

HS2 & HSUK : CONNECTIVITY COMPARED

In all the controversy that has surrounded the HS2 project, it's easy to lose sight of its true purpose. Fortunately, former HS2 Ltd Technical Director Andrew McNaughton has provided a succinct definition. On 30th November 2015, he stated in evidence to the House of Commons HS2 Select Committee:

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

The aim of improved rail network connectivity and capacity seems incontrovertible. Transport congestion, especially on routes between regional cities, is commonly accepted as a critical factor holding back the economy, and maintaining the North-South Divide. If rail network connectivity and capacity can be improved, then major economic benefits should result.

But whilst Mr McNaughton is doubtless sincere in his aim for "hugely enhanced capacity and connectivity", there is growing evidence that HS2 will fail to deliver the promised benefits. There is also compelling evidence that HS2 Ltd seems never to have troubled to design HS2 as an optimised network to deliver the required enhancements in capacity and connectivity.

This paper seeks to put HS2 Ltd's connectivity promises to the test, and to determine whether HS2 represents the optimum solution that its proponents claim. But first, it's necessary to determine the true extent of the problem.

Connectivity can mean a lot of things; but in the context of an intercity rail network, there should be a basic aspiration for trains of intercity quality providing direct links, at hourly or better frequency, between all principal cities. Taking this as the requirement, Figure 1 below presents an assessment of the connectivity that the existing national network offers between London, Heathrow Airport and the 9 primary cities of the Midlands, the North and Scotland.

London	LO												High quality direct hourly intercity link
Birmingham		BI											Medium quality direct hourly intercity link
Nottingham			NG										Low quality direct hourly intercity link
Sheffield				SH									2 2-hourly direct intercity link
Manchester					MA								
Liverpool						LI							
Leeds							LS						
Newcastle								NE					
Edinburgh									EH				
Glasgow										GL			
Heathrow													LHR
	LO	BI	NG	SH	MA	LI	LS	NE	EH	GL	LHR		

Figure 1 : Connectivity offered by existing network between 10 UK Primary Cities
(timetable data from www.nationalrail.co.uk)

Figure 1 highlights:

- **The massive London-centricity of the existing network.** Only London enjoys direct services, at hourly or better frequency, to all other cities, and the trains operating these services are fast, and generally of high 'intercity' quality.
- **The poor links between regional cities.** There are several journeys between the UK's primary regional cities that cannot be accomplished by a single direct train, and most of the direct journeys that can be made are on mediocre or poor rolling stock, much inferior to that operating on intercity services to London.
- **The absence of any direct links between regional cities and Heathrow Airport.** All rail journeys to the UK's principal international gateway must be routed via central London, with an inconvenient Tube transfer.

The poor interregional connectivity highlighted in Figure 1 is both a symptom and a cause of the North-South Divide that afflicts the UK economy; it is therefore vital that any intervention of new high speed lines such as HS2 redresses these major deficiencies. By contrast, there appears to be relatively little problem in travelling from regional cities to London.

So there's no doubt that there's a connectivity problem to be solved. The next question is: which are the 'major conurbations' that HS2 Ltd intends to link?

Principal City	Primary City??	Within Scope??	Conurbation	KEY
London	Y	Y	Greater London	
Milton Keynes	N	Y	M1 Corridor	Primary City
Birmingham	Y	Y	West Midlands	Second-tier City
Leicester	N	Y	East Midlands	Heathrow Airport
Nottingham	Y	Y		City within scope of N-S high speed line
Derby	N	Y		City outside scope
Stoke	N	Y	Potteries	
Sheffield	Y	Y	South Yorkshire	
Manchester	Y	Y	Greater Manchester	
Liverpool	Y	Y	Merseyside	
Leeds	Y	Y	West Yorkshire	
Darlington	N	Y	Teesside	
Newcastle	Y	Y	Tyne & Wear	
Edinburgh	Y	Y	Lothian	
Glasgow	Y	Y	Strathclyde	
Bristol	Y	N	Avon	
Cardiff	Y	N	South Wales	
Heathrow Airport	N/A	Y	UK primary international gateway	

Table 2 : Principal UK cities and associated 'major conurbations'

In practical terms, intercity railways (whether 'high speed' or otherwise) don't link conurbations. Instead, they link the primary cities at the heart of the conurbation, and they work most efficiently when operating from city centre stations which also comprise the hub of the local suburban network.

There is a close correspondence between primary cities and major conurbations. Table 2 lists the 12 UK primary cities and the conurbation in which each city is located, generally at a centroidal position. The only exception is the poly-centric East Midlands conurbation, formed around the primary city of Nottingham and the second-tier cities of Derby and Leicester.

Other conurbations also need to be considered:

- Teesside – best represented by Darlington;
- Potteries – represented by Stoke (on Trent);
- M1 Corridor – best represented by Milton Keynes.

All the conurbations listed in Table 2 might reasonably be deemed 'major conurbations'; and since it is not certain which the 'major conurbations' are, to which HS2 Ltd intends to deliver 'hugely enhanced capacity and connectivity', this paper will assess HS2's connectivity for 3 different groupings of cities/conurbations:

Case 1: London, Heathrow Airport and the 9 primary cities of the Midlands, the North and Scotland.

Case 2: London, Heathrow Airport and all 11 UK primary cities including Bristol and Cardiff, both outside the direct geographical scope of the HS2 project.

Case 3: London, Heathrow Airport, the 9 primary cities of the Midlands, the North and Scotland plus the 5 other second-tier cities listed in Table 2.

In all assessments, HS2's connectivity will be contrasted with that of the High Speed UK 'exemplar alternative'. Source data is taken as follows:

- **Projected HS2 services** from Annex B : Modelled train service spec, High Speed Two Phase 2b Strategic Outline Business Case, (HMG, October 2016).
- **Intercity service reductions with HS2 in place** from Table 23, pp91-92, HS2 Regional Economic Impacts (HS2 Ltd, September 2013).
- **Northern Powerhouse Rail services** assumed to match HS3/NPR service specification.
- **Projected HSUK services** from HSUK Demonstrator Timetable, and as set out in the HSUK Service Diagrams.

In the assessments, journeys outside the geographical scope of a north-south high speed line and enhanced national rail access to Heathrow Airport (i.e. London to Heathrow, Bristol and Cardiff, and Bristol to Cardiff) are excluded from consideration. Additionally, HS2's proposed station at Toton (9km from central Nottingham) is not accepted as an intercity station for Nottingham.

Case 1: London, Heathrow Airport, Birmingham, Nottingham, Sheffield, Manchester, Liverpool, Leeds, Newcastle, Edinburgh, Glasgow (11 centres)

HS2's connectivity offer is set out in Figure 3. This reflects HS2's Y-configuration – good quality high speed links only to London and Birmingham, and little or no worthwhile links between other cities – and it does virtually nothing to remedy the deficiencies of the existing network. HS2's failure to achieve any connection between northern cities ultimately resulted in the belated launch of the Northern Powerhouse Rail (NPR) initiative; but this has proved only partially effective in redressing the connectivity deficiencies of the HS2 'Y-network'.

HS2's unbalanced introduction will also have the effect of damaging existing intercity connectivity, particularly along the ECML corridor between Yorkshire, the North-East and Scotland.

London	LO										<div></div>	Direct HS2 link at hourly frequency	
Birmingham	<div></div>	BI									<div></div>	Direct NPR link at hourly frequency	
Nottingham			NG								<div>2</div>	Only 2-hourly frequency offered	
Sheffield	<div></div>	<div></div>		SH							<div></div>	<div></div>	Existing link made worse by HS2
Manchester	<div></div>	<div></div>		<div></div>	MA					<div></div>			
Liverpool	<div></div>			<div></div>	<div></div>	LI							
Leeds	<div></div>	<div></div>		<div></div>	<div></div>	<div></div>	LS						
Newcastle	<div></div>	<div></div>		<div></div>	<div></div>	<div></div>	<div></div>	NE					
Edinburgh	<div></div>	<div>2</div>		<div></div>			<div></div>	<div></div>	EH				
Glasgow	<div></div>	<div>2</div>		<div></div>			<div></div>	<div></div>		GL			
Heathrow	<div></div>									LHR			
	LO	BI	NG	SH	MA	LI	LS	NE	EH	GL	LHR		

Figure 3 : Connectivity offered by HS2 and NPR between 10 UK Primary Cities (Case 1)

By contrast, HSUK achieves comprehensive direct high speed links between all 10 primary cities and Heathrow Airport. This represents an unprecedented gain in national intercity connectivity, and it is directly attributable to HSUK's design from the outset as a fully integrated national network.

























































London	LO					 Direct HSUK link at hourly frequency					
Birmingham		BI									
Nottingham			NG								
Sheffield				SH							
Manchester					MA						
Liverpool						LI					
Leeds							LS				
Newcastle								NE			
Edinburgh									EH		
Glasgow										GL	
Heathrow											LHR
	LO	BI	NG	SH	MA	LI	LS	NE	EH	GL	LHR

Figure 4 : Connectivity offered by High Speed UK between 10 UK Primary Cities (Case 1)

Case 2: London, Heathrow Airport, Birmingham, Nottingham, Sheffield, Manchester, Liverpool, Leeds, Newcastle, Edinburgh, Glasgow, Bristol, Cardiff (13 centres)

When the connectivity comparison is extended to all 12 UK primary cities, HS2's performance as a national network deteriorates even further. HS2 Ltd's selection of its Curzon Street terminus in Birmingham, totally disconnected from the existing intercity hub at Birmingham New Street, will effectively sever the north-east/south-west CrossCountry route and fragment the national network. This leaves no possibility of high speed services ever extending to Bristol and Cardiff, and therefore forming a genuine national high speed network.

London	LO														Direct HS2 link at hourly frequency
Birmingham		BI												2	Only 2-hourly frequency offered
Nottingham			NG												Direct NPR link as per HS3 spec
Sheffield				SH											Existing link made worse by HS2
Manchester					MA										City/airport not served by HS2
Liverpool						LI									Existing 'out of scope' intercity link
Leeds						LS									
Newcastle							NE								
Edinburgh			2					EH							
Glasgow			2						GL						
Bristol									BS						
Cardiff												CF			
Heathrow													LHR		
	LO	BI	NG	SH	MA	LI	LS	NE	EH	GL	BS	CF	LHR		

Figure 5 : Connectivity offered by HS2 and NPR between 12 UK Primary Cities (Case 2)

HSUK's radically different design philosophy of integrated development of new high speed lines and upgraded existing routes is exemplified in proposals for an upgraded West Midlands rail network, with 4-tracking along all key radial routes. This network, still focussed upon Birmingham New Street, will allow high speed services to extend to Bristol and Cardiff.

London	LO							Direct HSUK link at hourly frequency																	
Birmingham	BI								Existing 'out of scope' intercity link																
Nottingham		NG																							
Sheffield			SH																						
Manchester				MA																					
Liverpool					LI																				
Leeds						LS																			
Newcastle							NE																		
Edinburgh								EH																	
Glasgow									GL																
Bristol										BS															
Cardiff											CF														
Heathrow												LHR													
	LO	BI	NG	SH	MA	LI	LS	NE	EH	GL	BS	CF	LHR												

Figure 6 : Connectivity offered by High Speed UK between 12 UK Primary Cities (Case 2)

As the comparison extends to a greater number of major regional cities, HS2's performance becomes progressively worse, with significantly more intercity links made worse through the intervention of HS2, than will be improved. This is testament to HS2 Ltd's failure to design HS2 as a national network.



London	LO	Direct HSUK link at hourly frequency															
Milton K		MK															
Birmingham			BI														
Leicester				LE													
Nottingham					NG												
Derby						DE											
Stoke							ST										
Sheffield								SH									
Manchester									MA								
Liverpool										LI							
Leeds											LS						
Darlington												DL					
Newcastle													NE				
Edinburgh														EH			
Glasgow															GL		
Heathrow																LHR	
	LO	MK	BI	LE	NG	DE	ST	SH	MA	LI	LS	DL	NE	EH	GL	LHR	

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All of the comparisons presented in this paper unequivocally demonstrate HS2's hugely inadequate performance as a national network. This failure has not happened by bad luck, or by accident. It has happened because no-one at HS2 Ltd appears to have understood how the UK's railway network must perform to fulfil its fundamental purpose, of connecting the nation and enhancing the nation's economic performance. In the absence of this understanding, HS2 Ltd's technical leadership has focussed instead on the futile pursuit of extreme speed.

Whilst extreme speed might result in spectacular improvements in 'headline' journey times from regional cities such as Leeds, Manchester and Birmingham to London, its wider effect is to prevent the integration necessary to ensure that the new high speed lines work in harmony with the existing network. In the absence of this integration, the effect of HS2 – as demonstrated in Figures 3, 5 and 7 – will be to:

- enhance the already higher-quality links to London;
- degrade many interregional links;
- reinforce the existing London-centricity of the national rail network.

As a whole, HS2 seems certain to have the perverse and unintended effect of exacerbating, rather than redressing the North-South Divide.

The extent of HS2 Ltd's failure can only be truly appreciated when HS2's performance as a national network (and as a high speed railway) is compared with that of the High Speed UK 'exemplar alternative'. HSUK's vastly superior performance demonstrates clearly that it is possible to design an improved national network in which all primary cities can be fully interlinked, to create a better-connected nation – and in doing so, achieve far greater journey time reductions and overall economic benefits. It also demonstrates the opposite truth – that if you don't bother to design a network, you probably won't get one.

HS2's performance in delivering "hugely enhanced" connectivity between the UK's major conurbations is set out in numerical form in Table 9, and contrasted with that of HSUK.

However the UK's 'major conurbations' are defined, HS2's comprehensive connectivity failure is clear and unambiguous.

			HS2 & NPR & Mids Rail Hub		High Speed UK	
	No. of centres in network	No. of possible journeys	No. of direct, no-change journeys	No. of journeys made worse	No. of direct, no-change journeys	No. of journeys made worse
Case 1	11	54	24	6	54	0
Case 2	13	74	24	11	74	0
Case 3	16	119	36	23	119	0

Table 9 : Connectivity Comparisons between HS2/NPR/MRH and High Speed UK