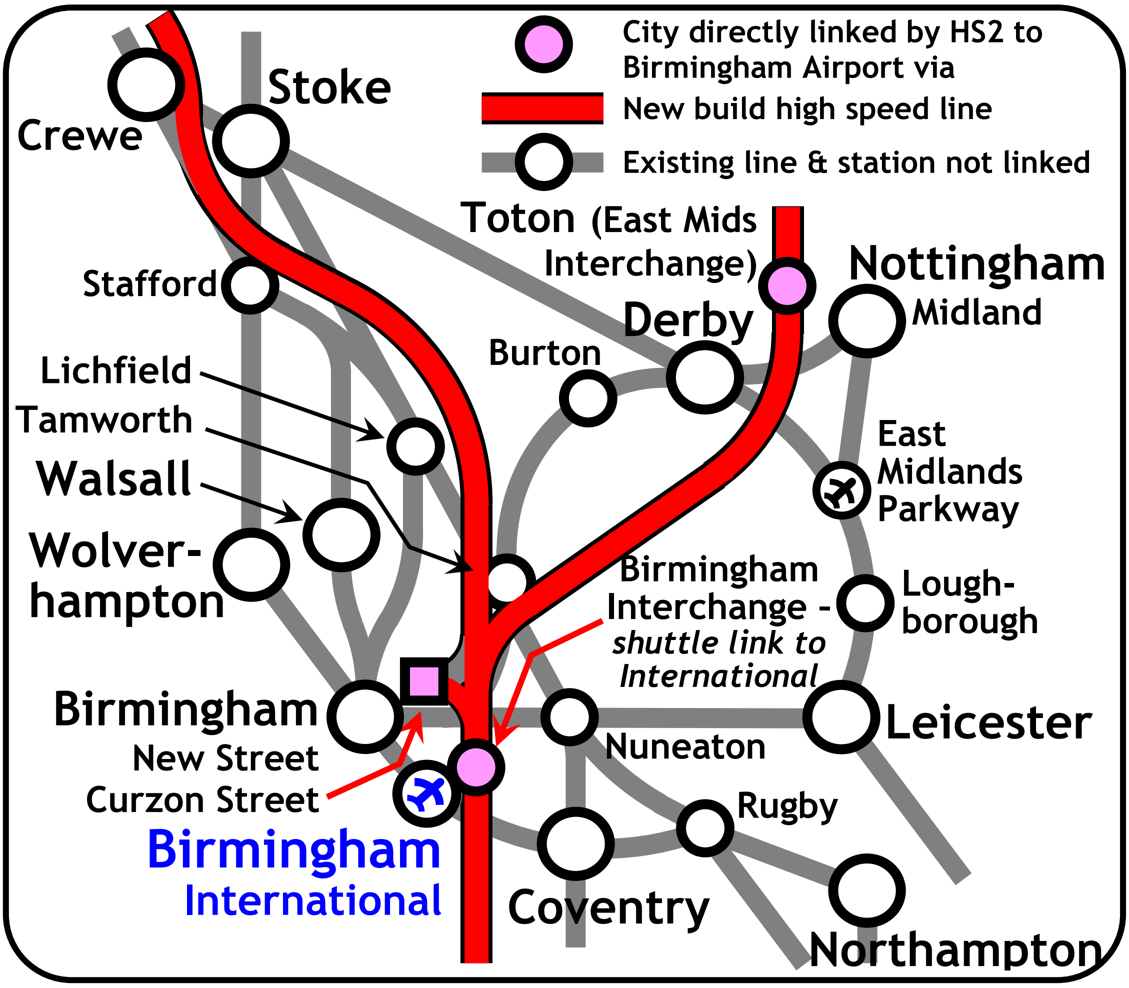


Figure 5.23 : HS2 High Speed Links to Midlands Cities from Birmingham Airport

HSUK cannot match HS2's few long-distance links for journey time, but it achieves comprehensive connectivity for Birmingham Airport around the Midlands through its strategy to create a 'Midlands Ring' interconnecting all principal communities of the West and East Midlands. Birmingham Airport's station at Birmingham International is a key node in the HSUK Midlands Ring linking Birmingham, Wolverhampton, Walsall, Derby, Nottingham, Leicester and Coventry, and most other key centres. HSUK's links from the Midlands Ring cities to Birmingham Airport are illustrated in Figure 5.24; the infrastructure works necessary to establish the Midlands Ring are described in Section 5.7.

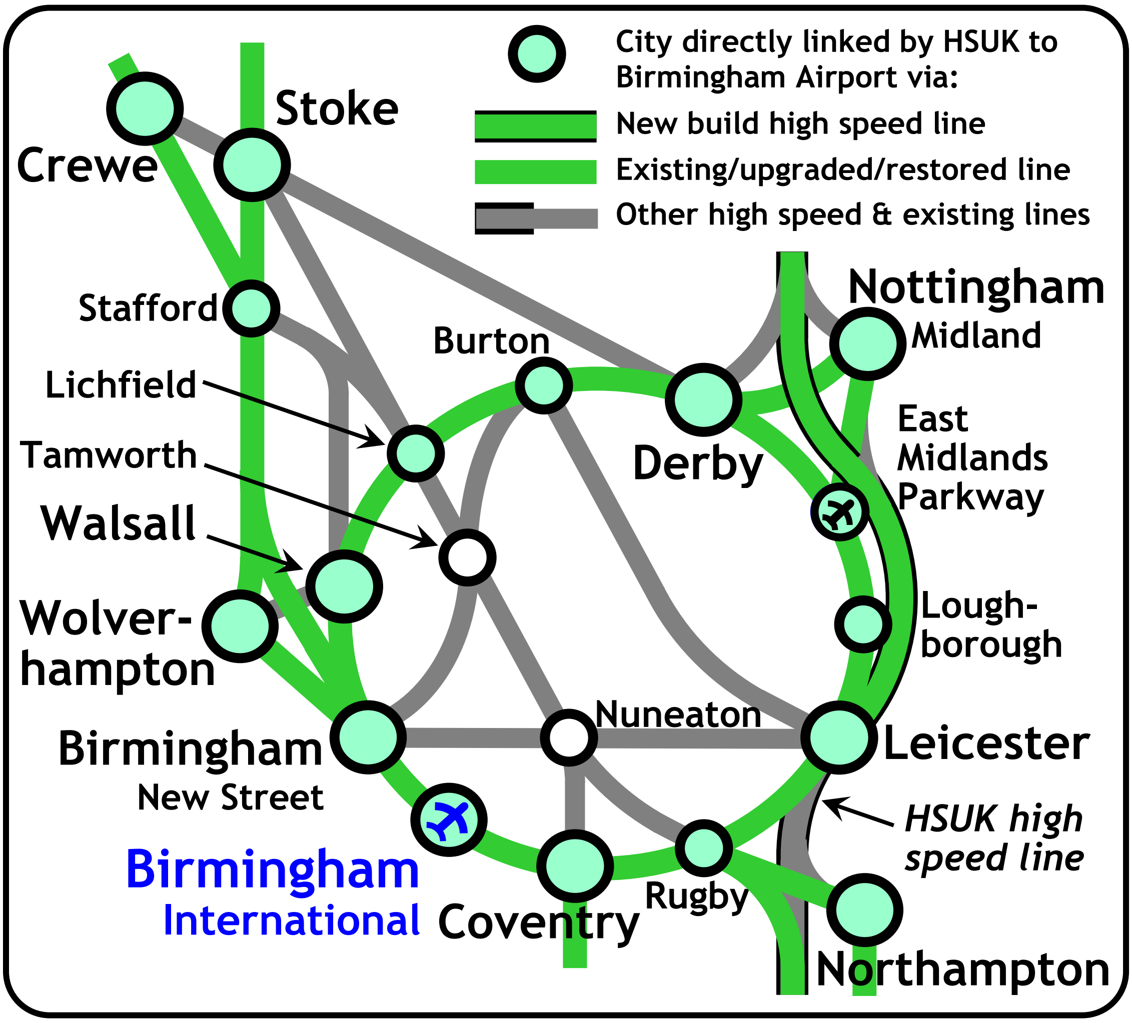


Figure 5.24 : HSUK High Speed Links to Midlands Cities from Birmingham Airport

Birmingham Airport's location on the existing main line from London to Birmingham, which is planned to be upgraded to 4 tracks, allows Birmingham Airport's connectivity to be extended to a large range of cities outside its immediate Midlands hinterland. HSUK will also link Birmingham Airport to London, Liverpool, Sheffield, Leeds, Hull and several other major cities.

The numbers of regional cities enjoying direct HS2 and HSUK links to Birmingham Airport are listed in Table 5.25 below.

HS2 to Birmingham Airport				HSUK to Birmingham Airport			
Number of direct links to Birmingham Airport from		Number of cities	Success rate	Number of direct links to Birmingham Airport from		Number of cities	Success rate
Southern cities	1	5	20%	Southern cities	4	5	80%
Midlands cities	1	10	10%	Midlands cities	9	10	90%
Northern cities	3	14	21%	Northern cities	10	14	71%

Table 5.25 : HS2 and HSUK Direct High Speed Links to Birmingham Airport

5.6.4 High Speed Links to Manchester Airport

HS2's failure to achieve worthwhile improvements in links to Manchester Airport is curiously similar to its failure in to improve links from Midlands cities to Birmingham Airport. HS2 only succeeds in creating 3 direct links, but two of these are long distance, to Birmingham and London. The third, to central Manchester, is of little or no value considering the fact that HS2's Manchester Airport station is nearly 2km from the airport that it is intended to serve.

With the HS2 'Y' unable to offer improved transpennine links, it is unsurprising that HS2 does nothing to improve links between Manchester Airport and the other cities of the Northern Powerhouse. However, HS2 does not simply fail to address the stated requirement[14] of Northern communities for enhanced direct links from all principal Northern cities to Manchester Airport. It is also positively counterproductive to this aim.

The problem stems from the fact that the HS2 spur, running via Manchester Airport to a new terminus station at Manchester Piccadilly, has been designed only to provide faster links to London. No consideration has been given to the greater priority of creating fast and efficient transpennine links between the cities of the Northern Powerhouse. Yet Transport for the North has adopted the HS2 Manchester Spur as a key element of its trunk east-west route from Liverpool to Hull and Newcastle.

Under current plans (see Figures 5.26 and 5.40) trains on this vital Northern Powerhouse route will be forced to reverse at HS2's 4-platform terminus at Manchester Piccadilly to continue eastwards to Yorkshire cities. This is totally inadequate both for the specified service frequencies (18 trains per hour arriving and 18 trains per hour departing) and also for the specified journey times (see Table 5.38). This issue is discussed in greater detail in Item 5.8.7.

[14] The requirement for direct links to Manchester Airport from all principal cities of the North is set out in *One North : A Proposition for an Interconnected North*, One North, July 2014. Note particularly the route diagram and journey time specification on pages 26 and 27, also reproduced in Figure 2.8 and Table 5.39.

Figure 5.26 : HS2 & HS3 Direct Links to Northern Cities from Manchester Airport

The High Speed UK design recognises that Manchester Airport's greatest priority for improved rail connectivity is to establish direct and accelerated rail links to all the principal communities of the North, in general accordance with the Northern Powerhouse specification set out in Table 5.38. HSUK achieves these requirements through its proposed transformation of the existing terminating Manchester Airport spur into a through 'South Manchester Loop'. This would diverge from the HSUK transpennine route to the east of Manchester, and run via new, upgraded and restored routes via Stockport, Manchester Airport and Altrincham, and rejoin the HSUK route to the west of Manchester.

HSUK's routes from Manchester Airport will extend to most principal communities of the North. With existing or projected airport links also taken into account (for instance to

Bradford and to Blackburn via the Ordsall Chord, currently under construction) Manchester Airport will enjoy near-comprehensive coverage of its regional hinterland.

The proposed transformation of Manchester Airport's existing terminus into a through station is crucial in achieving HSUK's vastly improved connectivity. Through operation not only offers routes to a greater number of destinations, all bypassing the congestion of central Manchester, it also hugely increases the station's capacity through avoiding the need for trains to stand for long periods between arrival and departure.

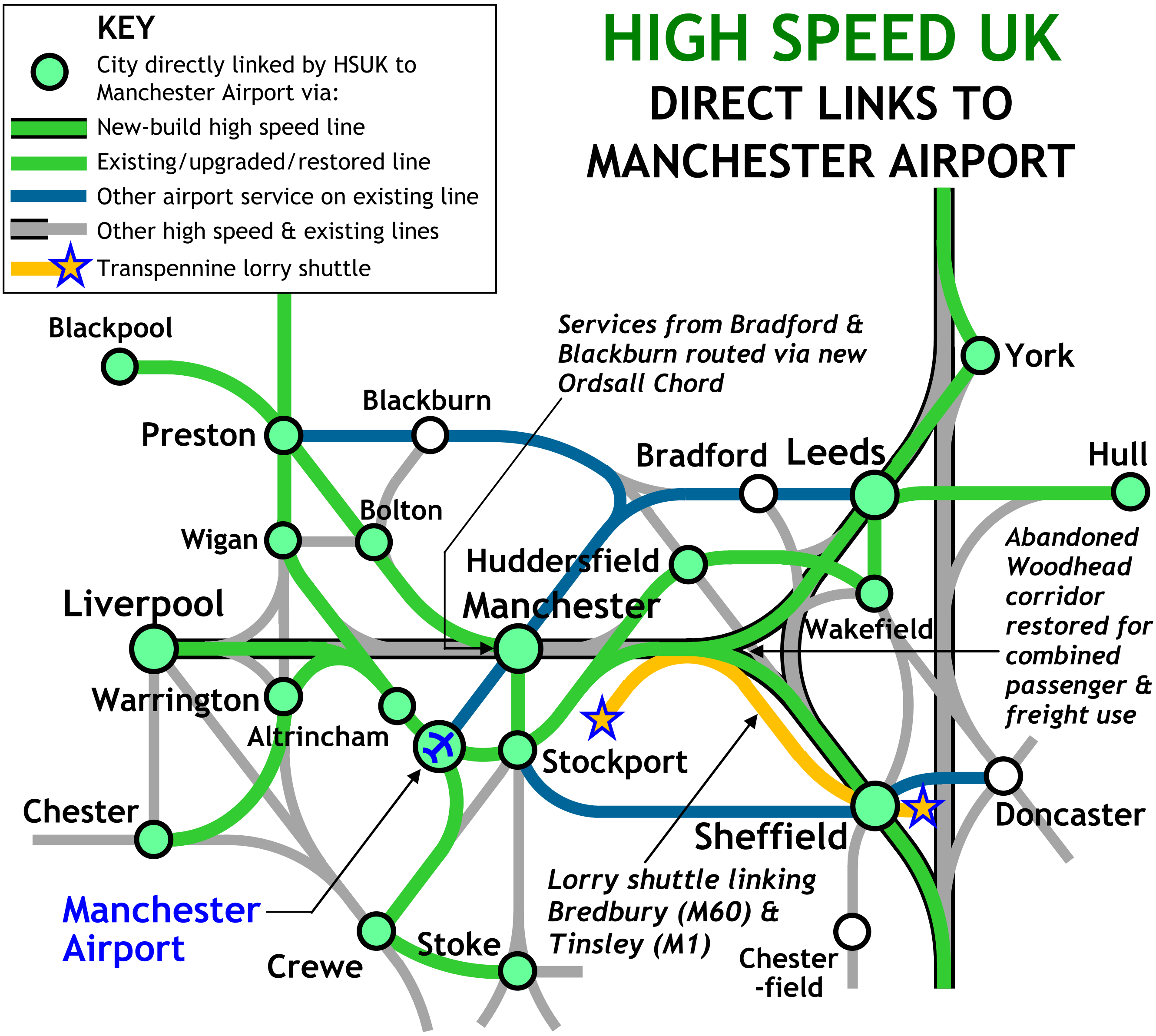


Figure 5.27 : High Speed UK Direct Links to Northern Cities from Manchester Airport

The numbers of regional cities enjoying direct HS2 and HSUK links to Manchester Airport are listed in Table 5.28 below.

HS2 to Manchester Airport				HSUK to Manchester Airport			
Number of direct links to Manchester Airport from		Number of cities	Success rate	Number of direct links to Manchester Airport from		Number of cities	Success rate
Southern cities	1	5	20%	Southern cities	0	5	0%
Midlands cities	1	10	10%	Midlands cities	2	10	20%
Northern cities	1	14	7%	Northern cities	11	14	79%

Table 5.28 : HS2 and HSUK Direct High Speed Links to Manchester Airport

5.6.5 High Speed Rail Airport Access : Conclusions

This study has demonstrated HS2's comprehensive failure to achieve effective rail links to any of the UK's principal airports. It should not be forgotten that the prospect of improved links from UK regional cities to Heathrow was one of the primary selling points of the HS2 project, and HS2's huge shortcomings in this respect constitute a massive missed opportunity to spur the regeneration of regional economies and redress the North-South divide.

HS2's failures provide the perfect illustration of a fundamental truth – that uniaxial high speed lines, such as those proposed by HS2, are totally inappropriate as means of improving connectivity between an airport and its hinterland. They fail to address any airport's 360-degree need for surface access in all directions, from all the communities near and far that rely upon the airport for their international connectivity.

This need can only be met through detailed integrated planning of airports' rail links so that they can take full advantage of the enhanced capacity and connectivity provided by new high speed rail lines. These new lines must of necessity be primarily aligned to connect cities, and it is only in the provision of connections to the existing network that efficient airport links can also be created. This is where HSUK has succeeded, and where HS2 has spectacularly failed.

5.7 HS2 : Failing to Start the Midlands Engine

The remit of the HS2 project, to connect London and the West Midlands by means of a new high speed line, was written with the clear intention of delivering major connectivity gains for all West Midlands communities.

However, the briefest examination of HS2 Ltd's proposals shows clearly that HS2 will fail to meet this simple objective. HS2 will only serve new and generally disconnected stations in the Boroughs of Birmingham and Solihull; most other West Midlands communities will be left isolated from HS2, and thereby unable to gain direct benefit. HS2 also fails to offer any direct links between the principal cities of the West or the East Midlands, and it will do nothing whatsoever to stimulate the development of a 'Midlands Engine'.

HSUK's alternative strategy of full integration with the existing network will generate far greater gains for the entire West Midlands. The required gains in capacity and connectivity are achieved not through the physical expansion of Birmingham New Street. Instead they are achieved by 4-tracking of key radial routes, and by the full inclusion of outlying centres such as Coventry, Walsall and Wolverhampton into the HSUK network.

The many initiatives in both West and East Midlands, that are necessary to create HSUK's transformed national network, will combine to create a 'Midlands Ring'. This will for the first time efficiently interconnect all the principal communities of the Midlands and also provide comprehensive links to Birmingham Airport. Unlike HS2, HSUK will deliver all of the connectivity objectives of the Midlands Engine.

5.7.1 HS2 Connectivity in West Midlands

HS2's problems of connectivity, capacity and integration set out in Sections 5.2 to 5.6 can be seen most markedly through the varying benefits that HS2 will bring to the West Midlands. It must be remembered that HS2 Ltd's remit (see Appendix A5) was to formulate proposals for a new high speed line from London to the West Midlands, and as such it would be reasonable to expect that HS2's benefits should extend to all West Midlands communities.

For the purposes of this study's Quantified Journey Time Assessment, 5 key centres of the West Midlands will be considered:

- Central Birmingham;
- Birmingham Airport;
- Coventry;
- Walsall; and
- Wolverhampton.

HS2's stations will be located in central Birmingham (the proposed Curzon Street terminus, close to the existing Moor Street station) and near Birmingham Airport (the proposed Birmingham Interchange station, linked to airport and existing Birmingham International station via a 2.5km long dedicated shuttle). The other centres of Coventry, Walsall and Wolverhampton will not be directly served by HS2.

As Table 5.29 demonstrates, the location and connectivity of HS2's stations is crucial to how HS2's benefits will be distributed. Birmingham and Birmingham Airport, both directly served by HS2, will enjoy by far the greatest journey time reductions, will be directly linked to more cities and will see more journeys made faster and fewer made worse.

	Average journey time reduction	Cities directly linked by HS2 services	Cities directly linked by existing I/C services	Journeys made faster (out of 30)	Journeys made worse (out of 30)
Birmingham	**23%**	**8**	**24**	**12**	**2**
B'ham Airport	**20%**	**6**	**12**	**9**	**4**
Coventry	**9%**	**0**	**12**	**9**	**5**
Walsall	**0%**	**0**	**2**	**0**	**10**
Wolverhampton	**2%**	**0**	**15**	**3**	**6**

Table 5.29 : HS2 Quantified Connectivity for West Midlands Cities

For major population centres such as Coventry, Walsall and Wolverhampton – which collectively comprise a population of nearly 1 million – the benefits offered by HS2 are small, and appear to be considerably outweighed by the connectivity that will be lost through the introduction of HS2. These communities, all bypassed by HS2, will experience reduced intercity services on the existing main line network, most notably Coventry which will see its present 3 trains per hour service to London reduced to a single train per hour.

5.7.2 HS2 Links to West Midlands Boroughs

HS2's connectivity performance, considered in terms of its coverage of the 7 Metropolitan Boroughs that comprise the West Midlands (see Figure 5.30), is set out in Table 5.31.

This analysis demonstrates that HS2 will achieve only very limited direct benefits for the Boroughs of the West Midlands. Only the Boroughs of Birmingham and Solihull will enjoy HS2 services; Coventry, and all 4 Boroughs located to the west of central Birmingham ie Dudley, Sandwell, Walsall and Wolverhampton will not be directly served by HS2.

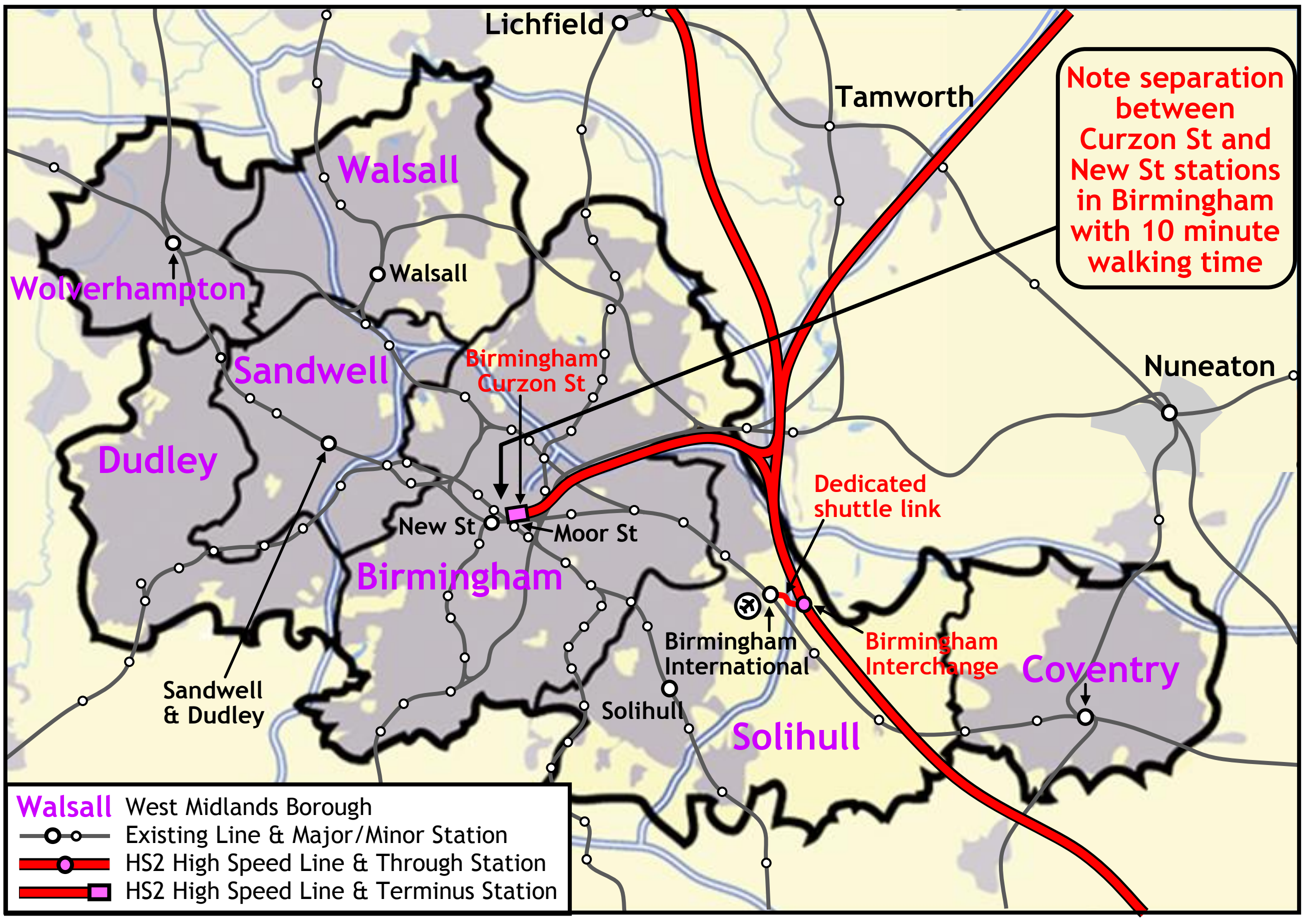


Figure 5.30 : HS2 Links to West Midlands Boroughs

West Mids Metropolitan Borough	Population/ East or West of central Birmingham?	Primary Intercity Station	Served by HS2?	Intercity services maintained?	Enhanced local services?	Local links to high speed services?
Coventry	346,000 (East)	Coventry	**No**	**No**	**Local services enhanced along B'ham-Coventry corridor**	**Fair**
Solihull	207,000 (East)	Birmingham International	**Yes – at B'ham Int**	**No**		**Poor**
Birmingham	1,102,000 (N/A)	Birmingham New St	**Yes – at Curzon St**	**No**		**Poor**
Dudley	323,000 (West)	Sandwell & Dudley	**No**	**Limited i/c services to Sandwell & Dudley maintained**	**No**	**Links to HS2 via B'ham Moor St**
Sandwell	313,000 (West)	Sandwell & Dudley	**No**		**No**	
Wolver-hampton	250,000 (West)	Wolver-hampton	**No**	**?**	**No**	**Poor**
Walsall	279,000 (West)	Walsall	**No**	**N/A**	**No**	**Poor**

Table 5.31 : HS2 Connectivity Effects for West Midlands Boroughs

Any capacity benefits for local services – for instance along the Coventry-Birmingham corridor – will be achieved only by means of reducing existing intercity service levels. By contrast, along routes where existing intercity service levels will generally be maintained – for instance along the Birmingham-Wolverhampton corridor via Sandwell & Dudley – it will not be possible to enhance local services.

5.7.3 HS2 Implications for the Midlands Engine

As noted previously, the remit of the HS2 project was for a high speed line from London to the West Midlands conurbation, not just to central Birmingham and to a poorly-located peripheral parkway station. With such lack of connectivity, and especially with only 2 stations in the entire West Midlands region, it is difficult to see how HS2 will fulfil its fundamental remit and materially improve the local economy.

HS2's almost complete misalignment with the major communities of the West and East Midlands is illustrated in Figure 5.32.

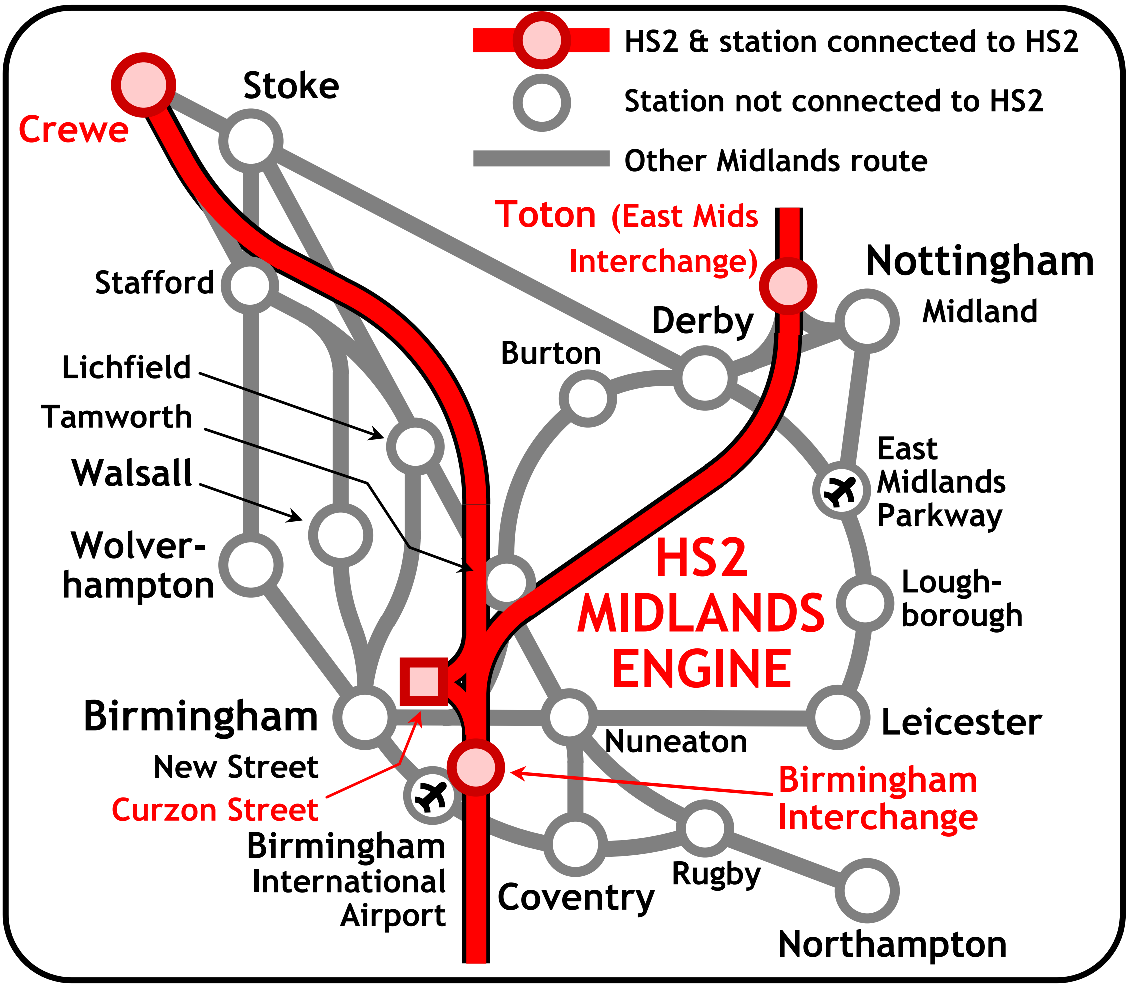


Figure 5.32 : HS2 and the Midlands Engine

In terms of service provision, HS2's failure to interconnect the Midlands cities that represent the 'Midlands Engine' is laid out in Figure 5.33. In a fully interconnected Midlands Engine, 55 direct links would exist between the 11 centres (10 towns/cities and 1 airport); however, HS2 offers not a single direct link, and it only succeeds in offering direct links from 2 of the 11 centres to London.

	HS2 Direct Intercity Link
o	No HS2 Direct Link

Coventry	CV										
B'ham Airport	o	BHX									
Birmingham	o	o	BI								
Wolverhampton	o	o	o	WV							
Walsall	o	o	o	o	WS						
Crewe	o	o	o	o	o	CW					
Stoke	o	o	o	o	o	o	ST				
Derby	o	o	o	o	o	o	o	DE			
Nottingham	o	o	o	o	o	o	o	o	NG		
Leicester	o	o	o	o	o	o	o	o	o	LE	
Northampton	o	o	o	o	o	o	o	o	o	o	NN
	CV	**BHX**	**BI**	**WV**	**WS**	**CW**	**ST**	**DE**	**NG**	**LE**	**NN**
London	o	o		o	o		o	o	o	o	o

Figure 5.33 : HS2 Direct Intercity Connectivity between Midlands Engine Cities

The analysis presented in Figure 5.33 is based upon the proposed HS2 services set out in Figure A2.2 in Appendix A2. This analysis is based upon the following provisos:

- Despite HS2's projected high speed lines offering a possible direct connection between Birmingham Curzon Street and Crewe Hub, no HS2 services are proposed to link these two stations.
- The HS2 link from Birmingham Interchange station to Birmingham Curzon Street is not accepted as a direct link from Birmingham Airport to either Birmingham or Crewe, since an additional shuttle connection 2.5km long must be made from the existing Birmingham International station.
- With no proposals for a link from HS2 to the existing network at, or in the vicinity of Toton/East Midlands Interchange, there is no possibility of a direct HS2 link from Birmingham to Nottingham.

It is clear that with HS2 failing either to connect most Midlands communities to London, or to provide any direct connections between these communities, it is failing in its fundamental requirement, to deliver "**hugely enhanced... connectivity**". HS2 will neither be any sort of 'Engine for Growth' for the West Midlands, nor do anything to promote the cause of the 'Midlands Engine' which is at the heart of current economic initiatives for the region.

5.7.4 Consequences of HS2 Ltd's Selection of Birmingham Curzon Street

The adverse impacts of HS2 upon the West Midlands are greatly exacerbated by the selection of Curzon Street station as HS2's terminus in Birmingham in favour of New Street station. New Street is the natural hub of the West Midlands regional network, with Coventry, Walsall and Wolverhampton prominent among the many destinations served; the selection of Curzon Street, remote from New Street and requiring a 10 minute walking transfer, leaves most West Midlands communities effectively disconnected from HS2. It is also significant to note that even for Birmingham, which will enjoy the greatest number of HS2 connections, the majority of its intercity links will continue to operate from New Street station.

These connectivity issues call into question the rationale by which Curzon Street was selected as HS2's Birmingham station. This rationale appears to have been based upon an unquestioning acceptance of the major problems that currently exist at New Street. Its platforms are too short, and its approaches too narrow, to accommodate the high-capacity 400m long wide-bodied rolling stock that is planned to operate on HS2, and it is not physically possible to expand the station into surrounding property. The station is also already congested with local, regional and intercity services, and appears to lack the capacity to accommodate extra high speed services.

These are the considerations, essentially of capacity, congestion and potential disruption, that have led HS2's planners to select Curzon Street. But in attempting to optimise capacity, the more important consideration of connectivity has been neglected. Curzon Street's remoteness from New Street has the local effect of leaving the majority of the West Midlands conurbation isolated from HS2, and unable to benefit from any improved connectivity that it might offer.

The selection of Curzon Street also compromises the very integrity of the entire national intercity network. Birmingham New Street can justly be claimed to be the primary hub of this network, crucial for a huge range of cross-country connections, and many of these connections will be effectively severed by the introduction of the walking transfer between Curzon Street and New Street. This walking transfer, dictated by the selection of Curzon Street as Birmingham's HS2 terminus, is greatest single factor causing journeys to be made worse by HS2. Of the 94 journeys identified in this study as being made worse by HS2, 38 are directly attributable to the enforced walking transfer from Birmingham Curzon Street to Birmingham New Street.

It is deeply concerning that these local and national connectivity issues appear to have gone unrecognised in the development of HS2 proposals for Birmingham. The HS2 'solution' of the disconnected Curzon Street terminus has been superimposed, with no attempt to integrate with New Street station, or to resolve its capacity and congestion problems. This renders HS2 unfit for purpose both as a national intercity network and as the primary means of enhancing the capacity of the West Midlands network.

HS2 Ltd's selection of Curzon Street also fails entirely to understand the lessons of history. Curzon Street is also the site of the Birmingham's original intercity railway station, opened in 1838. Curzon Street was the Birmingham terminus of the London and Birmingham and the Grand Junction railways, which in 1846 coalesced into the London & North-Western Railway (LNWR). The LNWR rapidly found its Curzon Street terminus to be inefficient and impractical for their priority of running a national system with regional and longer-distance services crossing the West Midlands. The Midland Railway had exactly the same problem with its Lawley Street terminus, and in consequence the Midland and the LNWR combined to establish in 1854 the more central New Street station, which still serves Birmingham to this day.

The same priorities for through operation, fully integrated with other rail services, seem certain also to render HS2 Ltd's Curzon Street vision impractical and obsolete in the 21st century. As Edmund Burke (1729-1797) remarked: "Those who do not understand history are destined to repeat it."

No attention appears to have been given to the counterfactual alternative proposition, that if the necessary measures were taken to enhance the capacity of the existing network focussed upon New Street, then sufficient capacity would be generated at New Street to enable greater improvement in both national and local services, operating from a single integrated hub.

5.7.5 High Speed UK Connectivity in West Midlands

The benefits of such an integrated approach can be clearly seen in Table 5.34. This details the vastly improved connectivity, in terms of both journey time improvement and direct intercity links that High Speed UK will deliver for all principal centres of the West Midlands. This far outperforms anything that HS2 can offer.

	Average journey time reduction	Cities directly linked by HSUK services	Cities directly linked by existing I/C services	Journeys made faster (out of 31)	Journeys made worse (out of 31)
Birmingham	**36%**	**29**	**24**	**28**	**0**
B'ham Airport	**43%**	**24**	**12**	**29**	**0**
Coventry	**48%**	**24**	**12**	**29**	**0**
Walsall	**59%**	**18**	**2**	**31**	**0**
Wolverhampton	**47%**	**27**	**15**	**31**	**0**

Table 5.34 : HSUK Quantified Connectivity for West Midlands Cities

The necessary enhanced capacity cannot be achieved through the physical expansion of New Street station, which has rightly been deemed totally impracticable. Instead, it is achieved through the upgrading and 4-tracking of key radial routes towards Coventry, Derby and Wolverhampton/Walsall, as illustrated in Figure 5.35 below. In the latter case, 'virtual 4-

tracking' is achieved by means of constructing a new line from Soho Junction (on the Birmingham-Wolverhampton 'Stour Valley' line 3km west of New Street) to Tame Bridge (on the Birmingham-Walsall 'Grand Junction' line near Walsall). This enables the following benefits:

- segregation of local flows from intercity flows – creating far more capacity, both for local and intercity traffic, than HS2's segregated new lines possibly can.
- elimination of any necessity to terminate or reverse trains at New Street – reducing platform occupation times and thus allowing greatly increased train flows through the station.
- creation of a new main line to Walsall and faster north-westerly intercity 'exit route' from West Midlands.
- inclusion of the outlying communities of Coventry, Walsall, Wolverhampton and Derby into the HSUK network.

It is particularly significant to note that HSUK's full integration delivers the greatest benefits to Walsall, the West Midlands community which currently has the poorest connectivity. By contrast HS2's segregation tends to concentrate benefits at locations such as central Birmingham which already have the best connectivity.

5.7.6 HSUK Links to West Midlands Boroughs

HSUK's success in delivering enhanced connectivity and capacity to the principal rail hubs of the West Midlands is replicated in the much greater spread of benefits that are achieved for all of the region's 7 Boroughs, see Figure 5.35.

The analysis set out in Table 5.36 demonstrates that HSUK will deliver connectivity benefits for all of the West Midlands Boroughs that are an order of magnitude greater than what HS2 can achieve for the region. It must be stressed that they are all achieved as a natural consequence of the 4-tracking (or 'virtual 4-tracking') of the primary routes focussed on Birmingham New Street. There is no need for further local connectivity projects and major associated expenditure to allow HSUK's local connectivity and capacity benefits to be exploited to the full.

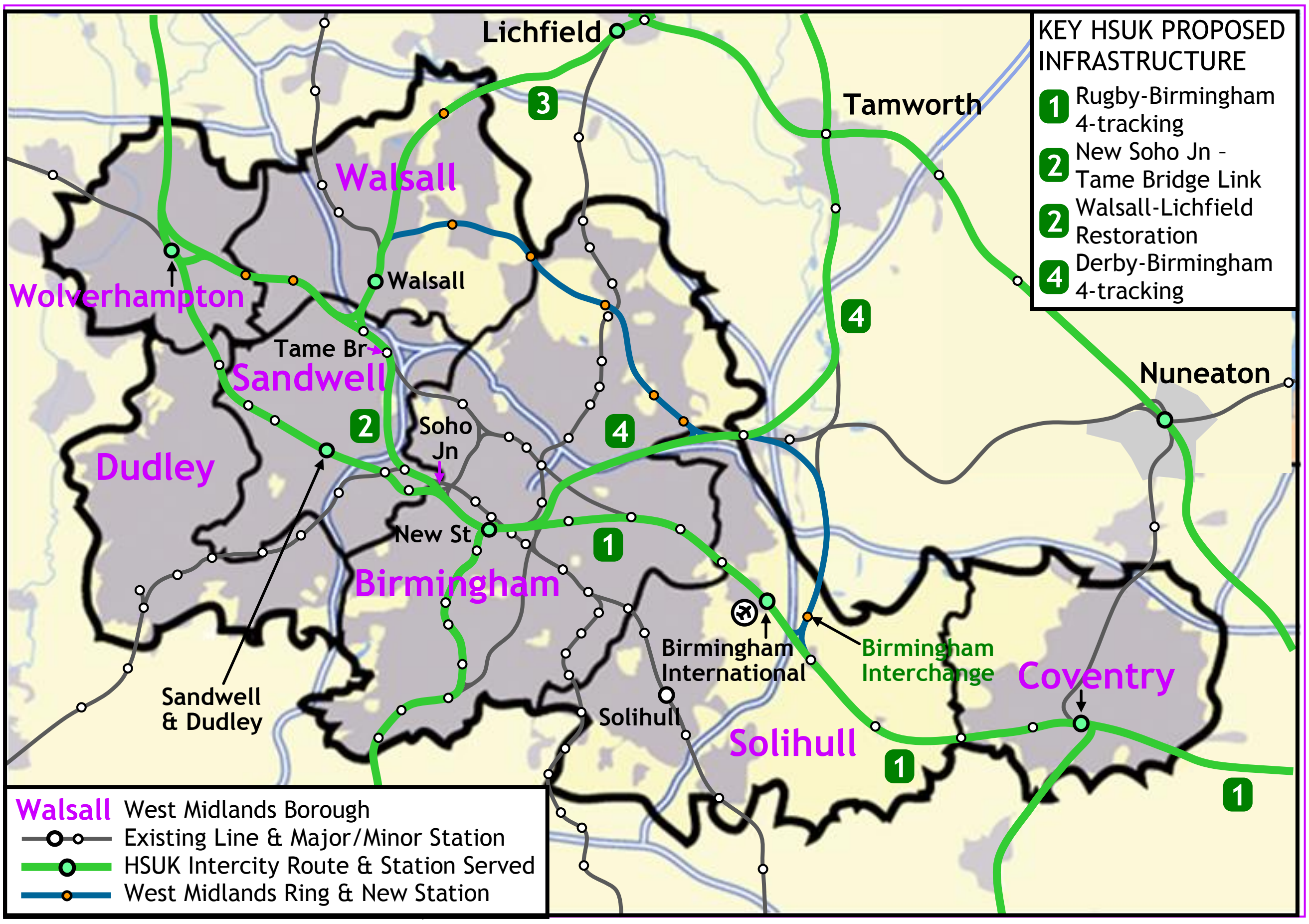


Figure 5.35 : HSUK Links to West Midlands Boroughs

West Mids Metropolitan Borough	Population/ East or West of central Birmingham?	Primary Intercity Station	Served by HSUK?	Intercity services maintained?	Enhanced local services?	Local links to high speed services?
Coventry	346,000 (East)	Coventry	**Yes**	**Yes**	**Local services enhanced along Coventry - B'ham - W'hampton corridor, with effective 4-tracking of radial routes**	**Yes**
Solihull	207,000 (East)	Birmingham International	**Yes**	**Yes**		**Yes**
Birmingham	1,102,000 (N/A)	Birmingham New St	**Yes**	**Yes**		**Yes**
Dudley	313,000 (West)	Sandwell & Dudley	**Yes**	**Yes**		**Comprehensive HSUK links at Birmingham & Wolverhampton**
Sandwell	323,000 (West)	Sandwell & Dudley	**Yes**	**Yes**		
Wolver-hampton	250,000 (West)	Wolver-hampton	**Yes**	**Yes**		**Yes**
Walsall	279,000 (West)	Walsall	**Yes**	**Yes**	**Yes**	**Yes**

Table 5.36 : HSUK Connectivity Effects for West Midlands Boroughs

5.7.7 HSUK Benefits for the Midlands Engine

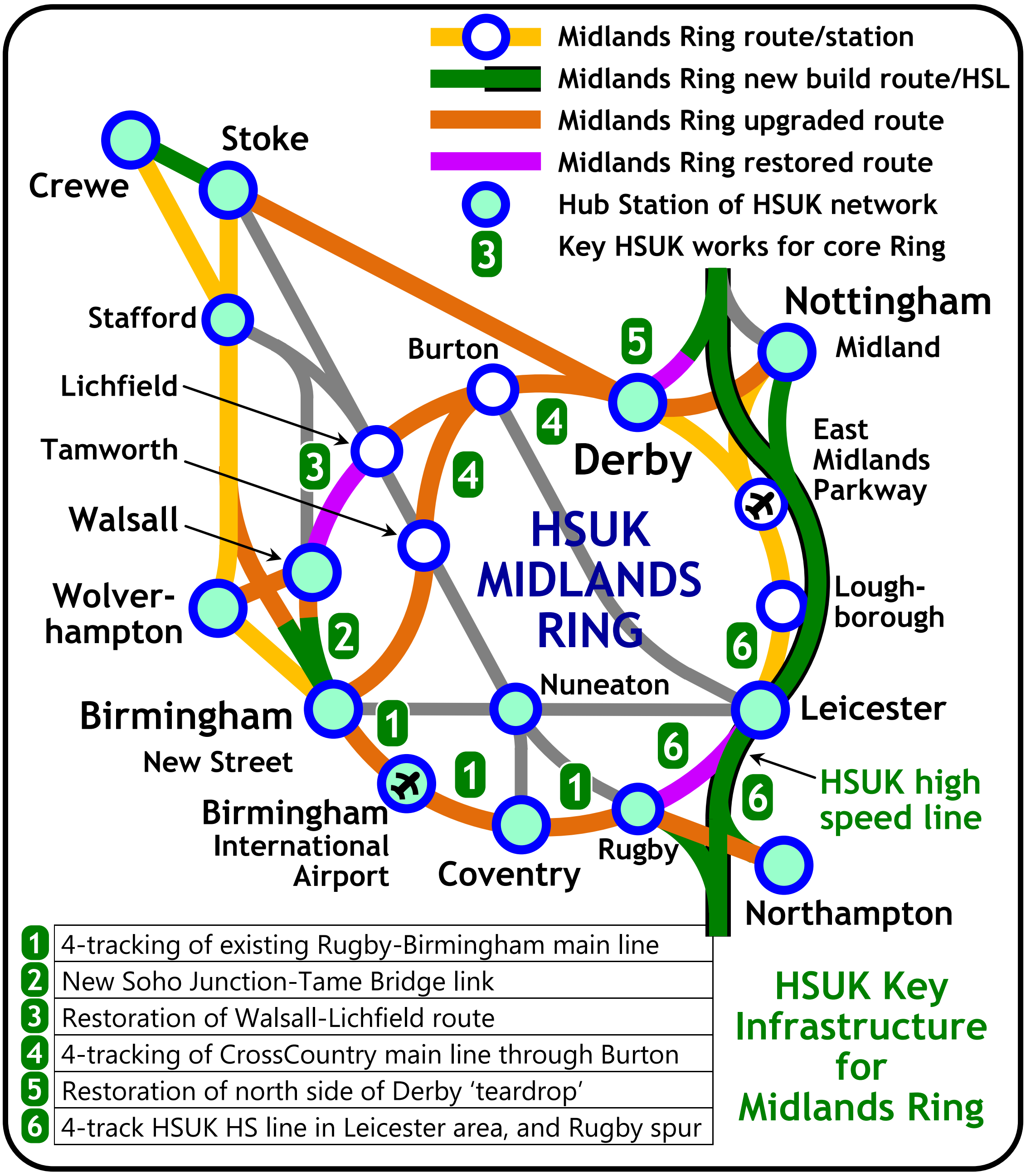


Figure 5.37 : HSUK and the Midlands Ring

The full benefits of HSUK's fully integrated approach can be seen in the creation of a 'Midlands Ring' (see Figure 5.37) that will for the first time directly interlink all principal communities of the West and East Midlands. Such connectivity – for instance Coventry-Leicester or Walsall-Derby-Nottingham direct links – is essential for an efficiently-functioning regional rail network at the heart of a 'Midlands Engine'; yet it will come about effectively as a byproduct of HSUK's initiatives to establish an optimised and fully integrated national network.

HSUK's success in achieving direct intercity links between the 11 principal centres of the Midlands Engine can be appreciated from Figure 5.38. The HSUK services listed in Appendix A1 will provide direct links, at hourly or better frequencies, 53 of the 55 possible journeys. For the remaining two journeys (Walsall to Crewe and Walsall to Northampton) easy connections will be available at Wolverhampton and Birmingham New Street respectively.

	HSUK Direct Intercity Link
o	No HSUK Direct Link

Coventry	CV										
B'ham Airport		BHX									
Birmingham			BI								
Wolverhampton				WV							
Walsall					WS						
Crewe					**o**	CW					
Stoke							ST				
Derby								DE			
Nottingham									NG		
Leicester										LE	
Northampton					**o**						NN
	CV	**BHX**	**BI**	**WV**	**WS**	**CW**	**ST**	**DE**	**NG**	**LE**	**NN**
London											

Figure 5.38 : HSUK Direct Intercity Connectivity between Midlands Engine Cities

5.8 HS2 : Unwittingly Sabotaging the Northern Powerhouse

The failure of HS2 Ltd to include any transpennine link between Northern cities in its initial proposals (in 2010) for the HS2 'Y' led ultimately to the belated launch (in 2014) of proposals for 'HS3' transpennine links as part of a wider 'Northern Powerhouse' strategy. The HS3 initiative is underpinned by a detailed specification for improved journey times between the principal cities of the North, and from these cities to Manchester Airport.

Detailed examination of the timelines for both HS2 and HS3 projects raises serious concerns that the Government's greater commitment to HS2 will lead to increased London-centricity in the national transport system. This can only be to the detriment of Northern economies. The apparent 'dilution' of the new-build HS3 project into the 'Northern Powerhouse Rail' concept for upgraded transpennine routes gives further cause for concern.

However, the greatest cause for concern lies with the fact that HS2's routes and stations – which were designed with no thought for improved transpennine connectivity – will form the basis for Transport for the North's Northern Powerhouse Rail plans for improved 'HS3' transpennine links. This fundamental 'logic gap' will leave the Northern economy crippled by a dysfunctional and inefficient transport system:

- Two separate new transpennine routes required;
- No transpennine freight strategy;
- Terminus station in Manchester unable to cope with through flows;
- Circuitous and slow route from Manchester to Liverpool;
- No relief to existing congestion at Leeds station;
- Unsuitable station in Sheffield located on 66km long loop
- Many Northern cities bypassed by HS3;
- York bypassed by future HS3 line to Newcastle.

By basing HS3 upon the established HS2 proposals, HS3 will never deliver the efficient transpennine rail links demanded by the Northern Powerhouse specification.

All of these problems are avoided in the High Speed UK scheme. HSUK has been designed from the outset with a transpennine route to Manchester and Liverpool that will be fully integrated with the HSUK north-south spine and fully integrated with the existing network. As a result, HSUK will meet all the requirements of the Northern Powerhouse specification.

5.8.1 Origins of HS3 and the Northern Powerhouse

The 'Northern Powerhouse' represents a political aspiration for major enhancements in the economic performance of the North of England, and the development of 'HS3' transpennine rail links is a key element in a suite of proposed infrastructure improvements. The HS3 concept (launched in 2014) arose from sustained regional political pressure in reaction to the most glaring deficiency of the HS2 proposals (first published in 2010) i.e. the lack of any transpennine link between northern cities.

5.8.2 Specification for Journey Time and Train Frequency

The HS3 project, now generally termed 'Northern Powerhouse Rail', is being developed by Transport for the North to a specification[15] which details the accelerated timings and enhanced frequencies to be achieved on key intercity and city-to-airport journeys between the principal cities of the North. A clear requirement for HS3 to serve city centre stations has also been established. The required timings and frequencies are set out in Table 5.39 below.

Journey between Northern Powerhouse cities	**Existing journey time** (mins)	**Specified journey time** (mins)	**Specified frequency** (trains per hour)
Sheffield-Leeds	40	30	6
Liverpool-Manchester	32	20	6
Manchester-Sheffield	48	30	6
Manchester-Leeds	49	30	6
Manchester-Manchester Airport	13	10	10
Leeds-Manchester Airport	62##	40##	2
Sheffield-Manchester Airport	73	30	2
Liverpool-Manchester Airport	65	30	2
Leeds-Newcastle	87	60	4
Leeds-Hull	55	45	2
Sheffield-Hull	86	60	2

calculated by adding specified Manchester to Leeds and Manchester to Manchester Airport journey times

Table 5.39 : Northern Powerhouse Journey Time & Train Frequency Specification

5.8.3 Longer Distance Direct Connections between Northern Cities

The timings given in Table 5.39 primarily address connections between 'adjacent city pairs' e.g. Liverpool-Manchester or Manchester-Leeds. But if the Northern Powerhouse is to function as a well-integrated economic unit, direct journeys must also be offered between

[15] The requirement for improved links (passenger and freight) between all principal cities of the North, and from these cities to Manchester Airport, was originally set out in *One North : A Proposition for an Interconnected North*, One North, July 2014. Note particularly the route diagram and journey time specification on pages 26 and 27 of the *One North* document. These are replicated in this study in Figures 2.8 and 5.39.

more distant city pairs e.g. Liverpool-Leeds, with at least a proportion of Liverpool-Manchester services extending to Leeds and ultimately either Hull or Newcastle. On this basis, the specification for the Liverpool-Newcastle link might reasonably be taken to be a single direct service per hour and a journey time of 110 minutes (=20+30+60), with a small additional allowance for dwell time at both Manchester and Leeds.

Similarly, as noted in Table 5.36, the specification for the Leeds-Manchester Airport link has been developed by adding the journey times of the two individual elements (Manchester-Leeds and Manchester-Manchester Airport) and by assuming a requirement for a 2 train per hour frequency to match the current service provision.

5.8.4 HS3 – no change in Government priorities

Whilst the belated launch of the HS3 initiative has been proclaimed by many as a change in Government priorities, the detailed timeline and official terminology reveal little change in the original London-centric emphasis of the UK high speed rail project:

- Just 14 months after the HS2 project was launched in January 2009, Phase 1 proposals (from London to the West Midlands) were published in March 2010, and were put forward for public consultation 1 year later, in 2011.
- To date (June 2017) it is now 3 years since then-Chancellor George Osborne launched the HS3 project. So far, the only detail to emerge is the journey time and frequency specification set out in Table 5.39.
- With recent rebranding of HS3 to 'Northern Powerhouse Rail' (NPR), the project has been refocussed upon the upgrading of existing routes rather than constructing new lines. There is a clear concern that this more incremental approach cannot deliver the step-change improvements in transpennine connectivity and capacity necessary to bring about the Northern Powerhouse.
- This is confirmed by detailed HSUK analysis of existing Manchester-Leeds (Diggle) and Manchester-Sheffield (Hope Valley) transpennine routes. This analysis indicates that there is no cost-effective option to upgrade these routes on their existing alignments to achieve the specified journey times. These timings are only achievable through the construction of extreme lengths of tunnel – around 25km for the Diggle route and a single tunnel over 30km long for the Hope Valley route.
- These lengths of tunnel, which would be unprecedented for a UK main line railway, are greatly in excess of what would be required for the HSUK scheme for a dedicated transpennine high speed line following the abandoned 'Woodhead' route, linking Manchester to both Sheffield and Leeds.

The Government's continued determination to prioritise the London-centric HS2 'Y' over transpennine HS3 links will have the inevitable effect of concentrating connectivity, and therefore economic activity, upon London and the South-East. Implementation of HS2's new north-south links, with no corresponding improvement in east-west transpennine connectivity, will clearly be to the detriment of the economy of the entire North of England.

The adverse economic effects will at best be only partially remedied by belated completion of HS3 to an as yet unspecified timescale. This argument of economic imbalance – which led to the HS3 proposals in the first place – is commonly recognised, and does not need to be developed further in this study.

5.8.5 HS2 – direct adverse effects upon HS3 & Northern Powerhouse

What has so far gone unrecognised is the hugely adverse effect that HS2 will have on the development of efficient high speed transpennine links necessary for the Northern Powerhouse. HS3/Northern Powerhouse Rail should offer cost-effective high speed links between Northern cities of equivalent quality to what HS2 might offer for links to London, and this is reflected in the Northern Powerhouse specification set out in Table 5.39.

However, these ambitions will be frustrated by the need to retrofit HS3's transpennine high speed links onto the established HS2 proposals for both routes and stations in the North – which were of course developed with no thought for future transpennine high speed links.

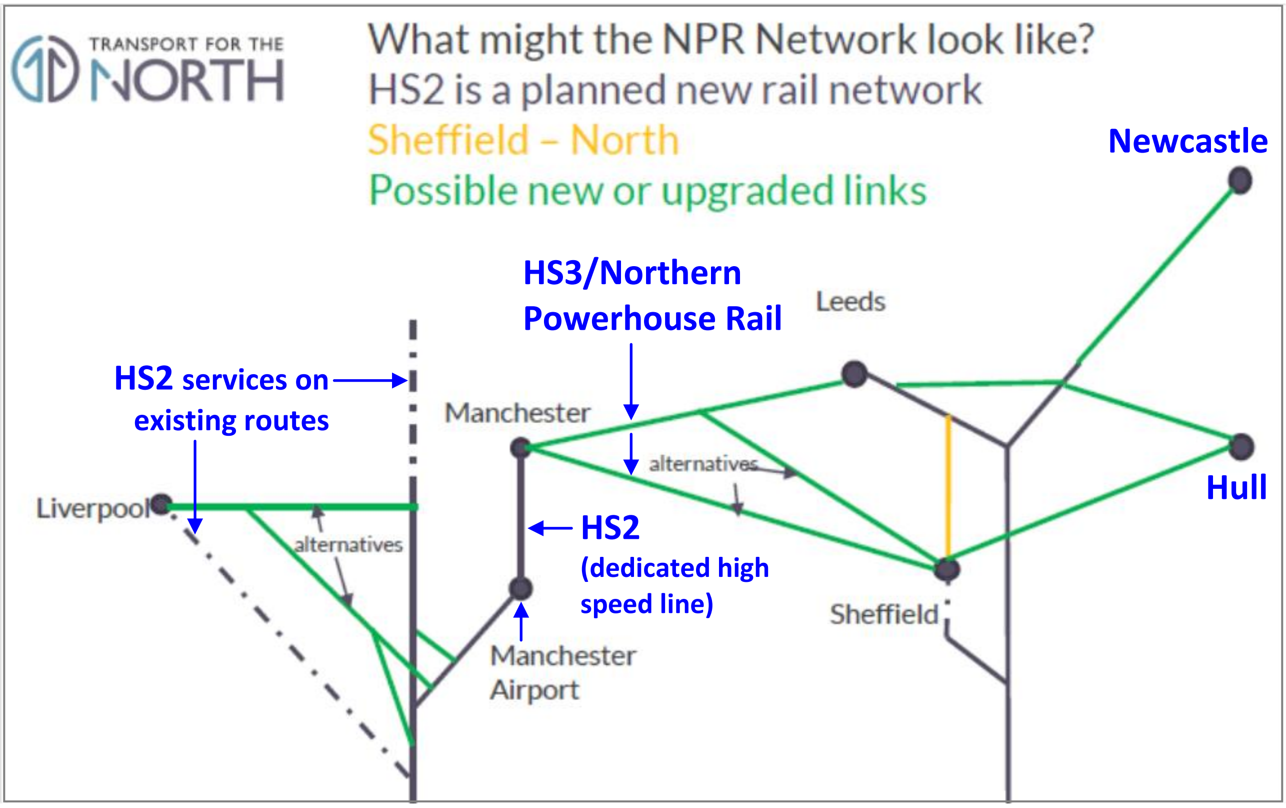


Figure 5.40 : HS3/Northern Powerhouse Rail links retrofitted onto HS2 proposals
Slide from Transport for the North presentation dated 21/2/17, captions (in blue) added by CSE

The terminus stations proposed for Manchester and Leeds, both located on spurs from north-south through routes, offer the clearest evidence of the unstructured London-centric thinking that underpins the current HS2 proposals. Not only are these stations plainly incompatible with future long distance transpennine routes, running from Liverpool through Manchester and Leeds to either Hull or Newcastle, they can be (in the case of the proposed HS2 terminus at Manchester Piccadilly, see Item 5.8.8) positively counter-productive to achieving this aim.

In other words, building HS2 to its current London-centric design will make it harder, not easier to achieve the efficient HS3 transpennine links essential for the Northern Powerhouse. Figure 5.41 shows the relationship between the defined HS2 scheme and likely HS3 routes, and highlights the principal concerns by which HS2 compromises HS3.

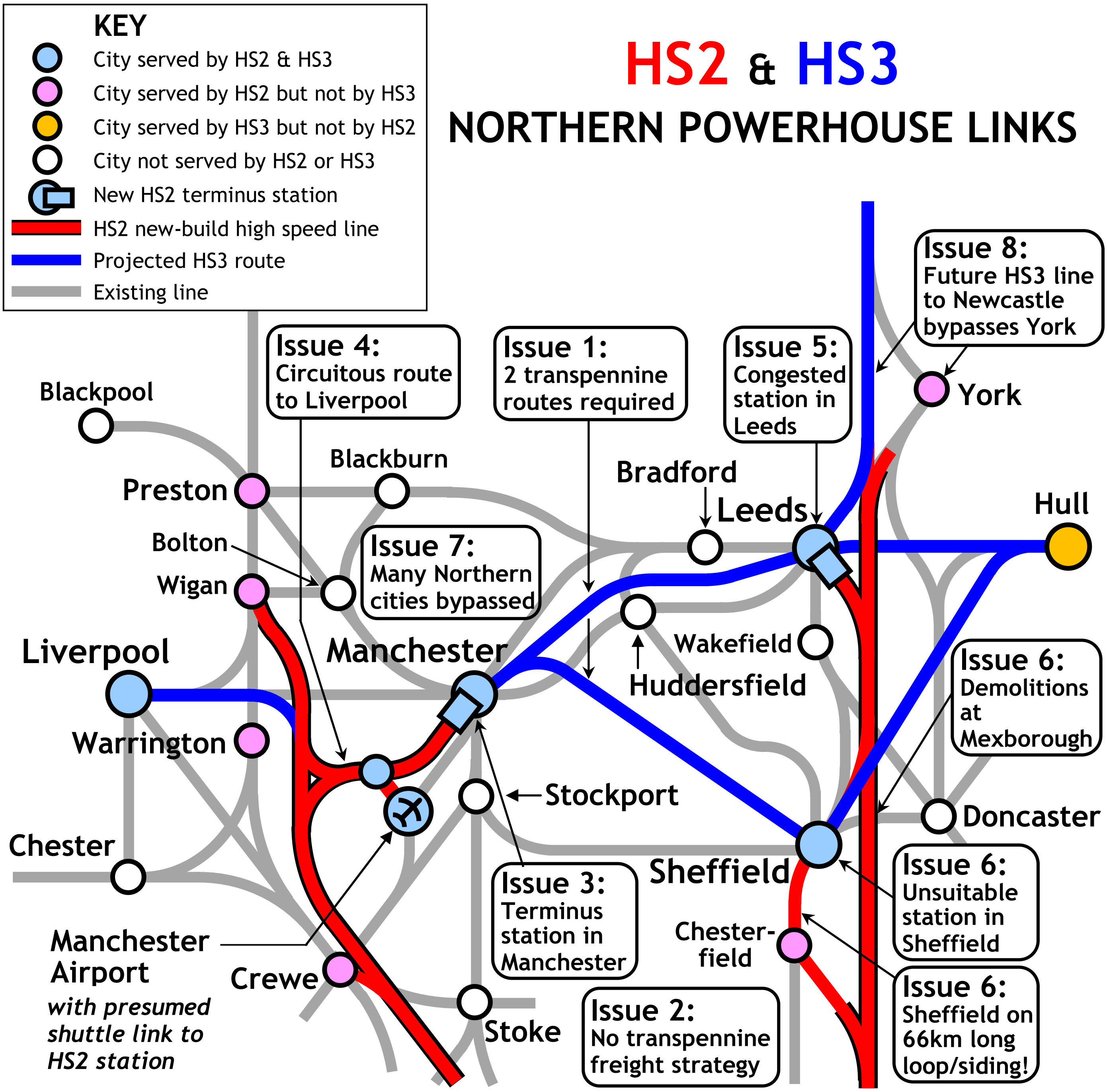


Figure 5.41 : HS2 & HS3 in Northern Powerhouse region

5.8.6 Issue 1 : Two separate new transpennine routes required

With the eastern arm of the HS2 'Y' passing just east of both Sheffield and Leeds, and with the necessary connections to central stations in both cities, the proposed HS2 infrastructure seems well aligned with the requirement for a Northern Powerhouse connection between Sheffield and Leeds. Detailed analysis by HSUK confirms that with the necessary upgrade to 4 tracks of the northward route from Sheffield Midland to the HS2 connection at Thurnscoe, the specified 30 minute Sheffield-Leeds journey time can be achieved.

With HS2's north-south route providing the basis of the Northern Powerhouse route between Sheffield and Leeds following, attention has then turned to the next perceived priority, a Manchester-Leeds route. At some point in the future, the question of a Manchester-Sheffield route will probably also be addressed, and this will ultimately lead to a triangle of routes linking the 3 cities. This triangle will include 2 transpennine crossings and will require – according to HSUK analysis – around 59km of tunnel to meet the journey time specification, and 199km of new or upgraded route.

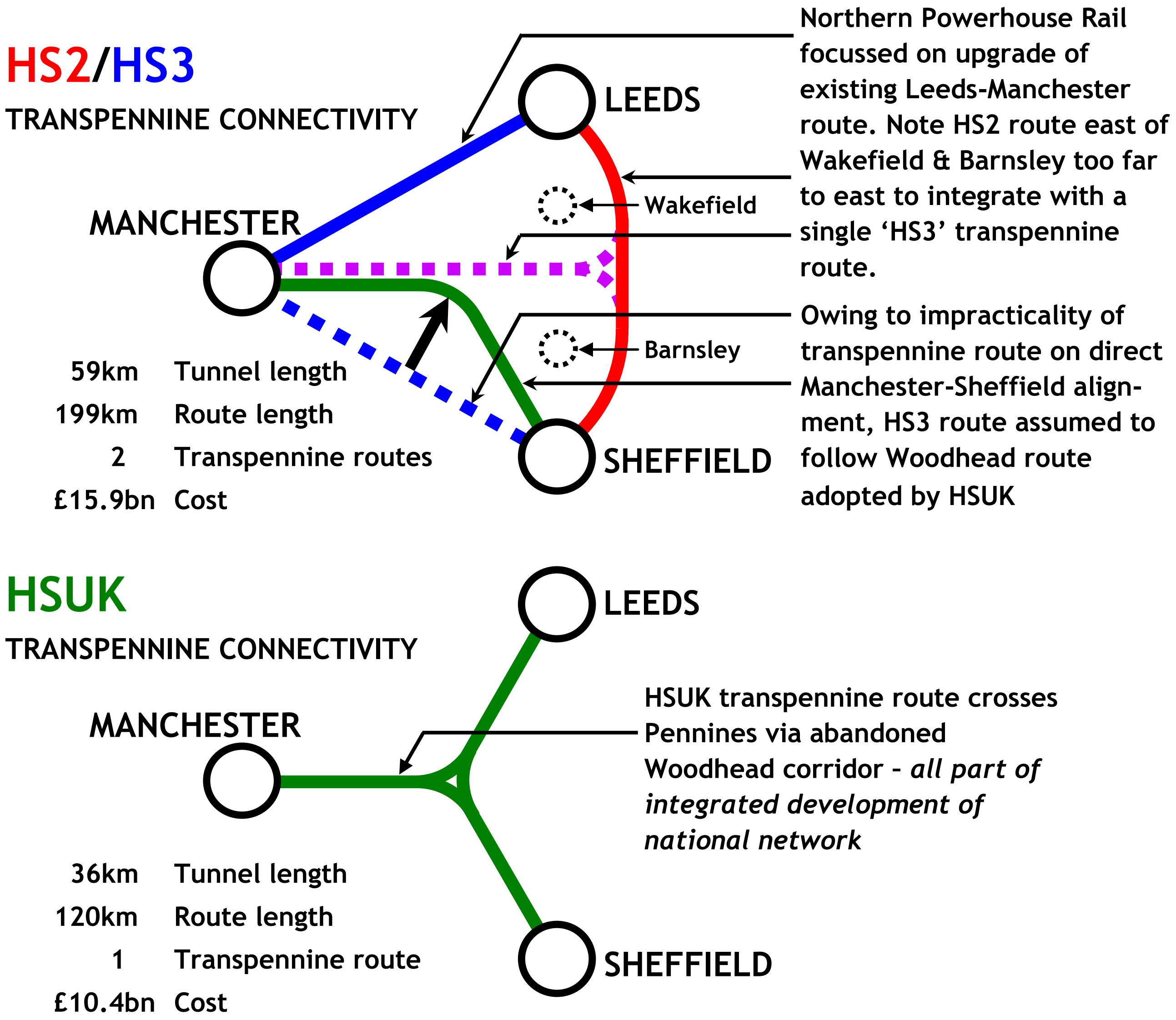


Figure 5.42 : HS2/HS3 and HSUK Performance in the Transpennine Triangle

Any rational examination of an upgrade of the Hope Valley line that requires over 30km of tunnel (which would be by far the longest main line tunnel in the UK) should require other less direct routes to be considered. The abandoned Woodhead route, located 15km to the north, is the obvious alternative; as the detailed HSUK design demonstrates, a high speed line routed along this corridor can easily meet the Northern Powerhouse journey time specification (see Table 5.39) and requires far less tunnelling than the Hope Valley route.

Accordingly, for comparisons between HS2/HS3 and HSUK transpennine 'solutions' (see Figure 5.42) the Manchester-Sheffield elements of the HSUK Woodhead route have been 'donated' to HS3.

As demonstrated in Figure 5.42, HSUK's '3-pointed star' configuration allows a much more efficient connection between the 3 cities. Only a single transpennine route (following the abandoned Woodhead corridor) is required, with a greatly reduced overall route length and a greatly reduced length of tunnel. These advantages will combine to give a cost saving of around £5.5 billion.

5.8.7 Issue 2 : No transpennine freight strategy

The fragmented and sequential approach to developing transpennine HS3/ Northern Powerhouse Rail links, as described in preceding paragraphs, has so far taken no account of a parallel requirement to develop an enhanced transpennine freight route. This was a key requirement of the 'One North' initiative on which the current Northern Powerhouse programme is based.

An enhanced transpennine freight route should be capable of offering greater capacity for more frequent and larger-bodied freight trains. Such improvements will be impossible to achieve along the Manchester-Leeds 'Diggle' corridor currently under consideration. Any freight improvements will only become possible at a much later date, and only if the HS3/ Northern Powerhouse Rail link between Manchester and Sheffield were to be developed along the lines of the HSUK scheme, see below.

HSUK's proposed restoration of the abandoned Woodhead route will establish a new 4-track railway between Manchester and Sheffield, with the existing trackbeds devoted to freight and local passenger traffic. The HSUK scheme will include a 'rolling road' lorry shuttle connection between the M60 at Bredbury in Greater Manchester and the M1 at Tinsley in South Yorkshire (see Figure 5.45). Implementation of this lorry shuttle will greatly reduce congestion on the A628(T) Woodhead Road, and will allow trunk HGV bans to be imposed on most transpennine roads between the A50 and the M62.

5.8.8 Issue 3 : HS2 terminus station in Manchester unable to cope with through HS3 flows

Transport for the North publicity material (see Figure 5.40) shows the HS3/NPR Liverpool-Manchester route to follow the planned HS2 spur to Manchester, and therefore to serve the proposed HS2 terminus at Manchester Piccadilly. This is incompatible with onward through routeing from Liverpool and Manchester Airport to either Leeds or Sheffield (see Figure 5.40). There is no physical connection to the existing network, and the HS2 terminus (currently proposed to comprise 4 platforms) would be unable to accommodate the specified 6 trains per hour services from Liverpool, Sheffield and Leeds (ie 18 trains per hour in total).

It is however not certain that HS3/NPR services from Leeds and Sheffield would be routed to Manchester Piccadilly. It is possible that these services will be directed instead to Manchester Victoria on account of the shorter journey time to Leeds that can be achieved from this station. This would then require through services to be routed across Manchester city centre via the new Ordsall Chord on routes that are highly congested with local traffic. If this were to be the case, any prospect of fast and direct HS3/NPR services from Liverpool or Manchester Airport to Leeds, Hull and Newcastle would appear to be lost.

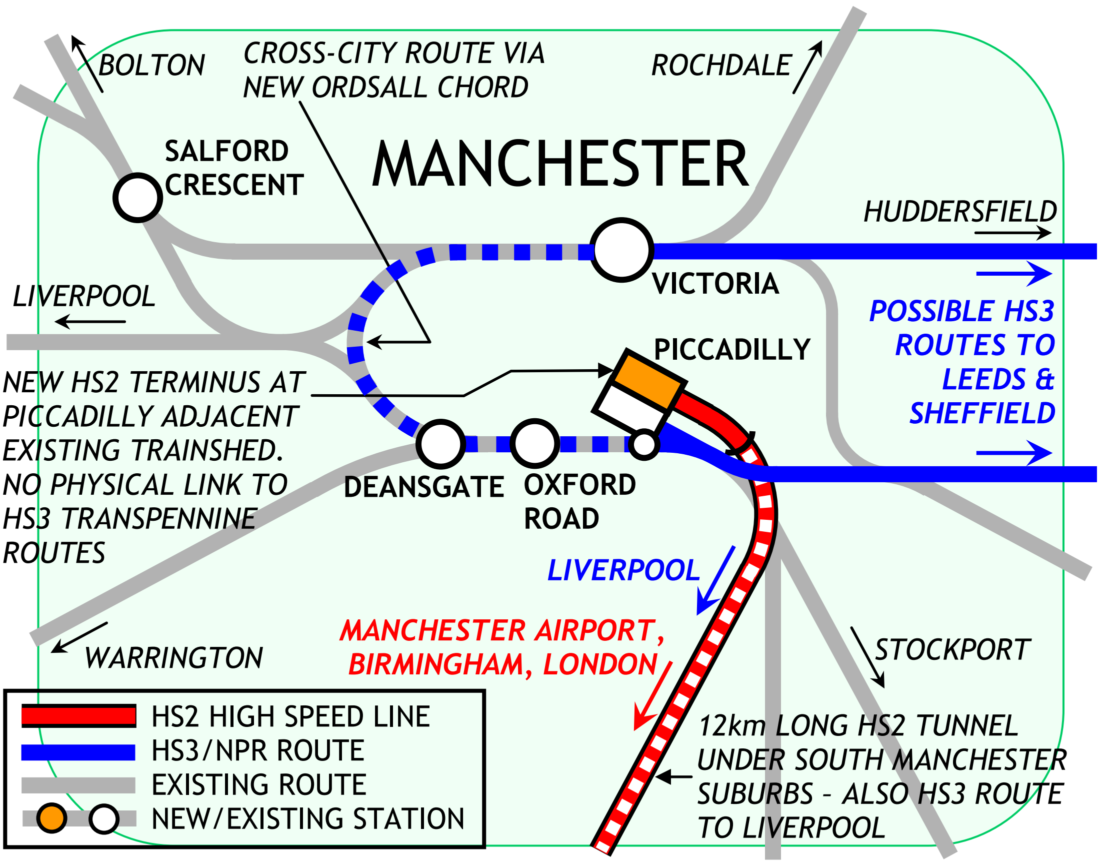


Figure 5.43 : HS2 and HS3 Proposals in Manchester

The service levels proposed for the Northern Powerhouse are only feasible with through operation. To achieve this HSUK has proposed a cross-Manchester tunnel (see Figure 5.44), with underground platforms at Manchester Piccadilly. This through route will have capacity to accommodate not just HSUK intercity services linking the Northern Powerhouse cities, but also local services on Bolton and Stockport routes.

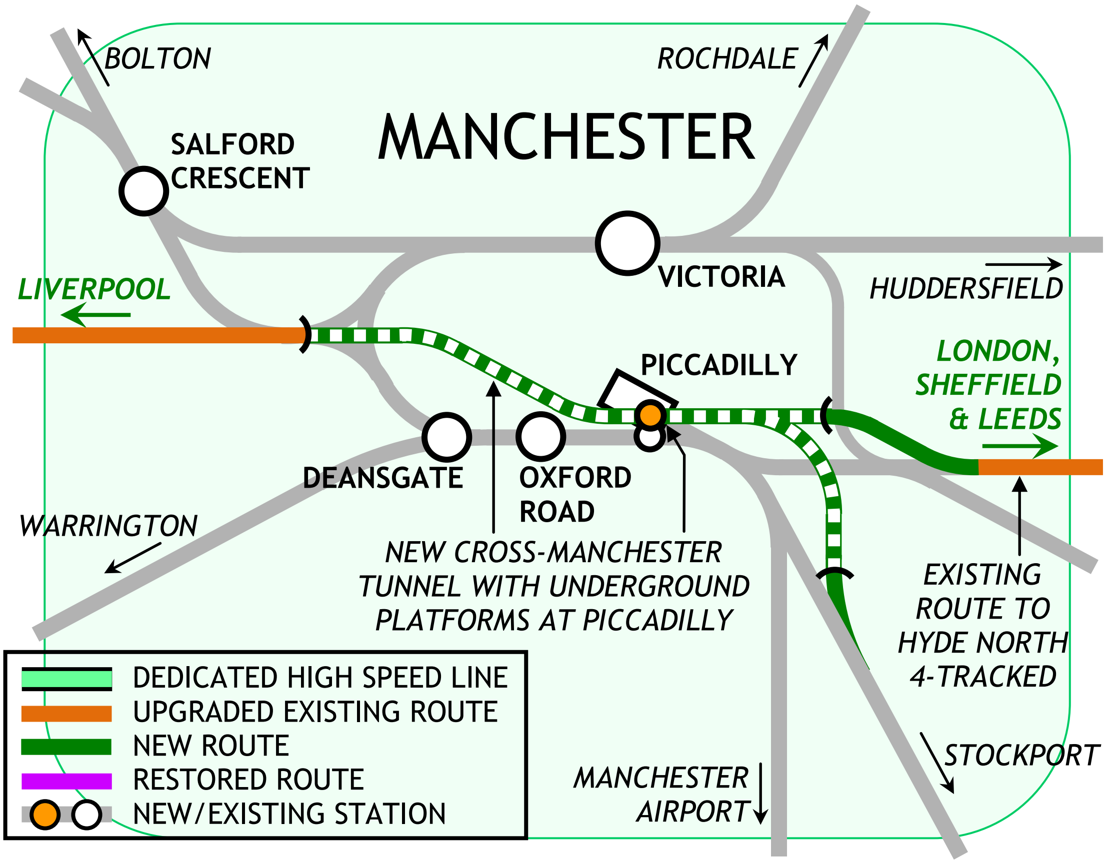


Figure 5.44 : Proposed HSUK scheme for Manchester

5.8.9 Issue 4 : Circuitous and slow route from Manchester to Liverpool

HSUK analysis proves conclusively that an HS3/NPR route from Manchester to Liverpool routed along the proposed HS2 Manchester spur cannot possibly meet the Northern Powerhouse specification for a 20 minute journey time even if the train runs non-stop through the HS2 Manchester Airport station. The non-stop timing would be 24 minutes, rising to 30 minutes with a stop at Manchester Airport.

The specified 20 minute journey time can only be met by the more direct HSUK route (see Figure 5.45), following the corridors of the Liverpool-Manchester ‘Chat Moss’ line, and of the M62. Separate services will be provided to link Liverpool and Manchester Airport via Altrincham and the South Manchester Loop.

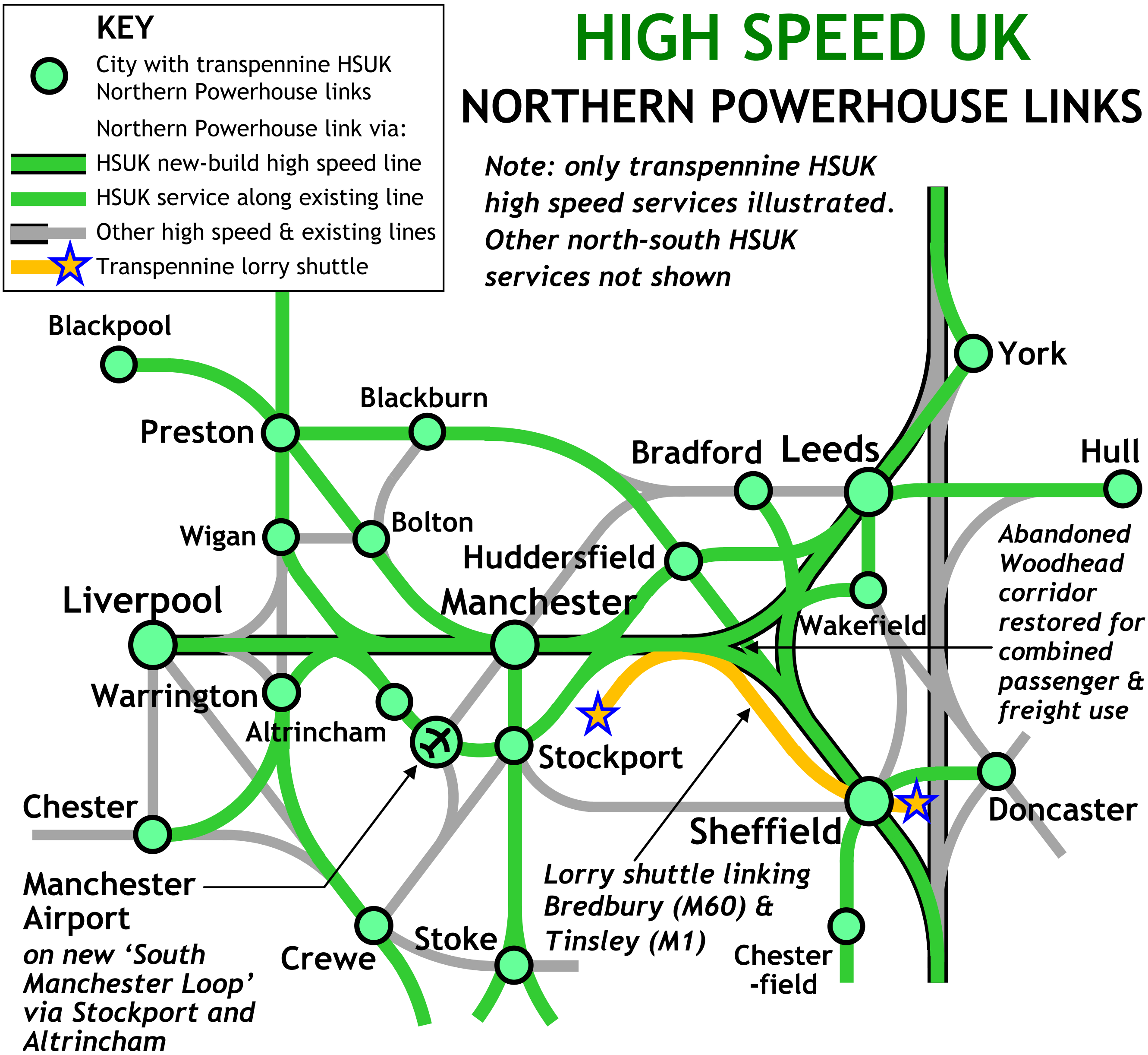


Figure 5.45 : High Speed UK in Northern Powerhouse region

5.8.10 Issue 5 : No relief to existing congestion at Leeds Station

Whilst HS2 Ltd's latest proposals[16] for its new station at Leeds (see Figure 5.46) resolved many of the dysfunctionalities of the originally proposed 'New Lane' terminus, they still failed to address the congestion problems of the existing station. Despite Leeds having 17 platforms, more than any other provincial UK station, it is still one of the most congested with most services terminating there, rather than running through. In its present configuration, with the vast majority of routes approaching from the west, it is incapable of accommodating all the proposed additional Northern Powerhouse services.

An additional problem is created by the inability of the proposed HS2 layout to accommodate through services to communities such as Bradford, Skipton and Harrogate that currently enjoy through East Coast intercity services from London.

[16] *The Yorkshire Hub*, HS2 Ltd, November 2015

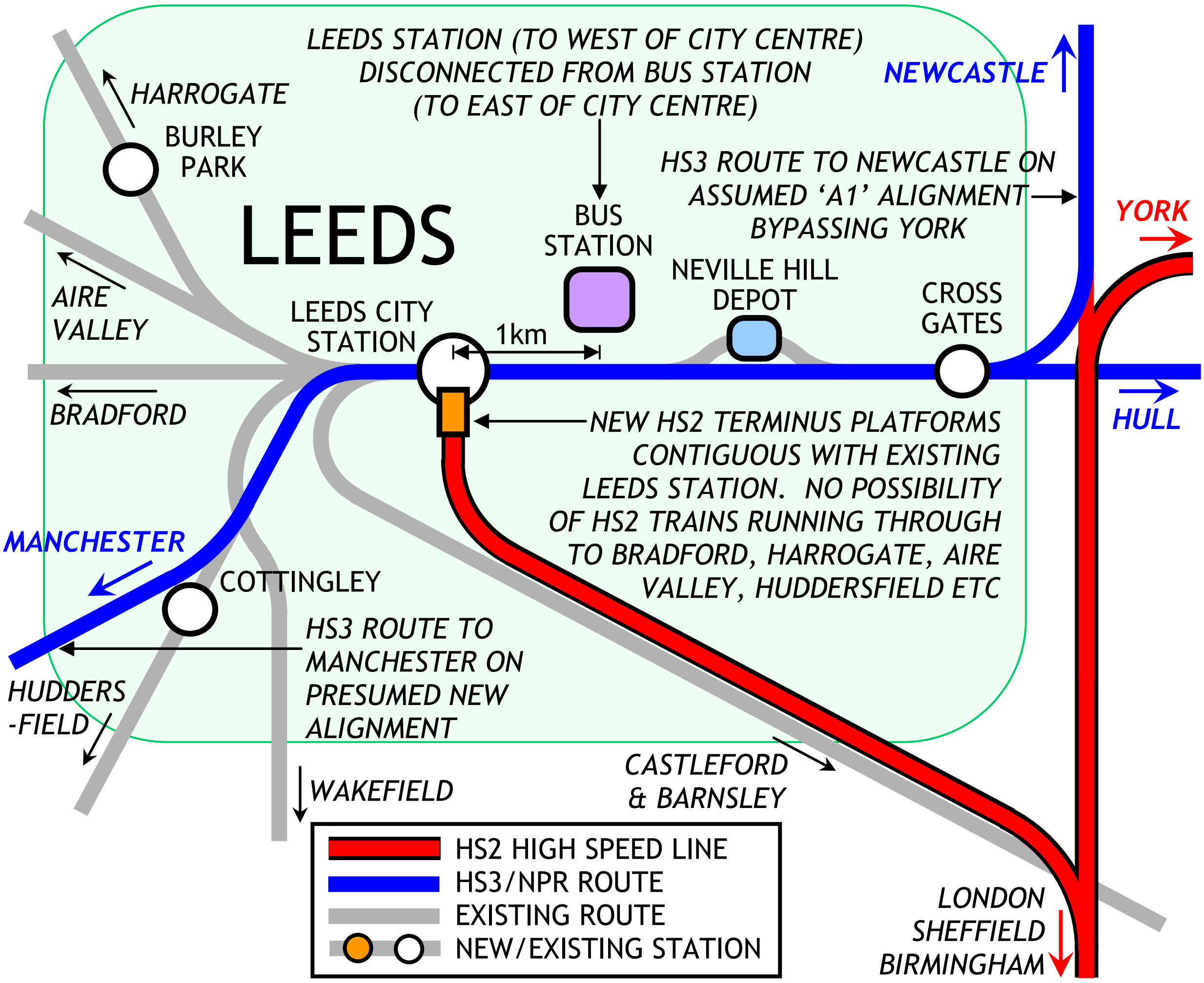


Figure 5.46 : HS2 and HS3 Proposals in Leeds

HSUK's proposals for Leeds (see Figure 5.47) will add 2 new tracks across the city from Cottingley in the south-west to Cross Gates in the east to create a dedicated route for high speed intercity services, segregated from local services. This will be achieved through 3 principal interventions:

- Restoration of Farnley Viaduct to the south-west of Leeds station;
- Widening of Leeds East Viaduct to 4 tracks;
- Restoration of 4 tracks along existing trackbeds from Neville Hill to Cross Gates.

With new tracks devoted to high speed intercity services, the existing tracks will have greatly increased capacity for local services. This creates the opportunity for new stations on the route east of Leeds, at Leeds Minster and at Neville Hill. Leeds Minster station will act as a catalyst for redevelopment of the east side of the city centre and provide a much-needed interchange with the city's bus and coach station.

Additionally, the construction of a new link from Stourton to Neville Hill will allow many of the services which currently approach Leeds station from the west and terminate there to approach instead from the east. Rather than terminate at Leeds and consume valuable platform capacity, these services can then continue to destinations such as Bradford and

Huddersfield. With many more through services operating, the capacity of Leeds station will be vastly increased.

Construction of the Stourton-Neville Hill link will also give access to a large area of industrial land on which anew rolling stock depot can be established, and thereby allow the existing cramped Neville Hill site to be developed for housing, close to the proposed Neville Hill station.

Overall, with the HSUK improvements in place, it should be possible for local services to Leeds to be almost doubled in frequency.

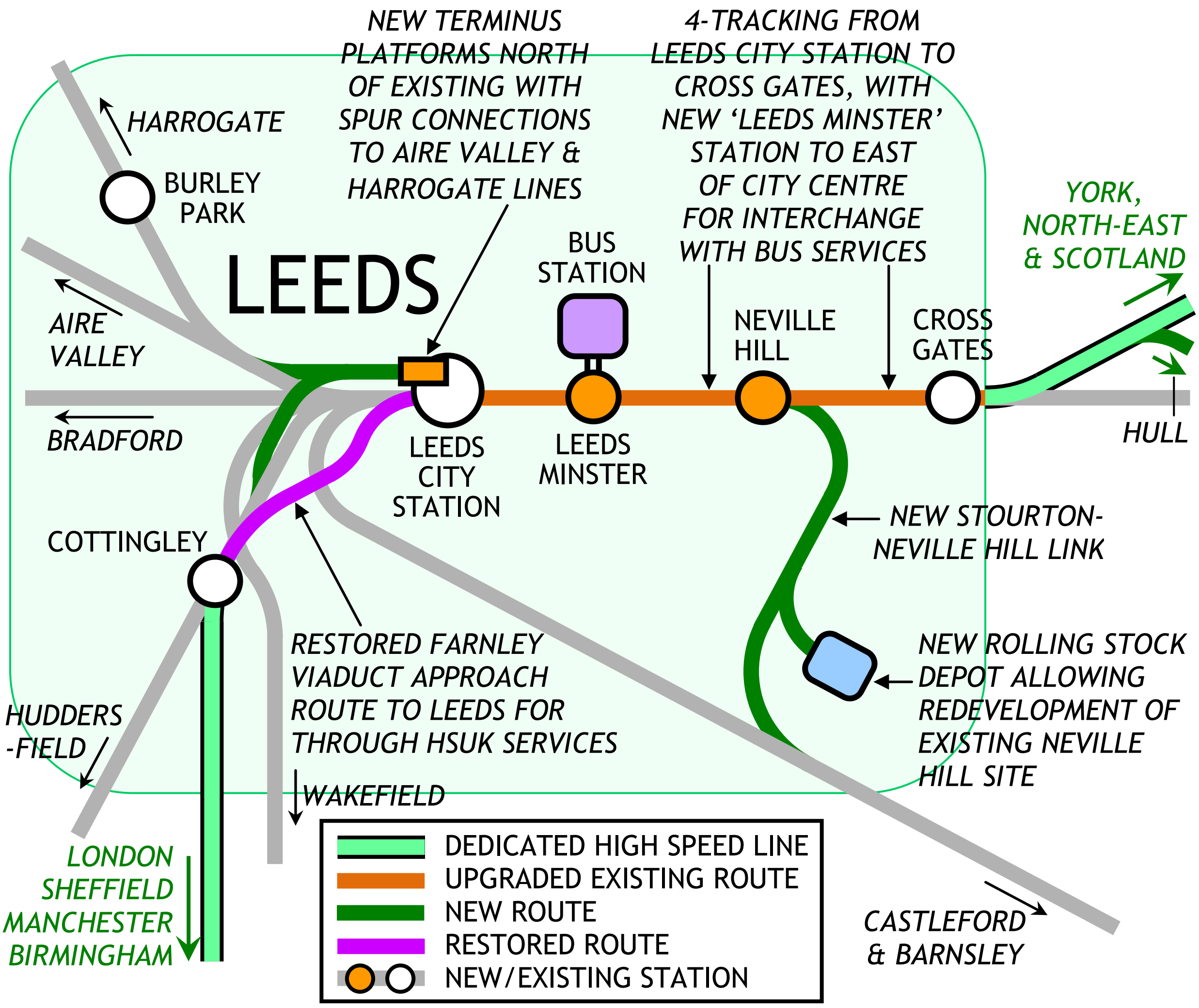


Figure 5.47 : Proposed HSUK scheme for Leeds

5.8.11 Issue 6 : Unsuitable station in Sheffield located on 66km long loop

The amended proposals for HS2 to serve Sheffield Midland station, released in July 2016, have ostensibly addressed the concerns of the local community at the previous HS2 proposal for a station at Meadowhall, 6km from the city centre. Sheffield Midland will certainly be a superior 'port of entry' to the city, but it carries several major drawbacks.

1. The station and its approach routes can only accommodate HS2's 'classic compatible' trains rather than the 400m long double-decker rolling stock proposed for use elsewhere on the HS2 system.
2. More seriously, the location of Sheffield Midland on a 66km long loop off the HS2 trunk route will effectively place Sheffield on a very long siding. This will significantly increase journey times to Sheffield, and it will also discourage the operation of through services, given the time penalty of around 22 minutes that will apply for through services routed via Sheffield Midland compared with services running non-stop via the bypassing route.
3. In terms of Northern Powerhouse links to other Northern cities, Sheffield Midland's greatest problem is that it lacks the capacity to accommodate all projected services. These comprise existing services, HS2 services and the 12 terminating services per hour (6tph from Leeds and 6tph from Manchester) specified for Northern Powerhouse links. Sheffield Midland is located on a confined site, and it lacks space into which it can feasibly expand.
4. A further problem is that Sheffield Midland feeds naturally into the Hope Valley route to Manchester, for which there is no feasible option – other than the construction of a new tunnel over 30km long – by which the specified 30 minute Sheffield-Manchester journey time can be achieved.
5. HS2's bypassing route around Sheffield will require major demolitions at Mexborough, where a new housing estate stands in HS2's path. This is HS2's greatest single impact upon residential property outside London.

HSUK's proposed Sheffield station (see Figure 5.48), to be constructed on the site of the former Sheffield Victoria, avoids most of the problems of Sheffield Midland. Sheffield Victoria's south-east to north-west orientation is well aligned with HSUK's onward routes to Manchester and Leeds, and its location on a through trunk route rather than on a loop makes Sheffield Victoria an attractive calling point on long-distance intercity journeys.

To enable full integration between local services and HSUK intercity services, new interchange platforms will be constructed on the existing route into Sheffield Midland, close to the location of the former Attercliffe Road station. This will allow passengers from outlying communities such as Rotherham and Barnsley easy access to HSUK's high speed services.

The HSUK timetable – see Appendix A1 – shows direct services from Sheffield Victoria to all major UK cities, and journey times to other Northern cities which meet the Northern Powerhouse specification (see Table 5.49). On routes to adjacent cities including Manchester and Leeds there are high service frequencies, sufficient to meet the frequency specification. The need for dedicated HS3/NPR services will either be very small or non-existent.

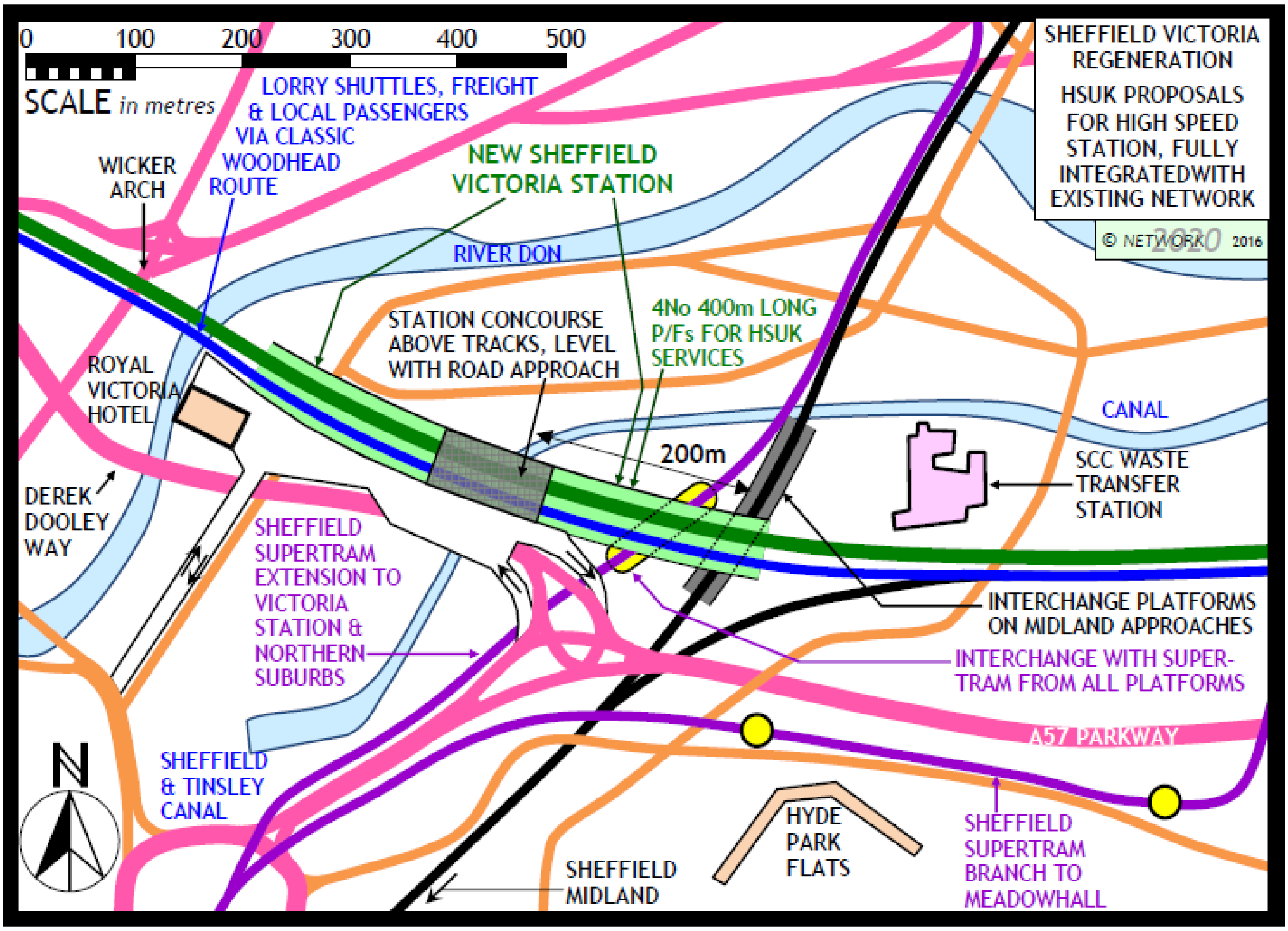


Figure 5.48 : Proposed HSUK scheme for restored Sheffield Victoria Station

5.8.12 Issue 7 : Many Northern cities bypassed

HS2 Ltd's selection of routes bypassing key intermediate centres such as Stoke, Stockport, Doncaster and Wakefield establishes a pattern of segregation by which transpennine Northern Powerhouse routes will similarly bypass other intermediate centres such as Bradford and Huddersfield. The result will be a system (see Figure 5.41) lacking in the integration necessary to offer to all major communities high speed connections either to London or on transpennine routes.

By contrast, HSUK's full integration enables all principal Northern communities to enjoy London-centric and transpennine high speed services (see Figure 5.45).

5.8.13 Issue 8 : York bypassed by Future HS3 line to Newcastle

HS2 Ltd's adoption of a time-sensitive north-south route passing close to both Sheffield and Leeds has the inevitable consequence that when projected further north as an 'HS3' high speed link to the North-East (see Figure 5.41), York will be left bypassed. The new route seems certain to follow the most direct route along the approximate corridor of the A1(M), while the existing East Coast Main Line route via York will be longer and slower. The resulting 'time penalty' of 19 minutes suffered by all high speed services to the North-East calling at York is likely to prove commercially unsustainable. As a consequence there is a high probability that York will lose most of the HS2 high speed services that are currently projected, and will also be bypassed by HS3/NPR services to the North-East.

By contrast, the more easterly alignment of HSUK's spine route (see Figure 5.45) will pass much closer to York, and the time penalty for high speed services calling at York is calculated to be only 8.5 minutes. Whilst some long distance services from London to Scotland will bypass York, most interregional services will sustain the time penalty, and will continue to call at York in accordance with existing service patterns.

5.8.14 HSUK Success in meeting Northern Powerhouse Specification

With no detail yet available of HS3/Northern Powerhouse Rail services and journey times, it is not possible to assess their success or otherwise in meeting the specification for improved rail services between Northern cities. But with HSUK's routes and projected train services on transpennine routes already defined (see Appendix A1), a rigorous assessment can be made of the degree to which HSUK succeeds in addressing the Northern Powerhouse requirement for accelerated journey times and improved frequencies.

Journey between Northern Powerhouse cities	**Existing journey time** (mins)	**Specified journey time** (mins)	**Specified frequency** (tph)	**HSUK journey time** (mins)	**HSUK frequency** (tph)
Sheffield-Leeds	40	30	6	19	7
Liverpool-Manchester	32	20	6	19	6
Manchester-Sheffield	48	30	6	23	6
Manchester-Leeds	49	30	6	26	4
Leeds-Manchester Airport	62	40	2	37[A]	2
Sheffield-Manchester Airport	73	30	2	34[A]	1
Liverpool-Manchester Airport	65	30	2	26[B]	2
Leeds-Newcastle	87	60	4	51[C]	6
Leeds-Hull	55	45	2	35[D]	3
Sheffield-Hull	86	60	2	56[E]	2

[A] – Journey times include stop at Stockport
[B] – Journey time includes stop at Altrincham
[C] – Journey time includes stops at York and Darlington
[D] – Non-stop timing. Longer journey times apply, with stops at Selby and Brough.
[E] – Best timing, routed via Leeds

Table 5.49 : HSUK Performance in Meeting Northern Powerhouse Specification

Table 5.49 demonstrates that the services already defined for HSUK come very close to satisfying all aspects of the Northern Powerhouse specification. Any shortfall in service frequency on the Manchester-Leeds route will be made up by services routed via Huddersfield which have not yet been incorporated into the full HSUK timetable. With regard to the 34 minute journey time from Sheffield to Manchester Airport, compliance with the specified 30 minute journey time could be achieved simply by eliminating the planned intermediate stop at Stockport. However, it is considered that greater value is added by the additional connectivity offered to other destinations in the Stockport and Cheshire area.

It should be noted that Table 5.49 also does not include the Manchester-Manchester Airport journey. This is omitted since it is a local journey which cannot practicably be improved by the intervention of a new high speed intercity railway.

HSUK's success in achieving direct intercity links between the 7 principal centres of the Northern Powerhouse can be appreciated from Figure 5.50. The HSUK services listed in Appendix A1 will provide direct links, at hourly or better frequencies, for all but two of the 21 possible journeys.

Hull	HU			HSUK Direct Intercity Link			
Leeds		LS		o	No HSUK Direct Link		
Liverpool			LI				
Manchester				MA			
M'ch'r Airport				o	MAN		
Newcastle	o					NE	
Sheffield							SH
	HU	**LS**	**LI**	**MA**	**MAN**	**NE**	**SH**
London							

Figure 5.50 : HSUK Direct Intercity Connectivity between Northern Powerhouse Cities

By contrast, HS2's near-complete failure to provide improved intercity services between the 7 principal centres of the Northern Powerhouse can be appreciated from Figure 5.51.

Hull	HU			HS2 Direct Intercity Link			
Leeds	o	LS		o	No HS2 Direct Link		
Liverpool	o	o	LI				
Manchester	o	o	o	MA			
M'ch'r Airport	o	o	o	o	MAN		
Newcastle	o	o	o	o	o	NE	
Sheffield	o		o	o	o	o	SH
	HU	**LS**	**LI**	**MA**	**MAN**	**NE**	**SH**
London	o						

Figure 5.51 : HS2 Direct Intercity Connectivity between Northern Powerhouse Cities

The HS2 services listed in Appendix A2 will provide direct links, at hourly or better frequencies, for only one of the 21 possible journeys. The HS2 link from the HS2 Manchester

Airport station to Manchester Piccadilly is not accepted as a direct link from Manchester Airport to Manchester; with the HS2 station at Manchester Airport 1.5km from the existing station, located at the approximate midpoint between the 3 airport terminals, an additional shuttle connection will have to be made. It must be questioned whether this 2 stage journey represents any sort of improvement in the rail connection from Manchester to its airport.

5.8.15 Northern Powerhouse Conclusions

This study has demonstrated how development of HS2 to its primarily London-centric agenda will have huge adverse effects upon the development of efficient HS3 transpennine links. This will have wide-ranging consequences not only upon the economic performance of the Northern Powerhouse, it will also result in greatly increased costs and a continuing failure to achieve transport CO_2 reductions in line with the requirements of the 2008 Climate Change Act. This latter consideration is discussed in greater detail in Section 5.10.

All these concerns can be attributed to HS2 Ltd's narrow focus upon following its remit to build new and generally disconnected high speed lines, and its failure to recognise the crucial importance of developing an enhanced national network capable of delivering the project's fundamental objective of **"hugely enhanced capacity and connectivity"** between the UK's major conurbations.

The conflicts that this study has identified between the existing HS2 proposals and the developing HS3/Northern Powerhouse Rail scheme offer the clearest possible demonstration that it is not possible to retrofit integration onto a scheme that has been specified and designed without integration. Integration has to be specified and designed into the project from the very start.

5.9 HS2 : Concentrating Connectivity and Economic Benefits on London and Other Economically-Advantaged Areas

There is a self-evident contradiction between the clear focus of the HS2 'Y' upon London, and repeated official predictions that HS2 will deliver step-change economic benefits to the UK regions. This accounts for much of the public scepticism that has persistently accompanied the HS2 project; yet HS2 Ltd has remained firm in its forecasts of transformed regional economies. The detailed connectivity analysis undertaken for this study now allows HS2 Ltd's predictions to be put to the test.

Two measures of connectivity have been adopted. The first measure is the **Average Journey Speed** for each of the 29 towns and cities under 3 scenarios i.e. the existing national network, and future national networks with HS2 and HSUK in place. The second measure is an empirical '**Intercity Connectivity Index**' (ICCI) based upon the availability of direct journeys with no change of trains, and the quality of rolling stock on offer. For each town/city, **Average Journey Speed** and **Intercity Connectivity Index** are plotted against the average **Gross Disposable Household Income** as an indicator of community prosperity.

The following conclusions can be drawn from review of the plots:

- For the existing network, there is a clear linkage between connectivity and community prosperity. London, by far the best connected city, is also the most prosperous.
- HS2's greatest connectivity gains are achieved for London and for other well-connected and prosperous communities. It generally achieves little or no gains for economically-disadvantaged communities.
- It therefore follows that HS2 will tend to reinforce, rather than redress existing economic disparities.
- By contrast, HSUK's achievement of greatest connectivity gains in the most disadvantaged communities suggests strongly that (unlike HS2) it should be effective in bringing major economic benefit to the UK regions and in so doing redress the North-South Divide.

5.9.1 Greatest Speeds on London-centric Journeys

The speed at which a journey can be undertaken between any two nodes in a network gives a reasonable indication of the relative importance, both historical and contemporary, of that particular journey. This can be seen most clearly in the high-quality (relatively) non-stop journeys that most regional cities enjoy to London; these operate at a far greater average speed (116 km/h), assessed across the network of 32 centres considered in this study) than would apply on a typical interregional journey.

5.9.2 Connectivity between Derby, Stoke and London

The connectivity between the three centres of Derby, Stoke and London offers perhaps the most pointed example of the inadequacy of present-day links between regional cities, when contrasted with links from regional cities to London. Derby and Stoke are linked by a direct local service, generally achieved in a single-coach single-class train running at hourly frequency; this stops at all stations and has an average journey speed of 56 km/h. This contrasts very poorly with the high quality 2 train per hour intercity service that both cities enjoy to London. These intercity services operate at much higher speed (124 km/h Derby to London, 149 km/h Stoke to London, averaging at 136 km/h) and employ much higher quality rolling stock, with a choice of first or standard class travel.

Average speeds (km/h)	Derby-London	Stoke-London	Average to London	Derby-Stoke	Speed disparity factor
Existing	**124**	**149**	**136**	**56**	**2.45**
HS2	**124**	**149**	**136**	**56**	**2.45**
HSUK	**197**	**185**	**191**	**90**	**2.12**

Table 5.52 : London/Stoke/Derby Speed Disparities

These disparities in speed (as set out in Table 5.52), frequency and quality of rolling stock are all indicative of the London-centricity of the existing railway system, which is both a cause and an effect of the divisions that have historically afflicted the UK economy. It seems clear that if high speed rail is to have a positive effect in benefitting the economies of the UK regions, it must have the effect of reducing these disparities through achieving greater improvements for interregional journeys than it will for London-centric journeys.

The failure of HS2 is exemplified by the fact that it does nothing to improve any of the journeys in the London-Derby-Stoke triangle. See Table 5.52 above. This is despite the fact that HS2's new routes pass close to both Derby and Stoke.

HSUK's full integration with the existing network is crucial in its achievement of much superior performance. Although its new-build high speed line will bypass Derby, its allied programme of upgrading of existing routes and comprehensive connection to these routes will enable Derby to be fully linked to HSUK and enjoy major acceleration of its services to

London. Similarly, although HSUK's route will run completely clear of Stoke, proposed upgrades in the Potteries region will also allow significant journey time reductions. However, the proposed upgrade of the Derby-Stoke line to create the new 'North Midlands' intercity route (service HSUK14 running Nottingham-Derby-Stoke-Crewe-Warrington-Liverpool, as detailed in Appendix A1) will bring about even greater reductions in proportionate terms. As shown in Table 5.52, the speed disparity between London-centric and interregional journeys will reduce, and this is indicative of the greater benefits that HSUK will achieve for regional economies.

5.9.3 Average Journey Speeds across National Network

In a more generic sense, the London-centricity of the UK rail network can be seen in Figure 5.53. This sets out the differences in average journey speeds for all of the 32 towns, cities and airports considered in this study. London enjoys by far the fastest journeys (116 km/h or 73 MPH average), while the best performing of the remainder is Milton Keynes (80 km/h or 50 MPH average) and the worst performing is Walsall (38 km/h or 24 MPH average).

These trends appear certain to be perpetuated by HS2. Of all the towns and cities under consideration, London enjoys one of the greatest accelerations in average journey speeds (exceeded only by Birmingham and Leeds) while most cities see little or no increase.

Worryingly, when HS2 average journey speeds are adjusted to take account of journeys made worse by HS2 (a nominal deceleration factor of 1.33, equivalent to a 25% reduction in speed, has been applied) 13 of the 32 centres considered in this study will see effective journey speeds reduced to below existing levels. This can be seen in Figure 5.54.

HSUK's alternative emphasis on creating a more balanced and integrated network through a programme of new-build high speed lines, augmented by upgrading of existing routes and restoration of abandoned routes, has precisely the reverse effect to that of HS2. Whilst the intervention of the new build high speed line will naturally increase journey speeds along its line of route, the new connectivity that it creates have a much greater effect in increasing journey speeds. HSUK's new connectivity is manifested in two ways:

- New journeys between previously unconnected (or very poorly connected) locations.
- A greater proportion of through journeys, with changes of trains eliminated on many journeys.

As shown in Figures 5.53 and 5.54, this superior performance, achieved through optimised integration rather than maximised operating and design speed, gives HSUK 2 huge advantages over HS2:

- HSUK offers average journey speeds greater than HS2 for every single town, city and airport considered in this study.
- HSUK's greatest enhancement of journey speeds applies to towns and cities such as Walsall, Northampton, Luton, Nottingham, Leicester and Bradford that are currently

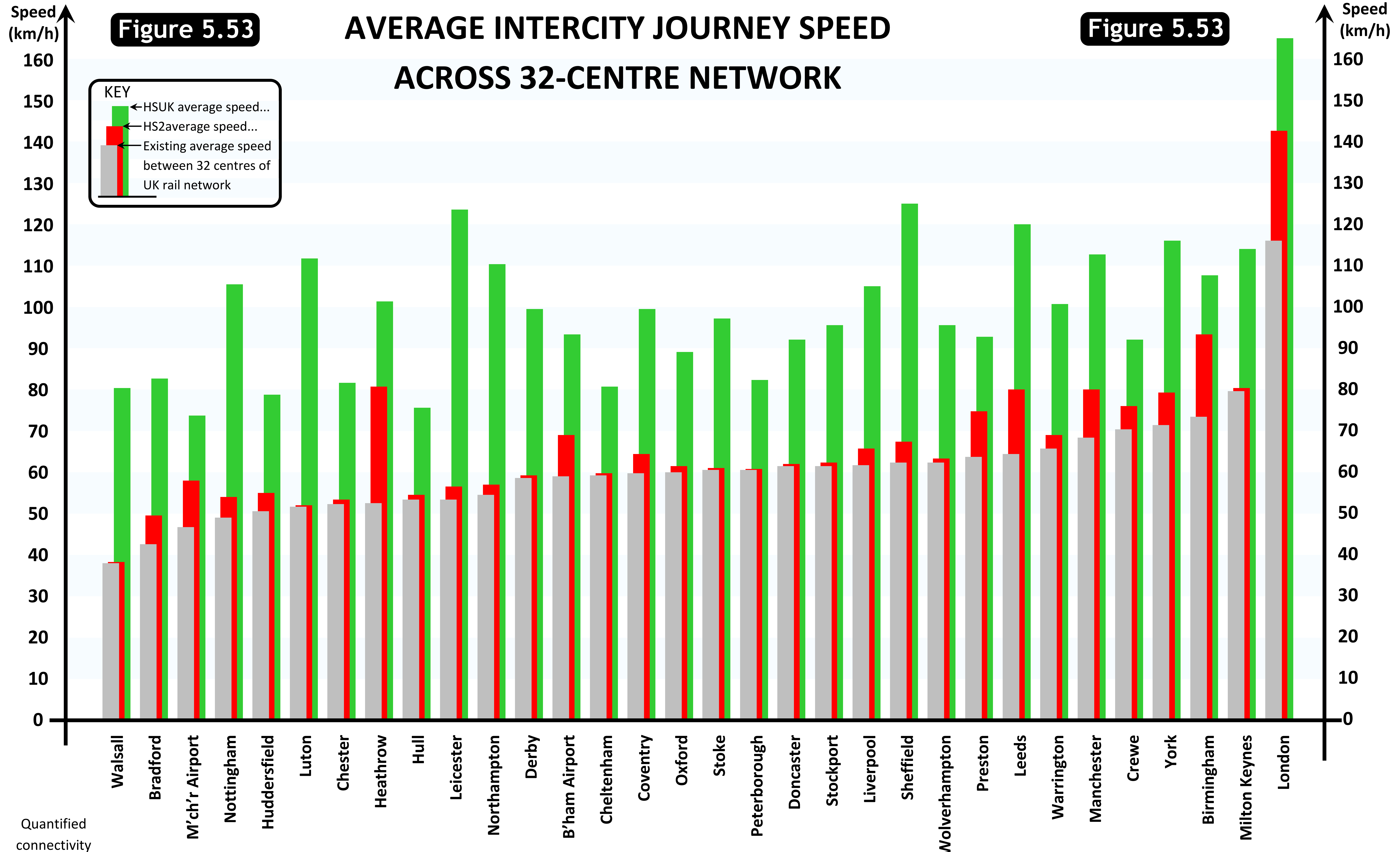
amongst the worst connected of the 32 centres considered in this study. Hence HSUK should bring about a highly positive effect in reducing disparities between London-centric and interregional journey speeds.

The extent to which the intervention of new high speed railways can reduce the London-centricity of the existing railway network is inevitably limited. It is particularly pertinent to note that with even with all of HSUK's proposed interventions in place, only 4 regional cities (ie Leicester, Sheffield, Leeds and York) will enjoy average intercity journey speeds that exceed the average speed of existing flows to London (116 km/h).

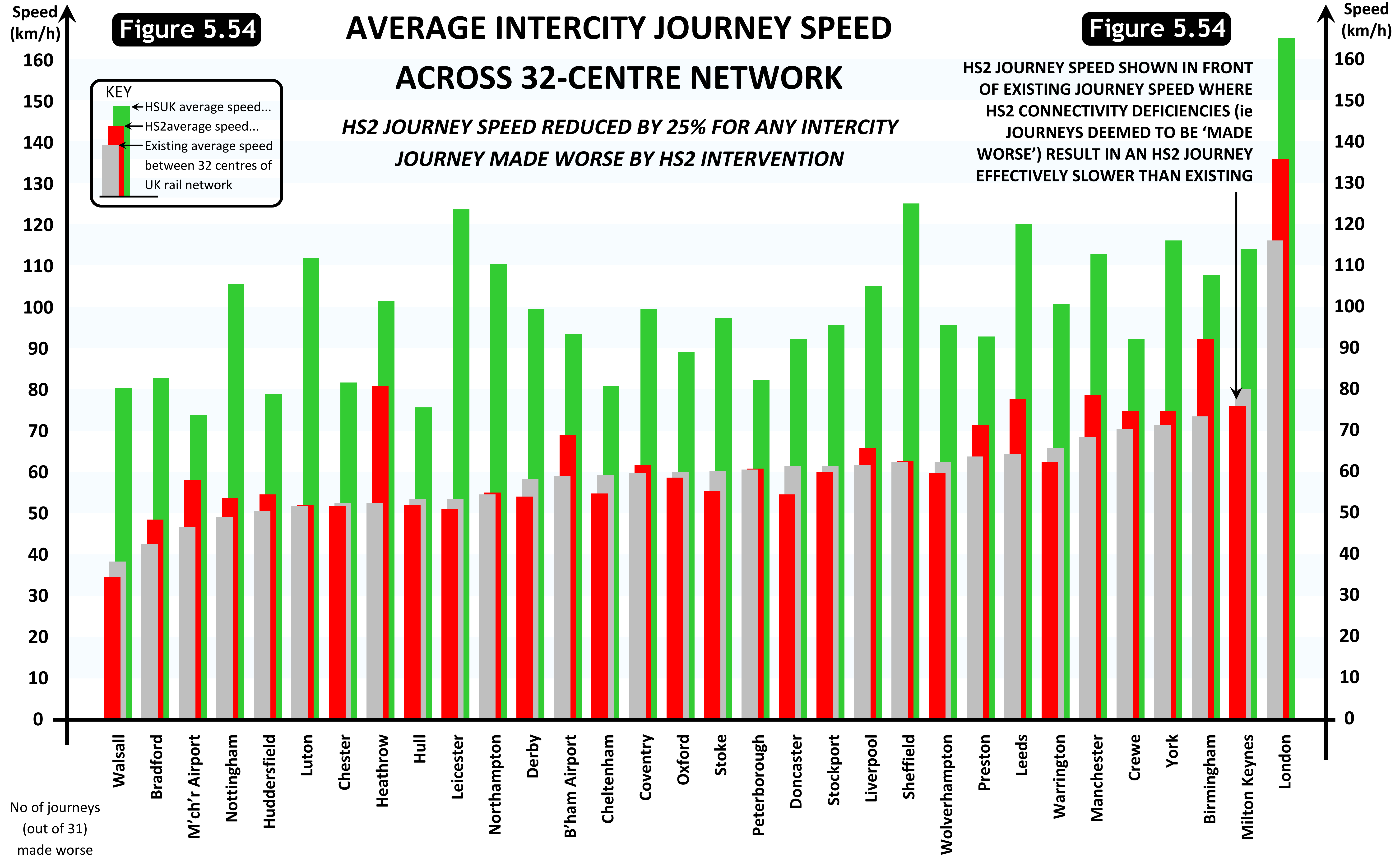
Unsurprisingly, HS2 fares far worse in this comparison. Figure 5.53 shows that the intervention of HS2 fails to elevate the average intercity journey speed of any regional city to a level greater than London's existing 116 km/h average. HS2's best performance for any town or city outside London is Birmingham's average journey speed of 93 km/h, still 18% slower.

However, the value of a simplistic comparison between speeds is limited, other than as an indicator of the extent of existing London-centricity in the UK transport system. The most important consideration is the ability of either HS2 or HSUK to reduce the speed and connectivity disparities the speed and connectivity disparities that give rise to this London-centricity, and thereby bring about more favourable conditions for economic growth in the UK regions.

AVERAGE INTERCITY JOURNEY SPEED ACROSS 32-CENTRE NETWORK



Quantified connectivity	Walsall	Bradford	M'ch'r Airport	Nottingham	Huddersfield	Luton	Chester	Heathrow	Hull	Leicester	Northampton	Derby	B'ham Airport	Cheltenham	Coventry	Oxford	Stoke	Peterborough	Doncaster	Stockport	Liverpool	Sheffield	Wolverhampton	Preston	Leeds	Warrington	Manchester	Crewe	York	Birmingham	Milton Keynes	London
for existing,	4	9	30	34	23	12	16	3	14	26	15	39	47	32	47	36	41	32	41	52	42	51	52	46	51	62	76	53	51	78	49	98
for HS2	4	9	45	34	23	12	16	3	14	26	15	39	62	32	47	36	41	32	41	52	44	56	52	51	61	65	81	57	54	94	49	113
& for HSUK	84	67	65	135	72	93	62	103	76	133	95	130	125	77	115	101	126	68	80	131	129	155	135	99	152	118	144	107	133	145	120	143



No of journeys (out of 31) made worse by HSUK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
& by HS2	10	4	2	1	2	N/A	4	1	8	12	5	12	4	8	5	5	11	0	16	4	1	11	6	7	5	12	3	1	10	2	8	8

5.9.4 Correlation between Connectivity and Economic Performance

The disparities in average speed set out in the foregoing paragraphs resonate strongly with popular perceptions of current regional economic divisions. London (and the wider South-East) is the most prosperous region of the UK, and on any measure of connectivity – either average journey speed to other towns and cities, or number of towns and cities directly linked (as per the 'Intercity Connectivity Index' described in Item 3.5) – London is also the best-connected city. Equally, towns and cities such as Luton, Leicester and Bradford are amongst the poorest in terms of both economic performance and connectivity.

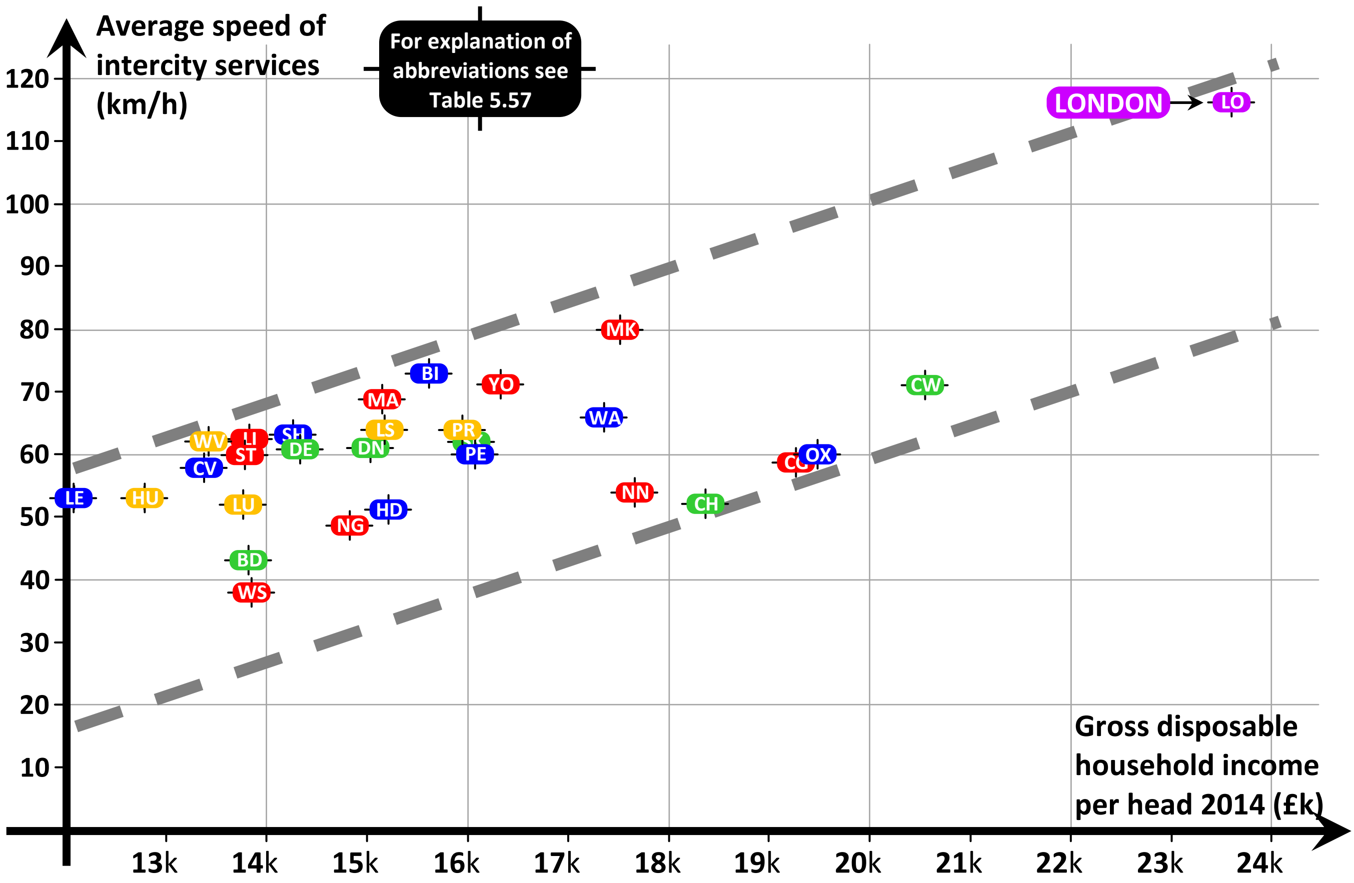


Figure 5.55 : Average Speed of Intercity Services, by city – Existing Network

BI	Birmingham	HD	Huddersfield	MK	Milton Keynes	ST	Stoke
BD	Bradford	HU	Hull	NN	Northampton	WS	Walsall
CG	Cheltenham	LS	Leeds	NG	Nottingham	WA	Warrington
CH	Chester	LE	Leicester	OX	Oxford	WV	Wolverhampton
CV	Coventry	LI	Liverpool	PE	Peterborough	YO	York
CW	Crewe	LO	London	PR	Preston		
DE	Derby	LU	Luton	SH	Sheffield		
DN	Doncaster	MA	Manchester	SK	Stockport		

Table 5.56 : Abbreviations used for major towns and cities

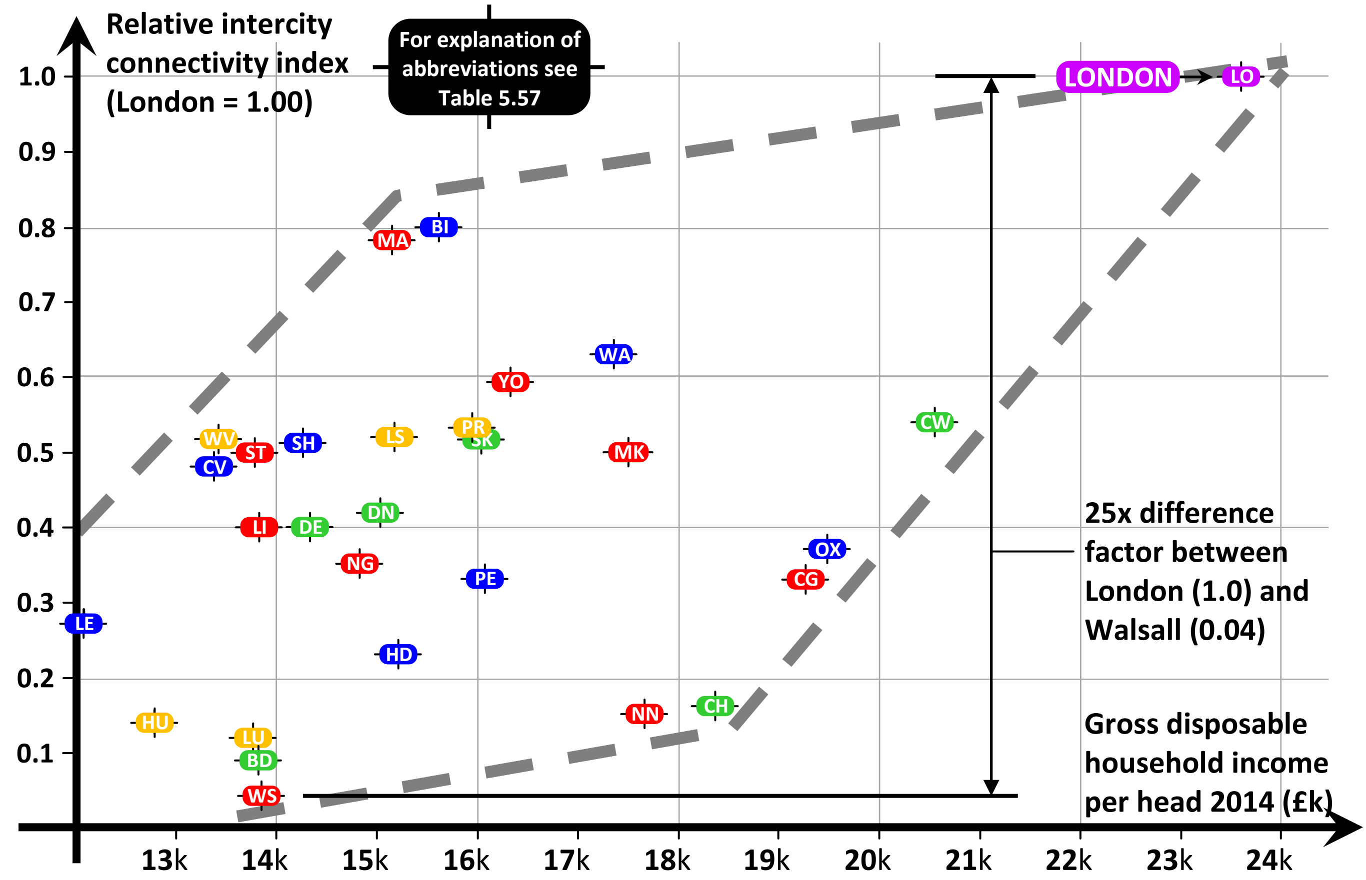


Figure 5.57 : Average Intercity Connectivity Index, by city – Existing Network

The correlation between current economic performance and connectivity offered by the existing rail network is established in the plots set out in Figures 5.55 and 5.57. In both, economic performance is represented by 2014 figures for Gross Disposable Household Income (GDHI) per head, as published by the Office for National Statistics.

Figure 5.55 displays a broadly linear relationship between GDHI and average journey speed, while Figure 5.57 displays a more lozenge-like distribution. In either case, the narrative is essentially the same. London enjoys the highest per capita income, and it enjoys the highest quality and the fastest links to other major UK towns and cities. This contrasts starkly with the situation of towns and cities such as Luton, Hull, Leicester and Bradford, where per capita incomes are amongst the lowest and whose intercity links are generally of the lowest quality and the lowest speed.

It is not for this study to determine what is cause, and what is effect, and what other factors might influence the relationship between connectivity and economic performance. However, it is abundantly clear that there is a relationship in which increased connectivity appears to be linked to increased economic performance, and that London – by far the best connected UK city – is also the most prosperous.

If the UK high speed rail project is to prove a worthwhile and responsible investment of double-digit (or possibly triple-digit) billion pounds of public money, it must not only achieve commensurate economic benefit, it must also achieve this in a manner that redresses current economic imbalances. Considerations of social inclusion dictate that the greatest gains are achieved where economic performance is the lowest, to create a better-balanced Britain.

This accords strongly with parallel considerations of sustainable development. London's economy is already hot-housed, and the city is barely able to sustain the development pressures that already exist. If the national transport system were to be developed in such a way as to increase its existing focus upon London, this can only result in these pressures increasing further to a level that may prove unsustainable. This dictates that high speed rail should be developed to achieve the greatest connectivity gains in the cities with lower existing economic performance, which can best accommodate increased development pressures.

5.9.5 Percentage Increase in Journey Speed equivalent to Percentage Journey Time Reduction

The performance of HS2 and High Speed UK in increasing journey speeds relative to household income for the 29 major towns and cities considered in the HSUK timetable is described in the following paragraphs. It should be noted that an increase in journey speed, expressed as a percentage, is exactly the same as a reduction in journey time, also expressed as a percentage. For consistency with findings in other parts of this document, the term 'percentage reduction in journey time' or 'percentage journey time reduction' will be used in the discussions in subsequent paragraphs.

5.9.6 Performance of HS2 in Improving Connectivity

The performance of HS2 in improving national connectivity is charted in Figures 5.58 and 5.59.

For HS2, the most significant finding is that London, which enjoys the highest per capita income, would also enjoy the third highest average percentage journey time reduction and the third highest increase in Intercity Connectivity Index. In both cases, HS2's performance for London is exceeded only by its performance for Leeds and Birmingham.

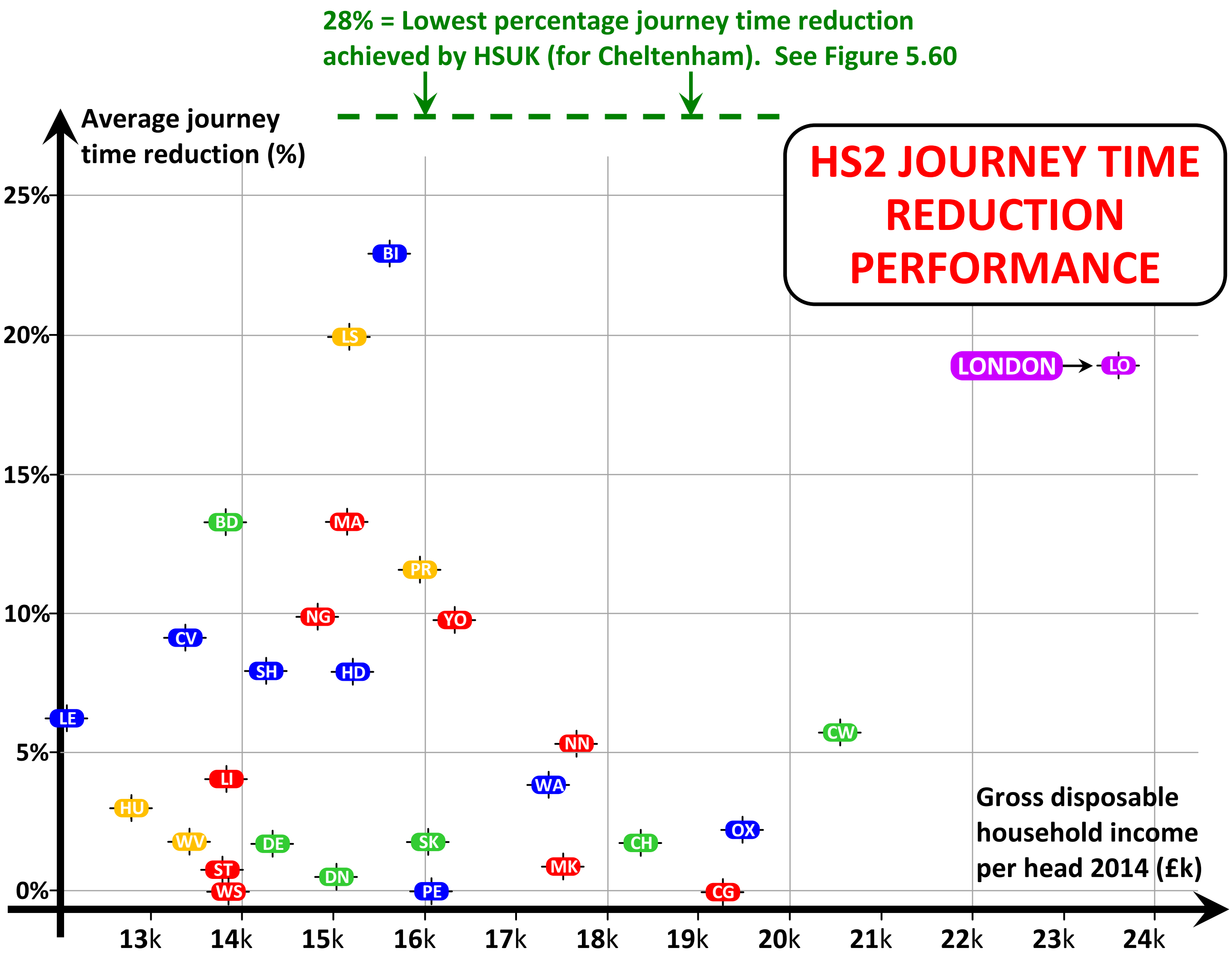


Figure 5.58 : Average %age Journey Time Reduction, by city – with HS2 in place

Neither diagram shows an especially strong relationship between connectivity improvements and income for the remainder of UK cities, a result which can probably be attributed to the patchy and limited nature of the HS2 intervention, and its generic lack of connection to many of the cities considered in this study.

However, Figure 5.59 does highlight once more the limited nature of the HS2 intervention, and its inability either to offer transformational benefits or to reach out to the majority of UK communities. It must be questioned whether even HS2's best performances – factored connectivity improvements of 1.21, 1.20 and 1.15 (or 21%, 20% and 15%) for Birmingham, Leeds and London – are worthy outcomes for the huge investment proposed for HS2. Certainly, HS2's inability to directly serve and therefore benefit the majority of cities (all clustered along the 1.0 'null score' baseline) seems utterly unacceptable.

For purposes of comparison, Figure 5.59 also illustrates HSUK's 'worst' performance – a 1.45 (or 45%) connectivity improvement for London. This is more than twice HS2's best performance of 1.21 (or 21%) for Birmingham.

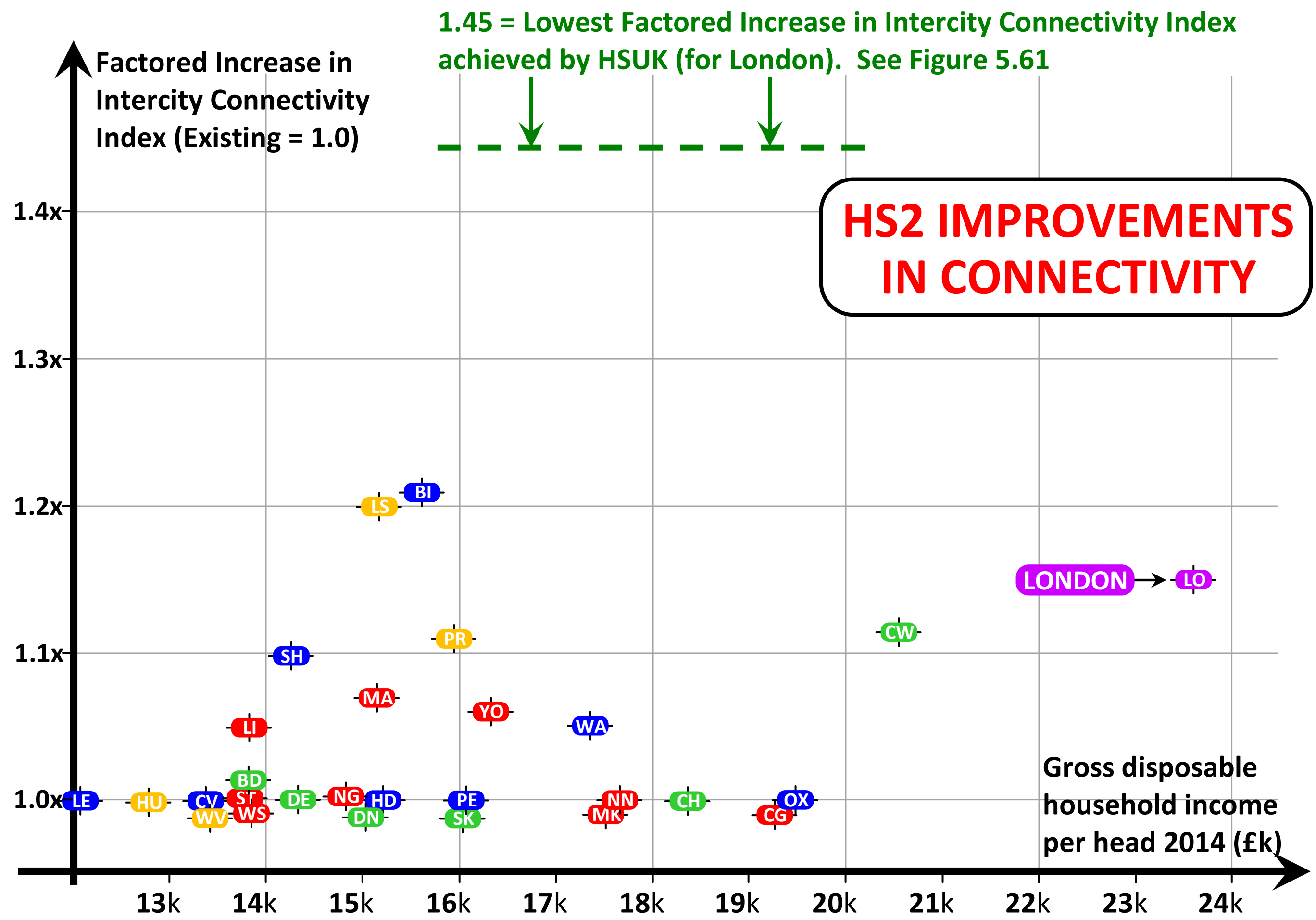


Figure 5.59 : Average Increase in Intercity Connectivity Index – with HS2 in place

5.9.7 Performance of High Speed UK in Improving Connectivity

Figures 5.60 and 5.61 display a radically different and more consistent picture in HSUK's performance in improving connectivity, relative to per capita income.

HSUK's strongest performance in achieving journey time reductions is in the poorest-connected towns and cities such as Walsall, Northampton, Luton, Nottingham, Leicester and Bradford. Many of these communities – in particular Luton, Leicester and Bradford – are also among the poorest in terms of per capita income. By contrast, London, the most prosperous city, sees one of the smallest average percentage journey time reductions. However, HSUK's figure of 32% for London still considerably exceeds HS2's best performance for any UK town or city (23% for Birmingham).

The more comprehensive and more balanced nature of the High Speed UK intervention results in a much closer 'banding' of the data plotted in Figure 5.60. Only Hull and Northampton lie significantly outside the trend lines. HSUK's relatively low performance (32%) in improving Hull's average journey speed, and its high performance (60%) in improving Northampton's average journey speed can both be accounted for by the proximity of each community to HSUK's proposed interventions.

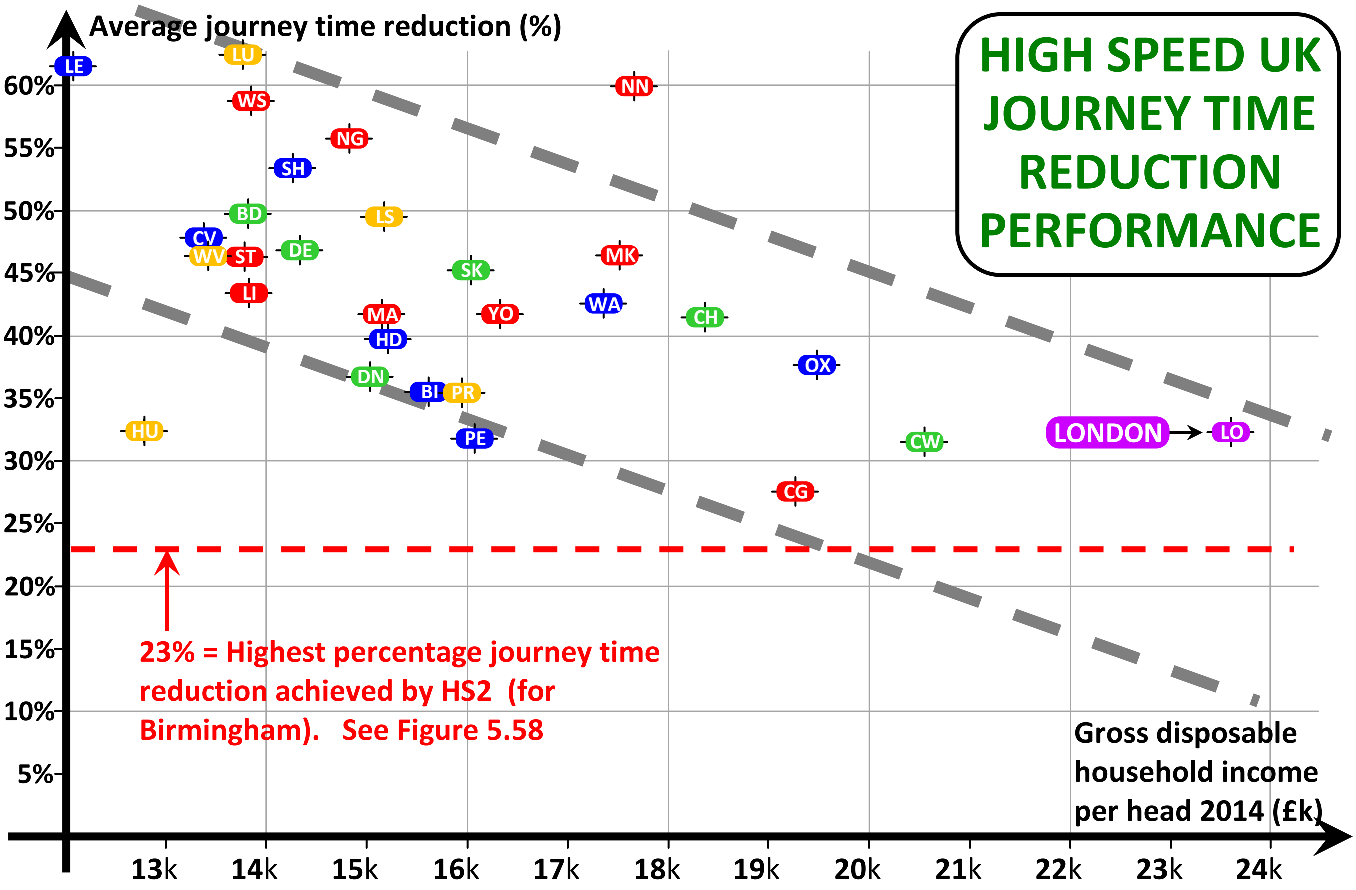


Figure 5.60 : Average %age Journey Time Reduction, by city – with HSUK in place

In the case of Hull, no improvements are yet schemed for its 55km long link to any element of new HSUK infrastructure, whereas Northampton – which is currently extraordinarily poorly connected to the existing intercity rail network – is only 5km from HSUK's 4-track north-south spine route.

Figure 5.61 illustrates HSUK's excellent performance in transforming the connectivity of some of the UK's worst-connected major towns and cities. Presently Walsall, Luton, Bradford, Hull and Leicester are, in relative terms, backwaters of the UK rail network, clear of the major long-distance rail corridors and (in the case of Walsall) lacking any sort of intercity service. All will become genuine hubs of the HSUK network, and all will gain massively under the HSUK scheme.

By contrast, London currently enjoys the greatest number of through services to the other 31 centres considered in the HSUK timetable, and its intercity services are of the highest quality by far. It is therefore unsurprising to note that London sees the smallest improvement in Intercity Connectivity Index.

However, the fact must still be highlighted that HSUK's 'worst' connectivity improvement for London (by a factor of 1.45) far exceeds HS2's best performance for Birmingham (by a factor of 1.21).

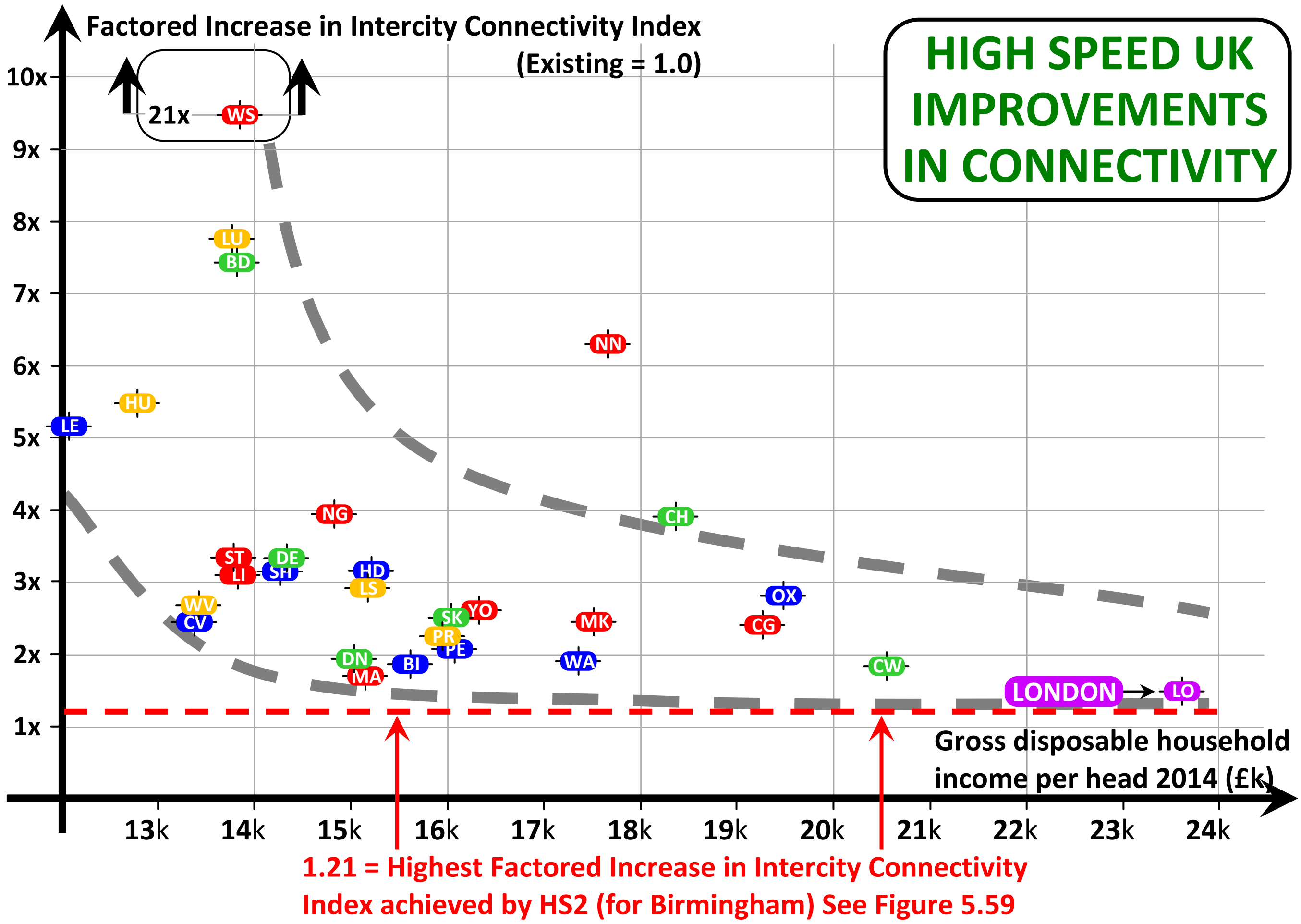


Figure 5.61 : Average Increase in Intercity Connectivity Index – with HSUK in place

5.9.8 Conclusions of Connectivity Analysis

This study has established a strong linkage between a community's economic performance and its connectivity to other communities. London is the best-connected city in the UK, and it is also the most prosperous, while poorer-connected regional communities suffer lower incomes and lower economic performance. It is vital that the intervention of new high speed rail has the effect of reducing current disparities, rather than exacerbating them.

Figure 5.62 illustrates HSUK's effectiveness in reducing connectivity disparities between the best-connected centre (now Sheffield) and the worst connected (now Chester). Using the empirical measure of 'Intercity Connectivity Index', Sheffield will be 2.5 times better connected than Chester. This represents a vast improvement over the existing network (see Figure 5.56) in which London is 25 times better connected than Walsall.

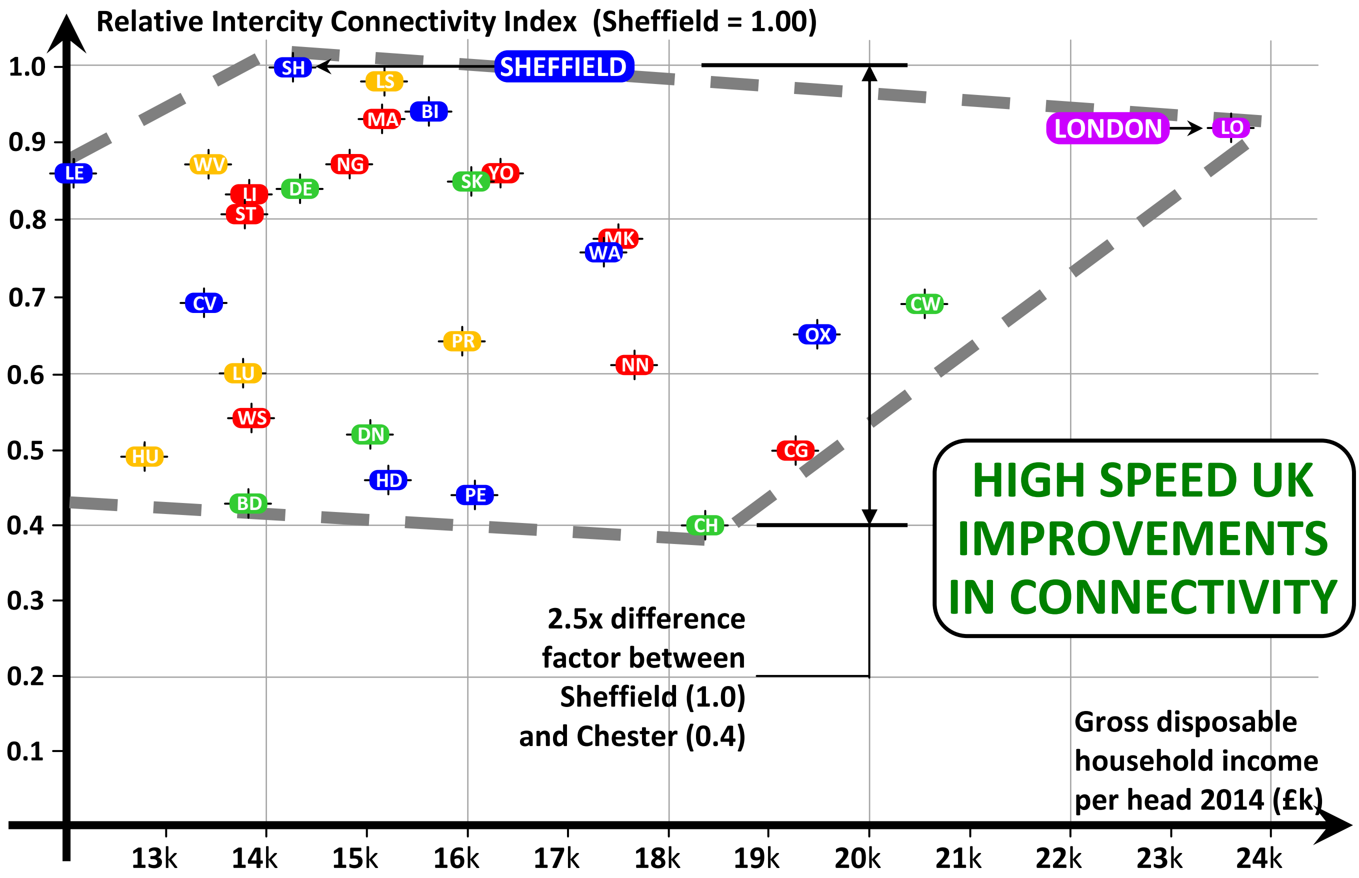


Figure 5.62 : HSUK Improvements in Intercity Connectivity Index

Whilst any disparity is undesirable, it seems inevitable that more populous centres such as London or Sheffield will enjoy superior connectivity to that of Walsall and Chester. However, it still remains the case that connectivity is relative, and that enhancing interregional links so as to reduce the speed disparity between London-centric and interregional journeys should bring about more favourable conditions for economic growth in the UK regions. Similarly, HSUK's specific interventions to address the poor connectivity of communities such as Luton and Walsall will also achieve the same benefits. On this logic, HSUK should encourage regional growth, and should play its part in redressing the current North-South Divide.

By contrast HS2's greater improvement of links to London, to the relative detriment of links between the UK regions, has the opposite effect of concentrating connectivity upon London. This can only lead to a similar concentration of economic activity upon London. This is of course precisely the reverse of what HS2 is intended to do, to stimulate the economies of the UK regions.

On this basis, it is impossible to see how HS2 can be any sort of 'Engine for Growth' for the UK regions.

5.10 HS2 : Implications for Transport CO_2 Emission Reductions

Given the 'green' credentials of rail transport, the implementation of HS2, the largest single intervention in UK surface transport for perhaps half a century, should provide a historic opportunity to achieve massive reductions in CO_2 emissions across the entire transport sector. However, HS2 Ltd's own figures show HS2 to be no better than carbon-neutral, completely at odds with the target of the **2008 Climate Change Act** for an 80% reduction in national CO_2 emissions by 2050.

HS2's failure can be very simply explained by the multiple capacity and connectivity failures documented in this study. With HS2 unable to meet its promise of **"hugely enhanced capacity and connectivity"** it cannot achieve the step-change modal shift from high-emitting road transport to lower-emitting rail transport necessary to achieve the radical target of the **2008 Climate Change Act**.

With HSUK's far greater capacity and connectivity, achieved on a national scale, CO_2 reductions in line with the **2008 Climate Change Act** appear to be feasible. HSUK's studies demonstrate potential CO_2 reductions of around 600 million tonnes.

5.10.1 HS2 and the 2008 Climate Change Act

HS2 is planned to be the most significant intervention in UK surface transport during the first half of the 21st Century. This is exactly the period in which the UK Government is legally committed by the 2008 Climate Change Act to achieve an 80% reduction in national CO_2 emissions by 2050.

The 80% reduction target is radical and unprecedented, and it demands fundamental structural changes to every aspect of how the nation lives, works and travels. It will only be achieved through a co-ordinated programme of Government-led interventions, with all aspects of public policy dedicated to the achievement of step-change reductions in CO_2 emissions.

With transport contributing around 25% of the UK's total CO_2 emissions, and with HS2 by far the largest national transport project, it would seem eminently reasonable to expect the Government to ensure that HS2 would be designed to make the maximum possible contribution to meeting the 80% reduction target of the 2008 Climate Change Act. However, HS2 fails utterly to make any worthwhile contribution.

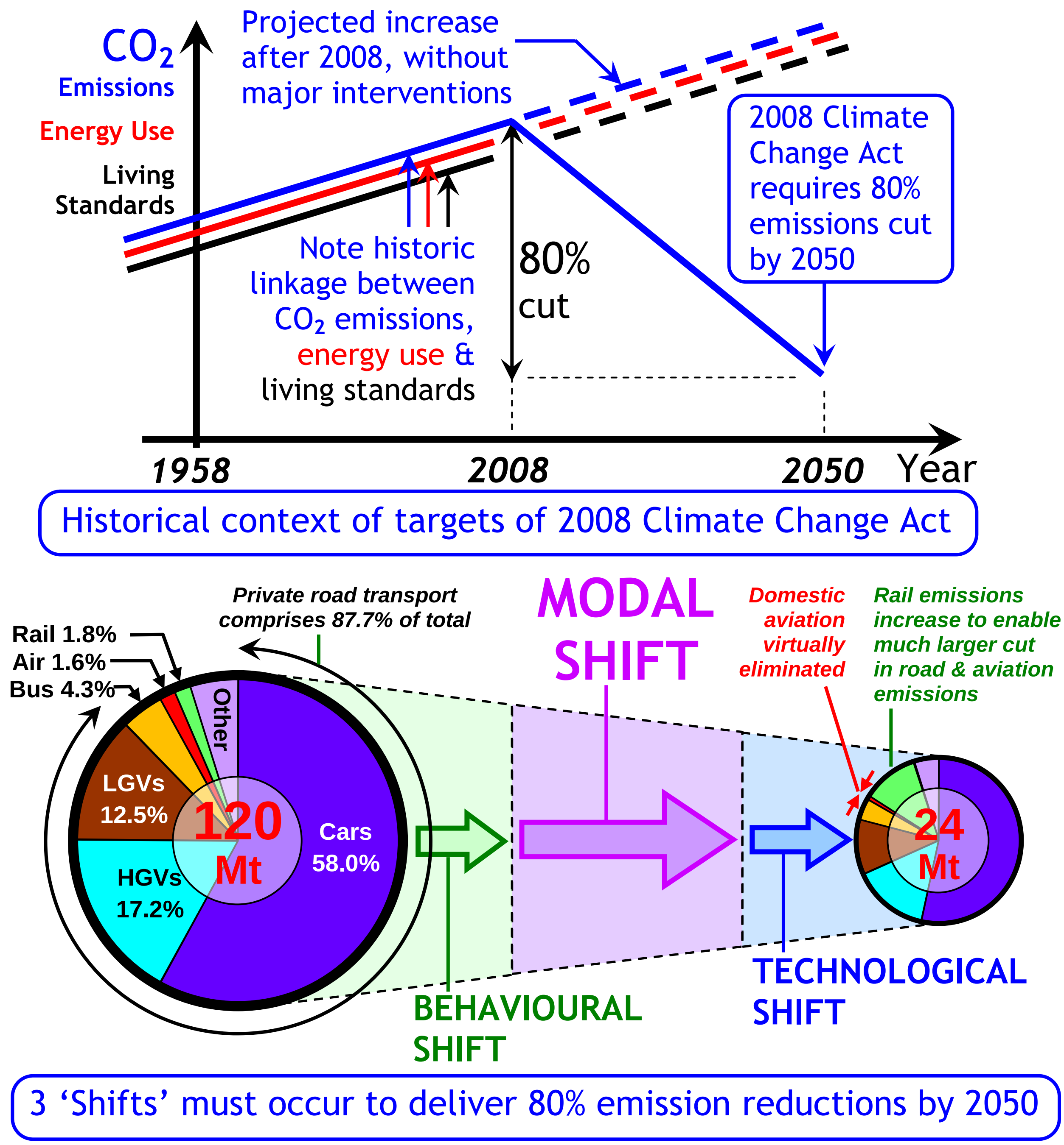


Figure 5.63 : 80% Emissions Reduction Target of 2008 Climate Change Act

HS2 Ltd's own reports[17] indicate that HS2 will offer no better than carbon-neutral performance ie it will achieve no significant overall CO_2 reductions across the entire transport sector. This failure can attributed very simply to HS2's extraordinarily poor performance in improving the capacity and connectivity of the national rail network. Without these improvements, it will not be possible to achieve the step-change road-to-rail modal shift necessary to bring about CO_2 emission reductions in line with the radical 80% target of the 2008 Climate Change Act.

When challenged on HS2's failure to make any meaningful contribution to national climate change targets, the Government has sought to deflect this criticism by claiming that with HS2

[17] DfT Command Paper *High Speed Rail* (March 2010), page 53 Table 2.5

being electric powered, and with electricity generation being progressively 'decarbonised' through the closure of coal- and gas-fired power stations, HS2 represents 'green' and emission-free transport.

However, the Government's stance fails to recognise the impacts of HS2's high demand for electric power, the limitations on overall generating capacity, and the fact that if 'green' electricity is ring-fenced for HS2, opportunities to decarbonise other sectors may be lost. Moreover, HS2's failure to meet its fundamental objective of ***"hugely enhanced capacity and connectivity"*** means that it can never achieve significant road-to-rail modal shift and thereby assist in the decarbonisation of road transport, which is responsible for over 90% of present-day transport CO_2 emissions.

5.10.2 HSUK : Capacity and Connectivity Crucial to Modal Shift

By contrast, the comprehensive connectivity and capacity gains achieved by HSUK will give the UK rail network the improved journey times, the enhanced service frequencies and the new journey opportunities that are all necessary to make rail the 'mode of choice' for a huge range of inter-urban journeys. If the rail network can outperform road transport for most intercity journeys, and if it has sufficient capacity to accommodate the resulting massive road to rail modal shift, then similarly massive reductions in CO_2 emissions can be anticipated.

HSUK's research[18] indicates that around 600 million tonnes of CO_2 reductions over a 40 year period are achievable. Further research is currently underway to validate the 600Mt figure in the light of this study's more detailed assessments of connectivity and capacity. This new research will investigate not only the issue of transport CO_2 emissions, but also the likely impacts on premature deaths brought about by pollutants in road vehicle exhausts.

[18] *High Speed Rail and CO_2*, Alan Brooke, 2011.
Note that Alan Brooke is a pseudonym adopted by Colin Elliff to avoid accusations of conflict of interest from his then railway industry employers.

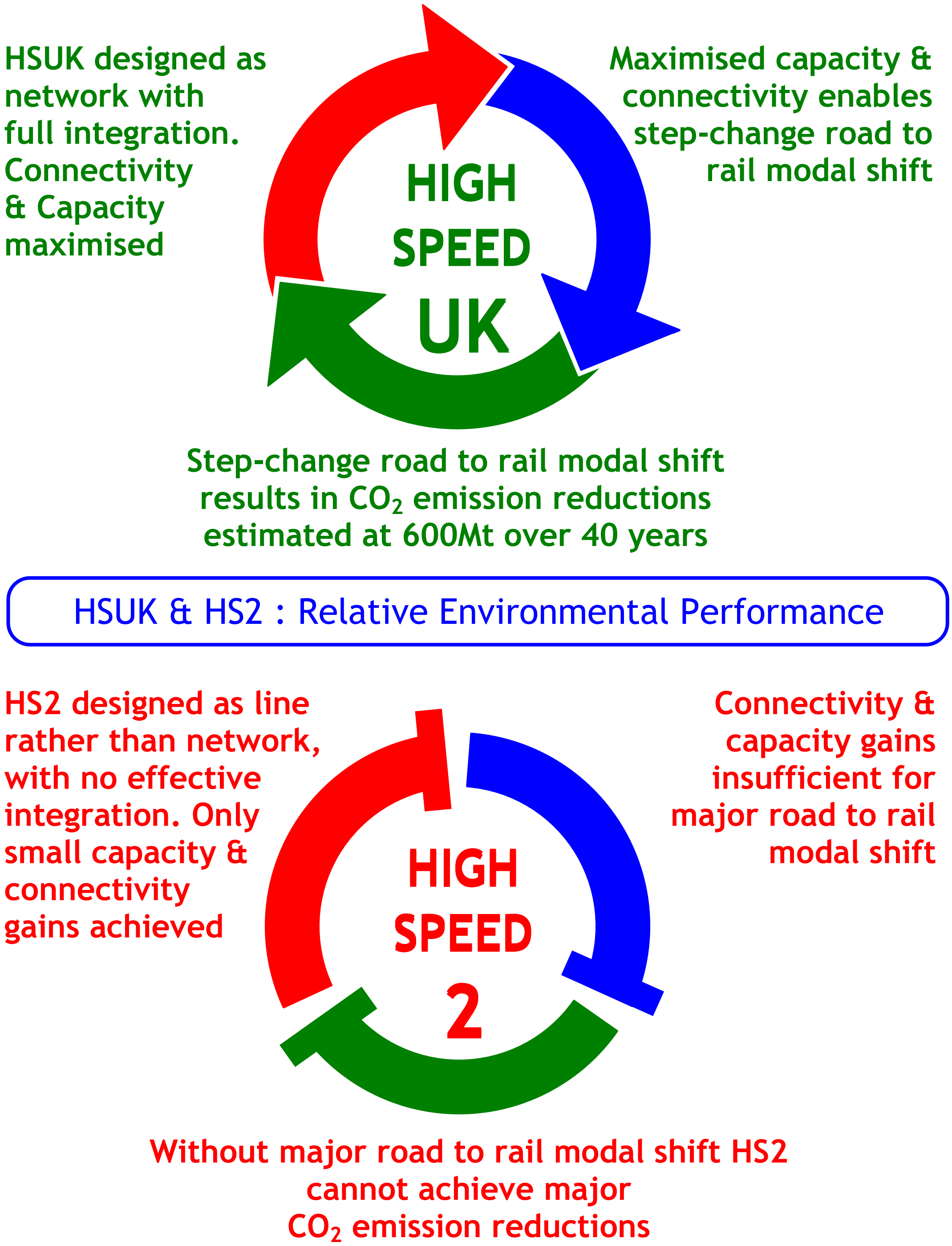


Figure 5.64 : Relative Environmental Performance of HSUK & HS2

5.11 HS2 : Extreme Design Speed Totally Counter-Productive to Efficient Performance of National Railway Network

HS2 has been designed to be the fastest railway in the world, with a proposed operating speed of 360km/h (225MPH) and allowance for future operation at 400km/h (250MPH). High economic value has been ascribed to every minute shaved off already-fast journeys to London, with little account apparently given to the adverse effects of extreme speed. These adverse effects include increased energy consumption and CO_2 emissions, increased maintenance costs and technical risk, and greater construction cost and impact on rural landscapes through adoption of ultra-straight alignments.

HSUK's achievement of far greater journey time reductions, despite its design for a lower ultimate speed of 360km/h and its greater focus on upgrading/ restoration of existing routes, indicates clearly that increased speed cannot be the uniformly positive factor that HS2 Ltd's designers have assumed it to be. Instead, integration with the existing network appears to be a far more powerful factor in achieving step-change journey time reductions across the national network.

Detailed analysis shows that HSUK's average journey time reduction of 46% would reduce to a slightly lower figure of 39%, if the entire network were operated at the existing maximum speed of 200km/h. This is more than 4 times the 9% average journey time reduction that HS2 could achieve, operating at 400km/h.

There is no indication that HS2 Ltd has ever undertaken the research necessary to establish the relationship between the speed for which a new railway intervention is designed, and the speed at which the entire national rail system can operate. This represents a catastrophic design failure, and it stands testament to the wider design failure of the entire HS2 project.

5.11.1 High Speed UK : Greater Journey Time Reductions for Shorter Length of New High Speed Line

High Speed UK's vastly superior performance in achieving journey time reductions across the national network (46% for HSUK compared with 9% for HS2) is achieved with a significantly shorter length of new build high speed line capable of operating at 360 km/h (the maximum speed assumed in the calculation of journey times for both HSUK and HS2). This indicates strongly that maximum speed cannot be the primary factor in achieving network-wide journey time reductions, and that other factors, in particular full integration between high speed line and existing network to allow a much wider spread of high speed services to access all major communities, have far more influence.

5.11.2 Calculations of Journey Time Reductions for Different High Speed Line Operating Speeds

To illustrate this point, a sensitivity analysis has been undertaken, with the HSUK timetable reevaluated for progressively reduced maximum speeds, to determine at what speed the 'crossover point' occurs, whereby HS2 (still operating at a maximum speed of 360 km/h) starts to offer greater overall journey time reductions.

Full re-evaluation of the HSUK timetable would entail major difficulties for the 27% of journeys (134 out of the 496 comprising the HSUK timetable) that require a change of trains. The connections between HSUK services have been optimised for the maximum operating speed of 360 km/h, and it is certain that many of these connections will be compromised (either going negative ie the first train arrives after the second train has departed, or becoming unacceptably long) by the changed journey times resulting from a change in maximum speed. Hence for any journey time involving a change of trains the overall timings for speeds other than 360 km/h will not be reliable without a full recasting of the timetable.

However, the HSUK timetable demonstrates (see Figure 5.4 depicting the 21-centre Direct Connectivity Assessment) that 17 of the 32 centres considered in the Quantified Journey Time Assessment can be fully interconnected with direct services. For this more limited network (comprising 136 possible journeys), changes of trains are eliminated and the running time on board train becomes the only element in a journey time calculation. For these journeys, changes in maximum speed can be accurately reflected into amended journey times.

The following procedure is used in the calculation of overall journey time reductions across a 32-centre network for various maximum speeds:

- Calculate average journey time reductions for a 32-centre network, operating at 360 km/h maximum speed. (A_{360}) – output from HSUK timetable spreadsheet, in *underlined italics*.
- Calculate average journey time reductions for a 17-centre network, operating at 360 km/h maximum speed. (B_{360}) – output from HSUK timetable spreadsheet, in *underlined italics*.
- Calculate difference in performance ($C = B_{360} – A_{360}$)
- Calculate average journey time reductions for a 17-centre network, operating at a lower maximum speed. (B_{320}) – output from HSUK timetable spreadsheet, in *underlined italics*.
- Apply same performance difference to derive an approximate average journey time reduction for a 32-centre network ($A_{320} \approx B_{320} – C$)
- Repeat calculation for progressively lower maximum speeds.

The results of these calculations are tabulated below, with outputs from the HSUK timetable spreadsheet shown in *underlined italics*.

	HS2	High Speed UK					
Maximum design speed (km/h)	400	360					
Maximum operating speed (km/h)	360	360	320	300	280	240	200
Average HSUK journey time reduction for 17-centre network (B)	--	48.8%	48.3%	47.9%	47.3%	45.5%	42.1%
Difference (C) – assumed constant	--	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Average HSUK journey time reduction for 32-centre network (A)	--	45.8%	45.3%	44.9%	44.3%	42.5%	39.1%
Average HS2 journey time reduction for 31-centre network	9.0%	--	--	--	--	--	--

Table 5.65 : Percentage Journey Time Reduction for Varying Operating Speeds

Table 5.65 and Figure 5.66 indicate clearly that there is no 'crossover speed' at which the fully integrated HSUK offers lower overall journey time reductions than the stand-alone HS2, operating at 360 km/h maximum speed. Even at 200 km/h (125 MPH), the maximum speed at which existing main lines operate, HSUK would offer an average journey time reduction of 39%, over 4 times greater than that of HS2 (ie 9%) operating at 360 km/h.

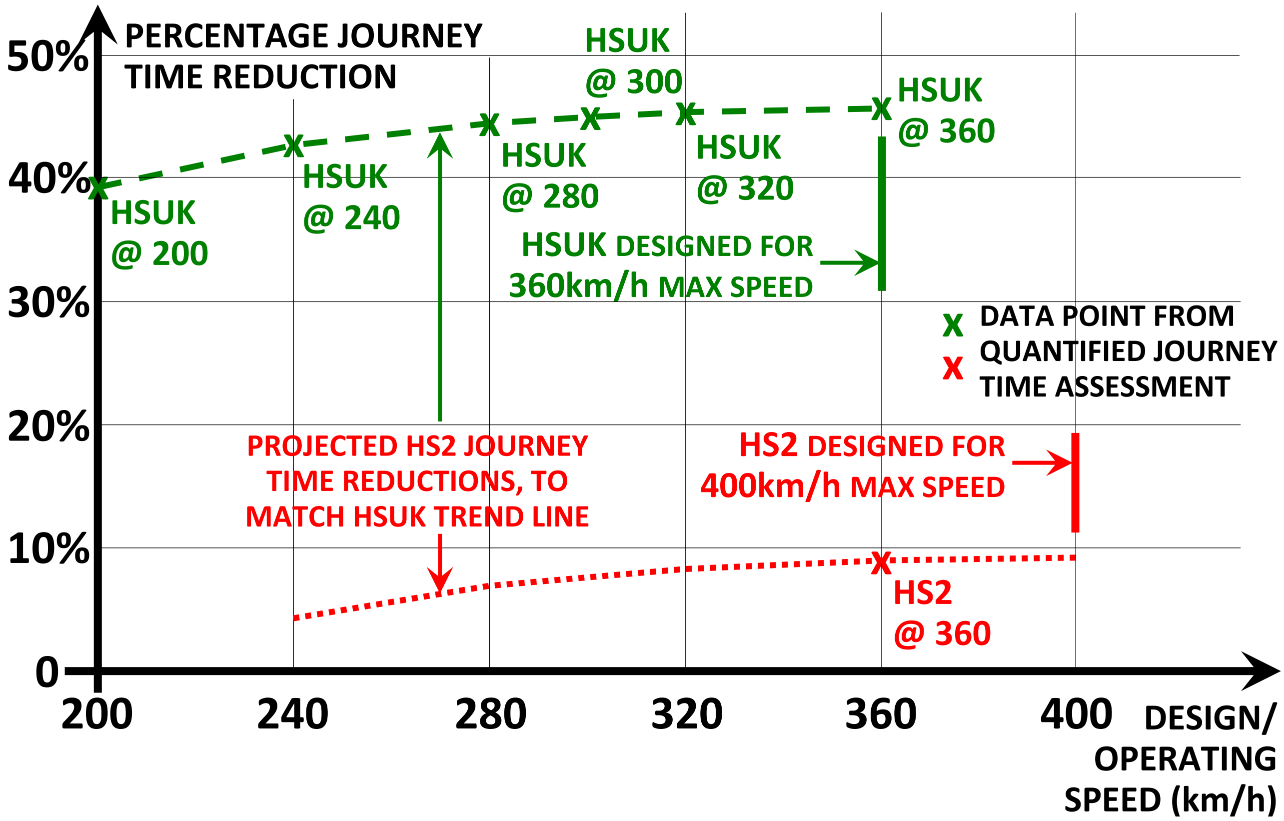


Figure 5.66 : Relationship between %age Journey Time Reduction and Operating Speed

This confirms that operating speed is a relatively minor factor in HSUK's vastly superior performance in reducing intercity journey times. Instead, there must be other factors causing the huge difference in performance between HSUK and HS2. Two factors appear to be crucial:

- HSUK's far greater integration with the existing network allows its journey time benefits to extend far beyond the high speed line.
- HSUK's superior connectivity, arising from both its new journey opportunities and its greater percentage of direct journeys, also brings about huge reductions in journey times, with no need to increase operating speed.

5.11.3 Consequences of HS2 Ltd Adoption of 400 km/h Design Speed

This analysis raises huge question marks over the rationales that HS2 Ltd has advanced to justify its decision to design for the extreme and unprecedented ultimate speed of 400 km/h (250 MPH). This decision has been resolutely defended by HS2 Ltd as necessary future-proofing against anticipated advances in technology, with a figure of 9% cited[19] as the difference in construction cost per kilometre between HS2's high speed line and a conventional railway designed for 200 km/h operation.

This 9% cost uplift figure seems highly dubious from any perspective of the increasing costs and difficulties of fitting a line constructed with 7800m minimum radius curves onto an undulating landscape, compared with the much lower 1900m radius required for a conventional railway designed for 200 km/h maximum speed.

However, this financial argument masks a much deeper issue. The most critical consequence of specifying for extreme speed is that it forces the new line away from established corridors, such as that followed by the West Coast Main Line and the M1, and it prevents the integration necessary for optimal network performance.

Instead, HS2 Ltd's 'need for speed' has dictated an intrusive and expensive rural route along which proper integration with the existing rail network is not practicable, and the comprehensive journey time benefits that accrue from full integration become unobtainable. The full consequences of HS2 Ltd's false prioritisation upon extreme speed are demonstrated both by the massive shortfalls in HS2's performance and by the success of HSUK in designing a new line closely following the M1 that is:

- capable of 360 km/h maximum speed;
- fully integrated with and physically connected to the existing network (both West Coast and Midland main lines);
- capable of delivering hugely improved intercity services to all major 'M1 corridor' communities ie Luton, Milton Keynes, Northampton, Coventry and Leicester – all of which are bypassed by HS2, and left with reduced intercity services;
- capable of offering 4-track capacity;
- clear of sensitive areas such as the Chilterns AONB (where 4-track construction is not practicable);

[19] The figure of 9%, for the cost uplift of constructing a high speed line designed for future operation at 400 km/h, compared with a conventional line, was given in evidence to the House of Lords Economic Affairs Committee on 9th December 2014 by David Prout, DfT Director General of HS2.

- capable of offering hugely greater overall journey time benefits on a national basis;
- cheaper to build through more favourable topography and lower design speed.

HSUK's success in designing an integrated and efficient national network with new routes designed for the maximum speed of 360 km/h, contrasted with HS2 Ltd's failure to achieve more than a fraction of HSUK's network performance and journey time reductions at the higher design speed of 400 km/h, points towards a very inconvenient truth. The received wisdom that has prevailed throughout HS2's development, that greater speed represents a uniform positive, and that increasing the design speed of the new high speed line must, almost by definition, increase the overall speed of the network, appears not to apply at the extreme speed of 400 km/h.

More research is required to:

- establish a rigorous correlation between design speed of high speed line and overall operating speed of network (network speed);
- identify the various factors and mechanisms that influence this relationship;
- determine the 'cut-off speed' at which a further increase in design speed results in a reduced speed at which the entire network can operate.

5.11.4 Indicative Determination of 'Cut-off Speed'

As noted previously, HS2's design for 400 km/h future operation forces the new line onto intrusive rural routes along which integration with the existing network is generally not practicable. With little integration and with only 2 tracks HS2's journey time benefits cannot extend away from the high speed line.

By contrast HSUK proves the opposite point, that design for a lower speed of 360 km/h along the established M1 corridor permits the full integration and 4-track construction necessary to enable optimised capacity, connectivity and network performance.

This indicates clearly that the cut-off speed is essentially the point, somewhere between 360 and 400 km/h, at which it is no longer practicable to design a high speed line on a 'close parallel' alignment to the M1. Beyond this speed increased design speed results in reduced network performance.

5.11.5 Determination of Optimum Operating Speed

The results of this analysis set out in Table 5.65 and Figure 5.66 indicate that once the routeing and integration of the high speed line has been determined by the decision upon the design speed of the new line, the actual maximum speed at which the new high speed line operates is a relatively minor factor in governing the overall journey time performance of an entire railway network. The integration necessary to spread the journey time benefits beyond the physical extent of the new line and optimise network performance appears to have a much greater influence.

Given the minimal differences in average journey time reductions at very high speeds – HSUK's 45.8% performance at 360 km/h is less than 1% higher than its 44.9% performance at the more conventional high speed of 300 km/h – there must be further detailed analysis to determine the optimum operating speed. This analysis must consider not only the true economic benefit of each minute shaved off a journey, but also all the adverse effects of increased speed, including:

- higher energy costs;
- higher CO_2 emissions;
- greater noise nuisance;
- greater ground disturbance (e.g. the 'Rayleigh wave effect');
- higher maintenance costs for both trains and tracks;
- greater intrusion into unspoilt rural areas;
- greater construction cost and need for tunnelling;
- greater technical risk.

There is no indication that HS2 Ltd has given proper consideration to any of these issues.

5.11.6 Conclusions of Design Speed Analysis

HS2 Ltd's problem is a classic problem of system design – or in this case, the adaptation and development of an existing system – in which excessive focus upon one attribute – in this case the extreme and unprecedented speed for which the new intervention is designed – compromises the performance of the entire system.

In a properly regulated UK high speed rail project the potential 'adverse relationship' between the high speed line's design speed and the speed at which the entire network can operate should have been recognised and thoroughly understood. Unfortunately, in the case of the HS2 project, this understanding appears to be entirely absent.

There appears to have been no recognition on the part of HS2 Ltd that the UK rail network does comprise a system, that HS2 will become part of this system, and that the intervention of HS2 must be designed so as to optimise the performance of the entire system. Instead, HS2 Ltd has exceeded its remit in designing a stand-alone system of superfast high speed lines, and in so doing it has failed to give the necessary consideration to the performance of the wider UK rail network.

All this points up the ultimate failure in the design of HS2. Whilst higher speed is generally desirable in shortening journey times, HS2's specification for the extreme and unprecedented design speed of 400 km/h is positively counter-productive to the desired outcome of a fully integrated rail network, and this lack of integration prevents the distribution of the benefits of increased speed across the entire national network. HS2 Ltd's transparent desire to build the fastest railway in the world seems to have had the perverse and unintended consequence of driving down the overall speed at which the entire national rail network can operate.

This raises the very obvious question of how the decision to design for the extreme speed of 400 km/h was taken, and what the key factors were in driving this decision. There is no published record of any structured process by which the decision was reached; instead, reported comments from HS2's leadership indicate that 400 km/h was adopted essentially on the basis that "this is the way the technology is going", an attempt to future-proof against anticipated advances in train and track design. There was little or no balanced consideration either of the adverse effects of extreme speed, of the necessity for extreme speed on a small island, or of the relevant factors that contribute to the desired outcome of an optimally performing railway network.

HS2 Ltd's ill-considered adoption of 400 km/h – which might be characterised as the capricious whim of a technocratic elite to build the world's fastest railway – is just one aspect of a much wider technical failure, not only of decision making, but also of project governance. Essentially, this is a failure to understand the true purpose of high speed rail. This purpose is not to build a superfast showcase railway between arbitrary and poorly-connected fixed points. Instead, it is to employ the intervention of this new railway in the most responsible and cost-effective manner to meet the basic objective of the HS2 project, to bring about a transformed and optimised national rail network capable of delivering **"hugely enhanced capacity and connectivity"** between the UK's major conurbations.

6 Conclusions

The introduction to *HS2 : High Speed to Nowhere* identifies ten crucial questions which must be addressed if the HS2 project is to meet its fundamental objective of **"hugely enhanced capacity and connectivity"** between the UK's major conurbations, delivering its benefits to the greatest possible proportion of the UK population:

1. Do HS2's headline journey time reductions translate into comprehensive improvements across the wider UK rail network?
2. Will HS2's 2 tracks give sufficient new capacity to achieve these wider improvements?
3. What will the overall journey time reductions be?
4. Will HS2 deliver extra capacity for improved local services in regional conurbations?
5. Will HS2 be 'future-proofed' against growing demand for rail services?
6. How will the entire intercity rail network operate with HS2 in place?
7. Have HS2's routes and links to existing main lines been correctly selected to optimise the functioning of the entire network?
8. Is HS2's design for a future maximum operating speed of 400 km/h compatible with optimised functioning of the network?
9. Will HS2 bring about economic benefits for the UK regions and reverse the North-South divide?
10. Has there been proper technical optimisation of HS2?

These are relatively simple questions which the UK public might reasonably expect to be addressed before huge sums of public money and the future of the national railway system are gambled upon the successful outcome of the HS2 project. Yet neither HS2 Ltd nor the Government nor the wider transport establishment has ever undertaken the detailed railway engineering and operational study necessary to determine these issues.

This study's projection of HS2's journey times and connectivity across the national network[20], and its comprehensive comparisons with the alternative High Speed UK scheme, allow for the first time all of these crucial questions to be resolved:

1. HS2's journey time reductions are largely restricted to the much-promoted headline journey times between key primary cities; only 18% of journeys will see any improvement in journey time and a greater proportion will be made worse.
2. Lack of capacity of HS2's 2-track stem, together with an almost complete lack of integration with and connection to the existing network, are key factors in restricting the spread of HS2's benefits beyond the physical extent of the new high speed line.
3. HS2's achievement of 9% average journey time reductions across the national network compares very poorly with HSUK's figure of 46%.

[20] For the purposes of the Journey Time Assessment, the national network has been taken to comprise 32 major towns, cities and airports spread across the 'Zone of Influence' of the HS2 'Y' system, as detailed in Item 2.6 of this study.

4. HS2 will be ineffective in generating extra capacity for improved local services in regional conurbations; its capacity benefits are small, and largely confined to the corridor of the West Coast Main Line.
5. HS2's new capacity is already fully allocated, and cannot satisfy the reasonable demand of all current stakeholder cities to enjoy high speed services. There can therefore be no question of HS2 being future-proofed for anticipated increased demand for intercity rail travel.
6. No explanation has ever been provided for how the entire national rail network will operate, with HS2 in place. All the outputs of this study indicate strongly that the introduction of HS2 will have an overall negative effective upon the performance and the integrity of the network.
7. HS2's routes have been developed with no consideration of an optimised national network. All design effort has been confined to the question of how the new lines will perform, largely in isolation from the existing railway.
8. HS2's design for a future maximum operating speed of 400 km/h dictates intrusive and expensive rural routes and prevents effective integration with the existing network. Comparison with High Speed UK, designed for a lower maximum speed but capable of delivering far greater network-wide journey time reductions, and far greater overall gains in connectivity indicates clearly that design for extreme speed is incompatible with optimised functioning of the national network.
9. This study has established a clear linkage between the per capita income in different UK cities, and the journey times and connectivity offered by the existing network. With HS2 tending to deliver greatest journey time and connectivity benefits to London, it follows that HS2's economic benefits will also be concentrated in London. By contrast HSUK will transform interregional links, and will achieve the greatest connectivity and the greatest benefits for the poorest-connected cities with the lowest per capita income.
10. The vastly superior performance of High Speed UK on almost any reasonable comparator indicates clearly that HS2 cannot possibly have been technically optimised in a proper and professional manner to provide the greatest possible gains in capacity and connectivity for the least cost and environmental impact.

Every comparison presented on every page of this study proves beyond any reasonable doubt that HS2 cannot meet its fundamental objective of delivering **"hugely enhanced capacity and connectivity"** between the UK's major conurbations, and as such it cannot deliver its promise of transformational economic benefits. Any benefit beyond its few direct journeys linking a few primary cities that HS2 does deliver is at best by means of 'trickledown'; but this logic is simply unacceptable when the priority must be to deliver direct benefits to the greatest possible proportion of the UK population, and to offer value for the huge sums of public money that will be expended on HS2.

This study has also exposed three of the principal myths that have been propagated by the proponents of the HS2 project.

Firstly, this study has demonstrated that HS2 cannot bring economic benefits to the UK regions and help reverse the North-South divide. It has shown a strong linkage between a community's intercity connectivity and its economic performance; this explains, at least in part, the present North-South divide by which London enjoys much greater prosperity relative to the UK regions. With HS2's connectivity benefits concentrated upon London, and with links between UK regions damaged, it is inevitable that London is where any economic benefits that HS2 might generate will also be concentrated. HSUK's greater integration and focus upon network performance creates precisely the opposite effect of concentrating its connectivity benefits, and therefore its economic benefits, on the more disadvantaged communities of the UK regions – which of course is perhaps the primary rationale of the UK high speed rail project.

Secondly, this study has revealed HS2's failure to bring about a more united kingdom through improved links between the UK regions. HS2 Ltd's failure either to integrate with the existing network or to pay any attention to the performance of the overall national rail system that HS2 will create will have the effect of damaging many interregional links. HS2 will do nothing to stimulate the 'Midlands Engine', and its highly London-centric design is positively counter-productive to the establishment of efficient transpennine 'HS3' links between the cities of the Northern Powerhouse. Of equal concern is the fragmentation of direct links to the Scottish cities of Edinburgh and Glasgow; as Table 5.2 demonstrates, with HS2 in place, the 22 direct intercity links that currently exist[21] to English cities will be reduced to 9.

Thirdly, this study has conclusively established HS2's extremely poor performance as a high speed railway. Whilst it is designed for the unprecedented speed of 400 km/h, its almost complete lack of integration means that the journey time benefits that its high speed will generate are confined to the high speed line, and to certain primary routes extending beyond. Despite the fact that HSUK has been designed to a lower maximum speed of 360 km/h, its full integration with the existing network enables its journey time benefits to extend to all major communities. This enables HSUK to achieve 46% average journey time reductions across the national network, as opposed to the 9% reductions that HS2 can offer.

It is surely unarguable that if the nation is to invest upwards of £55 billion in the construction of new high speed lines to enhance the national rail network, the nation has a right to expect not any high speed rail scheme but the best possible high speed rail scheme. There is already deep public concern as to HS2's ever-rising costs and its extreme environmental impacts, but the Government has so far chosen not to listen to these public concerns. Instead, Government has kept faith with a small coterie of experts who continue to insist, in the face

[21] For the purposes of the Outline Connectivity Assessment, the national network has been taken to comprise 20 major towns and cities plus Heathrow Airport, as detailed in Item 2.4 of this study.

of mounting evidence to the contrary, that HS2 is still the best, and the only way forward for the development of the nation's railways.

The evidence presented in this study goes far beyond the symptomatic issues of excessive costs and impacts that have characterised previous critiques of the HS2 project. It proves for the first time the much simpler truths:

- HS2 is utterly unfit for purpose as an intercity railway system, completely failing to meet its fundamental objective of **"hugely enhanced capacity and connectivity"** between the UK's major conurbations.
- HS2's failures are not localised – they are systemic, extending across the full extent of the UK rail network, and they indicate a fundamental failure of the entire process by which HS2 has been designed.
- A superior alternative to HS2 exists in the form of High Speed UK, which addresses all of HS2's deficiencies, and which is far more capable of forming the improved national network that is necessary to meet HS2's fundamental capacity and connectivity objective.

The Government must take urgent action to get a grip on the UK high speed rail project. It must immediately halt the HS2 juggernaut before it runs completely out of control and it must launch an urgent public inquiry to determine how and why the HS2 project has gone so far wrong. Alternatively it must present a detailed narrative to explain how the comprehensive analysis presented in this study is either wrong, inappropriate or irrelevant.

The Government and the wider transport establishment must remember that wherever HS2 might be in the legislative or constructional process, the facts presented in *HS2 : High Speed to Nowhere* will not go away. To ignore these facts, and the analysis underpinning them – in other words to do nothing – would be an act of complete irresponsibility, when £55 billion of public money and the future of the national railway system are at stake.