Travel market demand and the HS1 – HS2 link

Greengauge 21
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1. Executive Summary

Current plans for HS2 include a connection with HS1 – the high-speed line from central London across Kent to the channel tunnel completed in 2007. The purpose of the connection has always been presumed to be to allow the provision of direct international services from Midland and Northern cities to Europe, and on that basis, HS2 Ltd has not been encouraged.

Over the three years since the HS1 connection was first published as part of the first phase of HS2, the business case has not been developed further. Work published by HS2 Ltd suggests demand for international direct services using the connection would be modest.

The current version of the connection has a single track connection between Old Oak Common and Camden Road junction.

What has been overlooked is the question of the potential use of the HS1 – HS2 connection for *domestic* high-speed rail services. The analysis presented here was commissioned by Greengauge 21 to address this shortcoming. The work was carried out by MVA and it identifies the level of demand that would be addressed by services using the connection and the potential market share that rail would attract. A comparison of the model forecasts against equivalent HS2 Ltd modelling shows good consistency. The analysis goes on to cover *international* demand as well.

1.1 Findings

There is a substantial market for domestic high-speed services over the HS1 – HS2 connection. It comprises travel demand between, on the one hand, the city regions in the Midlands and the North served by HS2 and the strong growth area of East London, including Canary Wharf and Docklands, served by the station on HS1 at Stratford, as well as South East London, Kent and Essex. As an indication of scale, this amounts to as much as 45% of the equivalent market from the HS2 catchment to and from central London. There are additional flows addressed by using the interchange at Old Oak Common: between the Thames Valley/Heathrow and the catchment on the East (and South East) side of London.

The projected use of domestic high-speed rail services over the HS1 – HS2 connection is summarised in the table overleaf. Projected passenger numbers would exceed the capacity of the twice hourly service assumption used in the demand modelling work that generated these forecasts. The demand level shown interchanging at Old Oak Common would be

approximately halved if a direct connection from the interchange to the West Coast Main Line (as proposed by Network Rail and others) is not provided.

1.2 Summary of domestic high-speed demand over a HS1 – HS2 connection (2033)

Market	2033 Annual demand	2033 Daily one-way demand
HS1 – HS2 demand (direct to/from Midlands/North)	13,540,000	18,500
HS1 – HS2 demand (via interchange at Old Oak Common)	13,695,000	18,700
HS1 – HS2 demand (direct to/from Heathrow (no interchange at Old Oak Common))	4,504,000	6,200
Total all markets	**31,739,000**	**43,500**

The increase in rail market share is forecast to be in the range 7% – 23%, varying across the different travel market geographies. This is due to cross-London journeys becoming possible without the need for double interchanges and this provides a real alternative to travel around London on the M25. Transfers from other travel modes bring wider benefits, not just to the HS1 – HS2 link, but also to HS2 as a whole. On this basis, it would appear likely that the HS1 - HS2 link would strengthen the overall business case for HS2.

Domestic services operating from HS2 onto HS1 would also provide convenient access to international HSR services at a suitable interchange station such as Ebbsfleet, which already has border control facilities in place and segregated arrangements for international passengers.

If direct *international* passenger services are also operated over the HS1 – HS2 link, they would attract demand levels as shown below. There is sufficient demand for limited frequency direct international services, both to/from Heathrow and the Midlands/North. High-speed rail's attraction tails off sharply as journeys become lengthier. Heathrow is as attractive a destination as a combination of Midland and Northern locations.

1.3 Summary of international demand

Market	2033 Annual demand *mppa*	2033 Daily one-way demand
Europe – Midlands/Northern England	1,893,000	2,600
Europe – Stratford (an intermediate station stop on services to Midlands/North/Heathrow)	4,434,000	6,100
Europe – Heathrow	1,639,000	2,200

There are two ways that the HS1 – HS2 connection can address the international travel market. The first is by providing *domestic* high-speed services that require interchange at an HS1 station – we selected Ebbsfleet in the analysis. This provides for interchange with a full range of existing and future services into Europe that start and terminate at St Pancras. In the modelling work, this adds a thirty minute journey time (interchange) penalty over a direct service. The second is by providing direct *international* services, but these would be unlikely to be as frequent or offer the same range of destinations in practice. Using *domestic* high-speed services and an interchange at Ebbsfleet, rail is expected to capture 29% of the available market in 2026, rising to 34% in 2033; with direct international services instead, the market share is forecast to be 37% in 2026 rising to 40%.

The important point is that a regular interval fast connecting service to a convenient same station interchange that is already served by international services to/from London will not only carry significant domestic demand, it will also achieve significant penetration of the international air/rail market for travel to near continental destinations.

1.4 Conclusions

While the work presented here does not itself represent a business case for the HS1 – HS2 connection, for the first time it does set out how the HS1 – HS2 connection could be expected to support services for which there would be strong demand and very widely spread benefits.

Instead of being seen primarily as a connection for direct international services, the analysis here points to the need to examine fully the role of the HS1 – HS2 link in supporting longer distance cross London domestic services, for which demand is forecast to be substantial. International services using the HS1 – HS2 link can then be considered as an overlay, a supplement to using Ebbsfleet as an interchange with international services.

1.5 Implications for HS2 and related infrastructure

The question arises as to whether the single track connection that forms the current plan for a HS1 – HS2 link is sufficient. It is not possible to answer this without a thorough and detailed examination of how the two high-speed lines would work with through services at varying frequency levels. The evidence suggests that there is demand for perhaps a 4 train/hour service (in each direction). This is unlikely to be accommodated easily on a single track arrangement.

There is also a need to consider the capacity of HS2 to address a combination of demand for services from Euston and from the HS1 – HS2 connection. A means of addressing this issue is described in the report.

1.6 Summary of Benefits

The HS1 – HS2 connection offers a wide set of benefits:

- Cross-London passenger demand would be taken out of congested central London interchanges;
- Domestic high-speed services would provide access at Ebbsfleet to international services provided by Eurostar (and in future Deutsche Bahn) to France, Belgium, Netherlands and Germany from all locations served by HS2;
- A viable alternative to the M25 for longer distance journeys would be provided, especially for those travelling to/from Kent and Essex;
- The growth areas of East London and Docklands would be provided with access to the national high-speed rail network at an existing (but under-used) HSR station (Stratford);
- A new geography would get direct benefit from HS2 services: Essex, East/South East London, Kent, parts of Suffolk and East Sussex;
- Heathrow could be accessed directly by HSR from the continent;
- The high levels of transfer to HS1 – HS2 services suggest a high level of benefits per passenger carried and significant relief to congested parts of the national transport network;

- The role and value of the Old Oak Common as a (domestic) interchange is strengthened and diversified;

- The demand for existing London international HSR services would be strengthened, improving the economics of these services and the value of HS1; and

- The overall business case for HS2 is likely to be strengthened by the addition of a HS1 – HS2 connection.

2. Introduction

An important part of the HS2 plan is a connection with HS1 – the existing high-speed route that extends from St Pancras International in central London through stations at Stratford, Ebbsfleet and Ashford to the channel tunnel. The proposed connection is relatively short, extending east-west from an existing (but little used) junction on HS1 immediately north of St Pancras to join HS2 at Old Oak Common, a distance of about 8km.

Such a connection has figured in early Greengauge 21 studies[1] as well as HS2 Ltd's plans since they were first published in March 2010. Its purpose has always been presumed to be to enable direct *international* services to be operated to/from the cities of the Midlands and the North that will be served by HS2. This would allow cities such as Birmingham, Manchester and Leeds to join London on Europe's high-speed rail network.

The link has always been envisaged to form part of the first phase of HS2. Indeed, it was initially seen as a component that had to be built early, because if its construction was deferred for any reason, its subsequent addition would be disruptive to services on the first phase of the railway into the London terminal at Euston. While there may be construction solutions that would allow the HS1 connection to be added later, deferral to a second or subsequent phase of HS2 development carries the risk that the connection is never built.

The design of the HS1 – HS2 connection has been updated, but appears likely to be a low capacity connection, provided with only a single track.[2] Over the three years since the HS1 connection was first published as part of the first phase of HS2, the business case has not been developed further, and the published work by HS2 Ltd suggests that demand for direct international services is modest.

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[1] See previous studies: http://www.greengauge21.net/content/publications/
[2] See HS2 Ltd Design refinement consultation: http://www.hs2.org.uk/design-refinement-consultation

This can be contrasted with Greengauge 21's own work on the same subject. Published in September 2009, a cost benefit appraisal of the incremental value of a HS1 – HS2 link was found to be over 5:1.[3] In this work, it was assumed that international services would also be able to carry domestic passengers. HS2 Ltd's assessments, on the other hand, have ignored the potential use of the connection for non-international demand.

The first intention in this work, therefore, is to look at the demand for *domestic* travel over a HS1 – HS2 link. If this demand is of sufficient size and brings sufficient additional benefit to the core HS2 scheme, then domestic travel may deliver a good case of funding investment in the link. The question of also accommodating international demand and services then becomes (potentially) a matter of added value, rather than underlying rationale. That way, international demand doesn't have to carry the burden of justifying the investment in the first place, which has been estimated to be in the order of £1bn.
If there is no link between HS1 and HS2, those seeking to travel by high-speed rail from (say) Birmingham to Paris would need to make an awkward transit *en route* between London's Euston and St Pancras stations. There are tube connections, but neither they nor the prospect of a walk along the busy Euston Road are conducive to encouraging this kind of travel by rail. The nation's high-speed rail network would be disjointed from the start. London would remain the only British city on the European high-speed network that now extends from Britain to France, Belgium, the Netherlands, Germany, Switzerland – and in due course – Spain and Italy too.

There is an urgency then about this subject, since there is now a published intention to deposit a Hybrid Bill for the first phase of HS2 in this session of Parliament, expected to be later in 2013. A number of public sector bodies came together to fund the Greengauge 21 studies[4] into the HS1 – HS2 link:

- The Passenger Transport Executive Group (pteg)
- Essex County Council
- Kent County Council
- South East Local Enterprise Partnership (SELEP)
- The London Borough of Newham

We also acknowledge the kind assistance of Transport for London in developing this research.

[3] *Fast Forward* p49, Greengauge 21, September 2009
[4] Besides this work into demand for services using the link, work is in hand to examine border control arrangements for international services. This will be the subject of a later separate report

Following a call for tenders, Greengauge 21 issued a brief (see Annex A) and selected the MVA consultancy to carry out the research into the markets for travel over a HS1 – HS2 connection.

The intention is simply to understand the scale of the markets that services using the connection could serve and to get a preliminary view of the level of demand that would arise. These are essentially cross-London markets, by definition. To put the analysis in context, we asked that comparisons were made with the scale and nature of the travel markets that HS2 would address to/from London itself.

It was beyond the brief of this demand study to seek to quantify benefits and we see little benefit in aiming either to second-guess the likely construction costs of the currently preferred scheme or variants to it. There are however some important matters around service frequency and operational feasibility, and we cover this area in Chapter 7.

3. Methodology

Travel demand in a number of domestic and international markets as specified in the brief (Annex A) was assessed in terms of:

(i) the total travel market in millions of passengers per annum (mppa) in a base year (2011) with a modal breakdown (car/rail/air); and

(ii) the same for 2026 (the introduction of Phase 1 HS2 services) and 2033 (the introduction of Phase 2 HS2 services).

The forecasts were generated using the demand model developed in a joint study by MVA Consultancy and Systra for a previous commission for Greengauge 21 in 2008/9. The model was developed to forecast UK high-speed rail demand, the outputs from which were subsequently used to prepare a Business Case for a high-speed network, see Fast Forward report from Greengauge21.

The mode choice model used takes the generalised cost for each mode and applies a LOGIT choice formula that predicts what the mode share, based on the generalised costs of each mode, of each mode on that route would be in the future. Full details of the demand model structure and functionality were provided in the original MVA Systra report published in September 2009[5] including:

[5] available to download at http://www.greengauge21.net/wp-content/uploads/Workstream-3-assessment-Methodology.pdf

- base demand matrix structure;
- derivation of the base year demand and generalised costs for each mode and the data sources used;
- future year growth factors used;
- mode choice functionality (LOGIT); and
- model calibration.

Several updates to the model have been carried out for the work reported here:

- the base year demand matrices (car, rail and air) were updated from 2007 to 2011; and
- growth factors were updated where applicable.

However, it is important to note that, in relation to the 2009 model:

- air and rail fares, and car costs remain unchanged;
- car, rail and air generalised journey times remain (with one exception) unchanged;
- the model has not been re-calibrated;
- the crowding functionality remains unchanged; and
- the fares assumptions remain unchanged, and in particular it is still assumed that no premium fare will apply to high-speed rail services compared to Classic services.

The updated model was used to test the impact of three scenarios:

- **No HS2** – this assumes high-speed rail services are not introduced in 2026 and that Classic rail journey times and frequencies remain unchanged;

- **HS2 only scenario** – this assumes Phase 1 HS2 services begin in 2026 and Phase 2 in 2033, but that there is no direct link between HS2 and HS1; and

- **HS2-HS1 scenario** – as per the HS2 scenario but with a direct link between HS2 and HS1 enabling direct high-speed services from Kent (via Ashford and Ebbsfleet) and East London (via Stratford) to destinations in the West Midlands and Northern England.

As a check the demand results from the model were benchmarked against the publicly-available demand HS2 Ltd forecasts. As shown in Table 1, forecasts of rail demand (Classic and high-speed) between London and the West Midlands, the North West, the East Midlands and Yorkshire & Humber in 2026 are consistent. Indeed, the MVA/Greengauge21 model projects somewhat lower demand than the HS2 Ltd forecasts.

Table 1 Comparison of rail demand forecasts in 2026

2026 Rail demand to/from London (Classic + HS)	West Midlands	North West	East Midlands	Yorkshire & Humber
Greengauge 21 study	17,078,000	12,862,000	14,070,000	8,328,000
HS2 Ltd	18,108,876	16,205,774	14,267,332	8,991,848

Further details of the modelling work are provided in Annex B.

4. The case for wider connectivity

There are two fundamental connectivity problems that would be left unresolved in a HS2 scheme without a suitable link to HS1. These are:

(i) The need for many HS2 users to cross London to access services at Euston (rather than to be able to access HS2 services at Stratford and Ebbsfleet/Ashford); and

(ii) The lack of connectivity between the new fast services over HS2 from midland and northern Cities and the international HSR services on HS1.

4.1 Cross London access

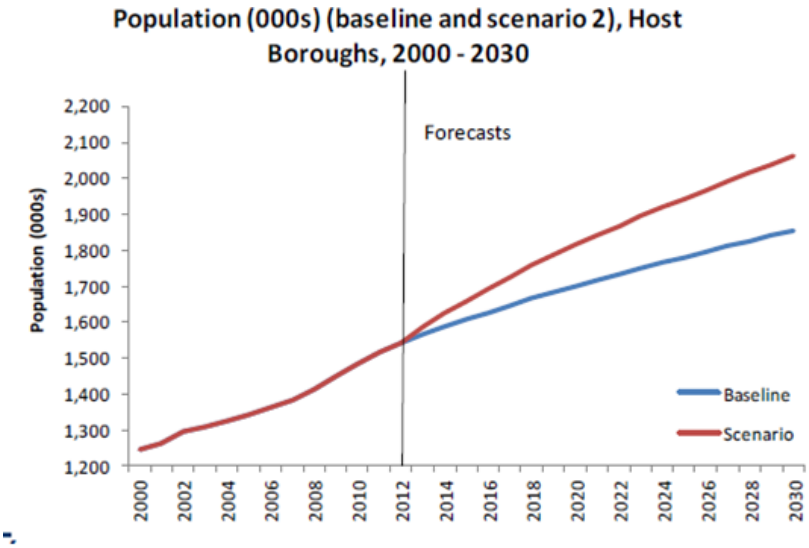
The first connectivity problem is the lack of direct cross London connectivity for long distance domestic travel.

Central London itself will be well served by the HS2 terminus at Euston. The plan to provide a new Crossrail station at Old Oak Common also means that the Old Oak interchange will also provide a good access point for travellers wishing to use HS2 from places along the Thames Valley towards Reading and those parts of central London served by Crossrail. But places east and south of London will still face cross-London journeys, with

double interchanges, to/from HS2. These travellers add to congestion on the Underground, just by passing through the busy central area.

There is a historic lack of long distance cross-London rail connectivity. The rail network geography means that a set of central London terminus stations serve specific slices of the national geography. For commuters in the south east, the ensuing 'cross-London' problem – which creates inefficiencies for train operations as well as inconvenience for travellers – is being overcome to a significant degree through the Thameslink and Crossrail projects. But neither of these projects serves Euston, and there is no equivalent for longer distance services to/from places outside the wider South East. The net effect is that many journeys end up being made by car – making use of the busy M25, simply to avoid the difficulties of cross London transfers.

Furthermore, the pattern of growth in London is towards the east. This is where the largest development opportunities arise, and the risk of lack of connectivity with HS2 impacting adversely on this development potential has already been clearly identified.[6] This is also where there is forecast to be a substantial proportion of London's projected population growth – in the so-called host boroughs that surround the East/Southeast London Olympic Games sites. These locations can all be accessed through Stratford.



Source; OEF Oxford Economics 2030 Forecast for London's Growth Boroughs – Summary, April 2013

[6] See presentation by the East/Southeast London organisation at http://www.esel.org.uk/wp-content/uploads/2012/01/Julian-Sanchez-LEP-presentation.pdf

4.2 International connectivity

The second connectivity problem is the lack of international connectivity – the Euston – St Pancras problem already mentioned. Of course, it may be possible to overcome this with a customer-oriented facility, designed for those unfamiliar with London's transport networks, and typically travelling with baggage. Options include both the Crossrail 2 project – which is now at the public consultation stage with a new underground station connecting at its western end with Euston and at its eastern with St Pancras, and an extension of the Docklands Light Railway from Bank to Kings Cross/St Pancras and Euston. But neither project is committed and each will be addressing other travel markets. Facilities such as these will be very busy, mainly with commuters at peak times and would still offer a far from ideal solution to the Euston Road 'gap' for long distance travellers.

4.3 Capacity and travel demand for connecting HS1 and HS2

It is recognised that cross-connecting HS1 and HS2 will only work if there is spare capacity for additional services on both lines. It is clear that HS1 has capacity to handle more train paths but the situation on HS2 is more constrained because much of the line capacity will be spoken for by services running to/from Euston. Solutions to this potential problem are discussed in Chapter 7.

If there is to be competition for train paths on the trunk section of HS2, then an important question is the relative size of the travel markets that can be addressed by the HS1 – HS2 link and the (central) London travel market (served by Euston), and the relative benefits that addressing each market brings.

To put this in context, the size of the travel markets in 2011 between London (both Greater and Central) and the West Midlands and North West is shown in Table 4.1. There are over 27 million person trips annually between Greater London and the West Midlands/North West (WM/NW) in our base year of 2011, and of these about half of these are to/from central London.

In comparison, the travel markets between the West Midlands and North West and places in the South East that would be served using the HS1 – HS2 connection are smaller, but still exceed 6 million person trips annually, that is roundly a quarter of the size of the Greater London travel market, and nearly half of that of the central London travel market.

Rail currently dominates the WM/NW travel market to/from Greater London (with 70% mode share) and to/from central London (95% share of all travel). These are travel markets where private car use is in the minority and air market share is very small.

Table 4.1 Greater/Central London to West Midlands and North West market in 2011

2011 Base Year		Car	Classic Rail	Air	Total
Greater London	Demand	6,974,000	19,251,000	1,151,000	**27,376,000**
	Mode Share	25%	70%	4%	**100%**
Central London	Demand	473,000	12,986,000	275,000	**13,734,000**
	Mode Share	3%	95%	2%	**100%**

This can be contrasted with the 2011 market shares from those parts of East London and the South East that would be served by HS1 – HS2 services; here current rail market share is much smaller, still high at 72% of trips from East London/Docklands to WM/NW, but just 17% from Kent and 13% from Essex/Suffolk.

If train paths were to be allocated simply in proportion to the current scale of domestic demand best served by Euston services and that best served by using HS1 – HS2, then there would be at least one HS2 service in four using the HS1 – HS2 link, and the impact on mode shift would be much larger on HS1 – HS2 link services. That in turn means that the benefits generated by trains taking the HS1 – HS2 connection would be proportionately higher than those serving Euston. The further growth of East London is significant and means that these proportionate indicators based on current demand patterns will shift in favour of using the HS1 – HS2 link for domestic travel over the decades ahead.

The travel volumes involved in international travel are, as would be expected, much smaller than these domestic travel flows. But the economic significance of international connectivity is proportionately greater. This type of connectivity was recognised as being of great importance, for example, in the Eddington Transport Report of 2006.[7] This is because of the significance of operating in global business markets where accessibility has a critical impact, amongst other things, on access to export markets and on business location decisions. Increasingly too, high-speed rail is a factor in tourism to Britain. Since the alternative to using high-speed rail for these travel markets is generally using short haul air services, there is a significant carbon benefit from addressing these markets too.

[7] http://www.thepep.org/ClearingHouse/docfiles/Eddington.Transport.Study%20-%20Rod.pdf

5. Demand in 2033 for cross London domestic HSR services

By using the demand model, it is possible to obtain initial estimates of the demand that services using the HS1 – HS2 link would carry in 2033. Here we concentrate on domestic services and each of the following specified domestic inter-regional travel markets:

(i) markets that could be served directly by services operating over the link from 2026:

Kent – West Midlands/North West England.
Essex/Suffolk – West Midlands/North West England.
East London/Docklands – West Midlands/North West England).

(ii) markets that could be served by services operating over the link from 2033:

Kent/Essex/Suffolk/East London/Docklands services – East Midlands/ Yorkshire.

(iii) markets that could be served by HS1 – HS2 services and an interchange at Old Oak Common:

Kent/Essex/Suffolk/East London/Docklands – Thames Valley/Heathrow/ West of England/South Wales.
Kent/Essex/Suffolk/East London/Docklands – North West London/Milton Keynes[8]*.*

For the purposes of this study, destinations further afield such as Scotland, North East England, North Wales and South West England have not been selected for market appraisal. There would, of course, be further benefits gained for domestic trips to/from these areas due to better connectivity to high-speed rail services with the HS2-HS1 connection in place.

We provide projections for each of the six identified markets in turn below. All the demand results shown below represent the total bidirectional demand between two geographical markets. The assumption is that services would operate Ashford – Ebbsfleet – Stratford – Old Oak Common – HS2 destinations.

[8] This market segment can only be addressed if there is connectivity form Old Oak Common to the West Coast Main Line, such as has been proposed through a Crossrail extension by Network Rail, TfL and Greengauge 21.

5.1 Kent – West Midlands/North West England

The scope of the Kent to/from West Midlands and North West England market is shown at Annex C, Figure C.1. Comparison rail demand forecasts are highlighted in Tables 5.1 and 5.2. and Figure 5.2.

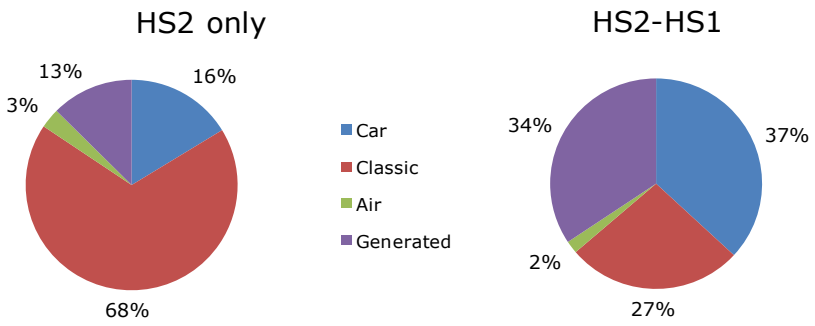
Table 5.1 Base Year Demand

2011 Base Year	Car	Classic Rail	Air	HS Rail	Total
Demand	1,135,000	231,000	32,000	-	**1,398,000**
Mode Share	81%	17%	2%	0%	**100%**

Table 5.2 2033 Forecast Demand

2033 Forecast Year		Car	Classic Rail	Air	HS Rail	Total
No HS2	Demand	1,711,00	325,000	24,000	-	**2,060,000**
	Mode Share	83%	16%	1%	0%	**100%**
HS2 Only	Demand	1,663,000	124,000	15,000	295,000	**2,097,000**
	Mode Share	79%	6%	1%	14%	**100%**
HS2-HS1	Demand	1,406,00	103,000	8,000	827,000	**2,344,000**
	Mode Share	60%	4%	0%	35%	**100%**
HS2-HS1 cf. HS2 only	Demand change	-257,000	-21,000	-7,000	532,000	**247,000**
	% change	-15%	-17%	-47%	180%	**12%**

Figure 5.2 Sources of High-Speed Demand in 2033 (HS2 only and HS2-HS1)



5.2 Essex/Suffolk – West Midlands/North West England

The scope of the Essex and Suffolk to/from West Midlands and North West England market is shown at Annex C, Figure C.3. Comparison rail demand forecasts are highlighted in Tables 5.3 and 5.4.

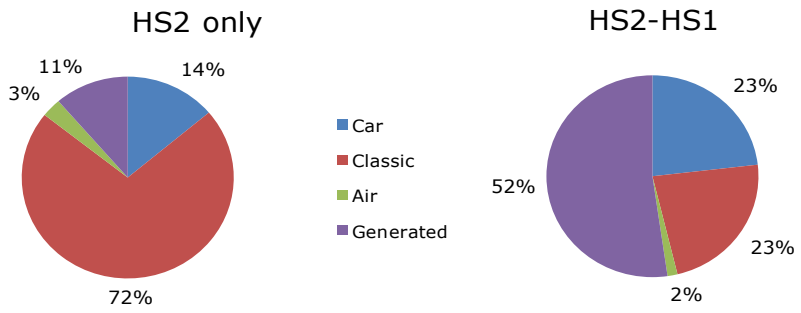
Table 5.3 Base Year Demand

2011 Base Year	Car	Classic Rail	Air	HS Rail	Total
Demand	4,216,000	643,000	14,000	-	**4,873,000**
Mode Share	87%	13%	0%	0%	**100%**

Table 5.4 2033 Forecast Demand

2033 Forecast Year		Car	Classic Rail	Air	HS Rail	Total
No HS2	Demand	6,116,000	958,000	72,000	-	**7,146,000**
	Mode Share	86%	13%	1%	0%	**100%**
HS2 Only	Demand	6,001,000	363,000	47,000	829,000	**7,240,000**
	Mode Share	83%	5%	1%	11%	**100%**
HS2-HS1	Demand	5,476,000	322,000	30,000	2,762,000	**8,590,000**
	Mode Share	64%	4%	0%	32%	**100%**
HS2-HS1 cf. HS2 only	Demand change	-525,000	-41,000	-17,000	1,933,000	**1,350,000**
	% change	-9%	-11%	-36%	233%	**19%**

Figure 5.4 Sources of High-Speed Demand in 2033 (HS2 only and HS2-HS1)



5.3 East London/Docklands – West Midlands/North West England

The scope of the East London/Docklands to/from West Midlands and North West England market is shown at Annex C, Figure C.5. Comparison rail demand forecasts are highlighted in Tables 5.5 and 5.6.

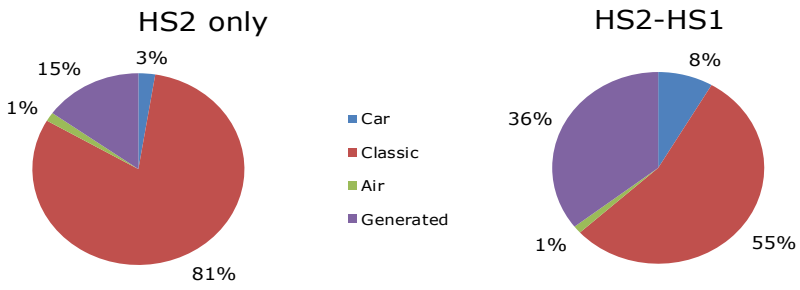
Table 5.5 Base Year Demand

2011 Base Year	Car	Classic Rail	Air	HS Rail	Total
Demand	905,000	2,767,000	145,000	-	**3,817,000**
Mode Share	24%	72%	4%	0%	**100%**

Table 5.6 2033 Forecast Demand

2033 Forecast Year		Car	Classic Rail	Air	HS Rail	Total
No HS2	Demand	1,598,000	5,102,000	203,000	-	**6,903,000**
	Mode Share	23%	74%	3%	0%	**100%**
HS2 Only	Demand	1,510,000	2,311,000	151,000	3,451,000	**7,423,000**
	Mode Share	20%	31%	2%	46%	**100%**
HS2-HS1	Demand	1,148,000	2,162,000	135,000	5,362,000	**8,807,000**
	Mode Share	13%	25%	2%	61%	**100%**
HS2-HS1 cf. HS2 only	Demand change	-362,000	-149,000	-16,000	1,911,000	**1,384,000**
	% change	-24%	-6%	-11%	55%	**19%**

Figure 5.1 Sources of High-Speed Demand in 2033 (HS2 only and HS2-HS1)



5.4 Kent/Essex/Suffolk/East London/Docklands services – East Midlands/Yorkshire

The scope of the Kent/Essex/Suffolk/East London/Docklands to/from East Midlands and Yorkshire market is shown at Annex C, Figure C.7. Comparison rail demand forecasts are highlighted in Tables 5.7 and 5.8.

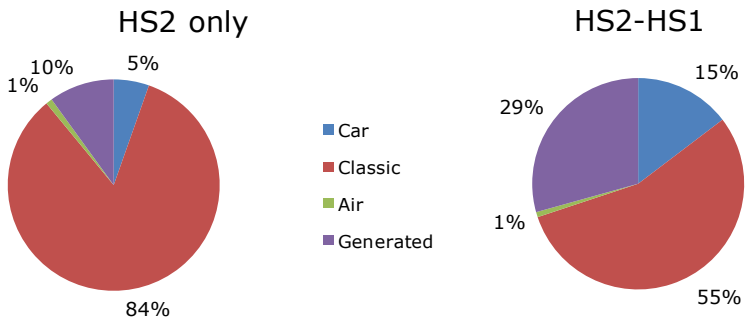
Table 5.7 Base Year Demand

2011 Base Year	Car	Classic Rail	Air	HS Rail	Total
Demand	33,416,000	3,492,000	14,000	-	**36,922,000**
Mode Share	91%	9%	0%	-	**100%**

Table 5.8 2033 Forecast Demand

2033 Forecast Year		Car	Classic Rail	Air	HS Rail	Total
No HS2	Demand	48,186,000	7,820,000	91,000	-	**56,097,000**
	Mode Share	86%	14%	0%	0%	**100%**
HS2 Only	Demand	48,042,000	5,587,000	65,000	2,669,000	**56,363,000**
	Mode Share	85%	10%	0%	5%	**100%**
HS2-HS1	Demand	47,514,000	5,285,000	55,000	4,589,000	**57,443,000**
	Mode Share	83%	9%	0%	8%	**100%**
HS2-HS1 cf. HS2 only	Demand change	-528,000	-302,000		1,920,000	**1,080,000**
	% change	-1%	-5%		72%	**2%**

Figure 5.8 Sources of High-Speed Demand in 2033 (HS2 only and HS2-HS1)



5.5 Kent/Essex/Suffolk/East London/Docklands – Thames Valley/Heathrow/West of England/South Wales

The scope of the East London/Docklands to/from West Midlands and North West England market is shown at Annex C, Figure C.9. This market includes an interchange at Old Oak Common to connect with services towards the West of England, with the exception of Heathrow. The Kent/Essex/Suffolk/East London/Docklands to/from Heathrow market assumes a direct service using HS2's planned direct connection into the airport. Comparison rail demand forecasts are highlighted in Tables 5.9, 5.10 and 5.11.

Table 5.9 Base Year Demand

2011 Base Year	Car	Classic Rail	Air	HS Rail	Total
Demand	61,135,000	27,643,000	-	-	**88,778,000**
Mode Share	69%	31%	0%	0%	**100%**

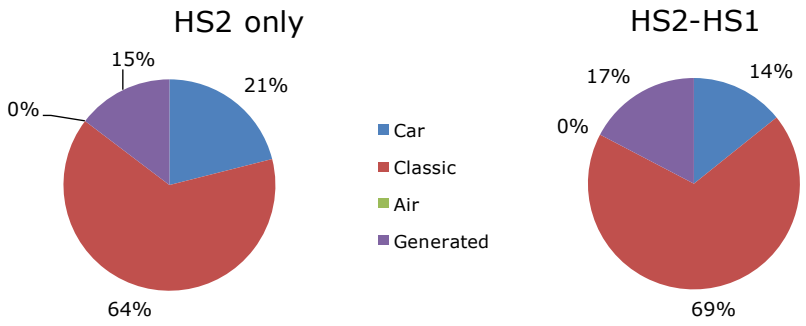
Table 5.10 2026 Forecast Demand

2026 Forecast Year		Car	Classic Rail	Air	HS Rail	Total
No HS2	Demand	79,836,000	45,924,000	-	-	**125,760,000**
	Mode Share	63%	37%	0%	0%	**100%**
HS2 Only	Demand	79,182,000	43,910,000	-	3,109,000	**126,201,000**
	Mode Share	63%	35%	0%	2%	**100%**
HS2-HS1	Demand	77,915,000	37,764,000	-	12,200,000	**127,879,000**
	Mode Share	61%	30%	0%	10%	**100%**
HS2-HS1 cf. HS2 only	Demand change	-1,267,000	-6,146,000		9,091,000	**1,678,000**
	% change	-2%	-14%		292%	**1%**

Table 5.11 2033 Forecast Demand

2033 Forecast Year		Car	Classic Rail	Air	HS Rail	Total
No HS2	Demand	87,262,000	58,214,000	-	-	**145,476,000**
	Mode Share	60%	40%	0%	0%	**100%**
HS2 Only	Demand	86,597,000	56,182,000	-	3,160,000	**145,939,000**
	Mode Share	59%	38%	0%	2%	**100%**
HS2-HS1	Demand	85,218,000	48,378,000	-	14,368,000	**147,964,000**
	Mode Share	58%	33%	0%	10%	**100%**
HS2-HS1 cf. HS2 only	Demand change	**-1,379,000**	**-7,804,000**		**11,208,000**	**2,025,000**
	% change	-2%	-14%		355%	**1%**

Figure 5.10 Sources of High-Speed Demand in 2033 (HS2 only and HS2-HS1)



5.6 Kent/Essex/Suffolk/East London/Docklands – North West London/Milton Keynes

The scope of the Kent/Essex/Suffolk/East London/Docklands to/from North West London and Milton Keynes market is shown at Annex C, Figure C.11. Comparison rail demand forecasts are highlighted in Tables 5.12, 5.13 and 5.14.

Table 5.12 Base Year Demand

2011 Base Year	Car	Classic Rail	Air	HS Rail	Total
Demand	79,788,000	32,647,000	-	-	**112,435,000**
Mode Share	71%	29%	0%	0%	**100%**

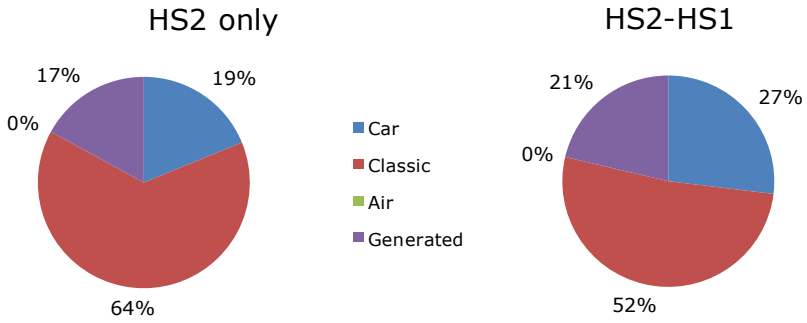
Table 5.13 2026 Forecast Demand

2026 Forecast Year		Car	Classic Rail	Air	HS Rail	Total
No HS2	Demand	104,210,000	49,040,000	-	-	**153,250,000**
	Mode Share	68%	32%	0%	0%	**100%**
HS2 Only	Demand	103,637,000	47,076,000	-	3,038,000	**153,751,000**
	Mode Share	67%	31%	0%	2%	**100%**
HS2-HS1	Demand	102,797,000	46,420,000	-	5,109,000	**154,326,000**
	Mode Share	67%	30%	0%	3%	**100%**
HS2-HS1 cf. HS2 only	Demand change	-840,000	-656,000		2,071,000	**575,000**
	% change	-1%	-1%		68%	**0%**

Table 5.14 2033 Forecast Demand

2033 Forecast Year		Car	Classic Rail	Air	HS Rail	Total
No HS2	Demand	114,367,000	61,943,000	-	-	**176,310,000**
	Mode Share	65%	35%	0%	0%	**100%**
HS2 Only	Demand	113,787,000	59,966,000	-	3,082,000	**176,835,000**
	Mode Share	64%	34%	0%	2%	**100%**
HS2-HS1	Demand	112,905,000	59,133,000	-	5,430,000	**177,468,000**
	Mode Share	64%	33%	0%	3%	**100%**
HS2-HS1 cf. HS2 only	Demand change	**-882,000**	**-833,000**		**2,348,000**	**633,000**
	% change	-1%	-1%		76%	**0%**

Figure 5.12 Sources of High-Speed Demand in 2033 (HS2 only and HS2-HS1)



6. International service demand

Here we present an estimation of the total demand to and from international destinations on the near-Continent that could potentially be served by high-speed rail with the HS2-HS1 link. Demand results are presented for the following markets:

- **Europe – West Midlands/North West England**[9]
- **Europe – Stratford**
- **Europe – Heathrow**

The 2011 base year demand to/from Europe consists of rail demand (Eurostar) to/from Paris, Lille and Brussels with London interchange where applicable; and air demand to/from Paris, Brussels, Lille, Amsterdam, Rotterdam, Antwerp, Aachen, Liege, Frankfurt and Cologne. Other travel modes such as car and coach are ignored, as well as any rail demand to destinations other than Paris, Lille and Brussels. The base year matrix for air demand was obtained by sourcing demand data for 2011 from the Civil Aviation Authority (CAA). The 2011 base air and rail Europe demand matrices were grown by the same factors as applied to domestic demand.

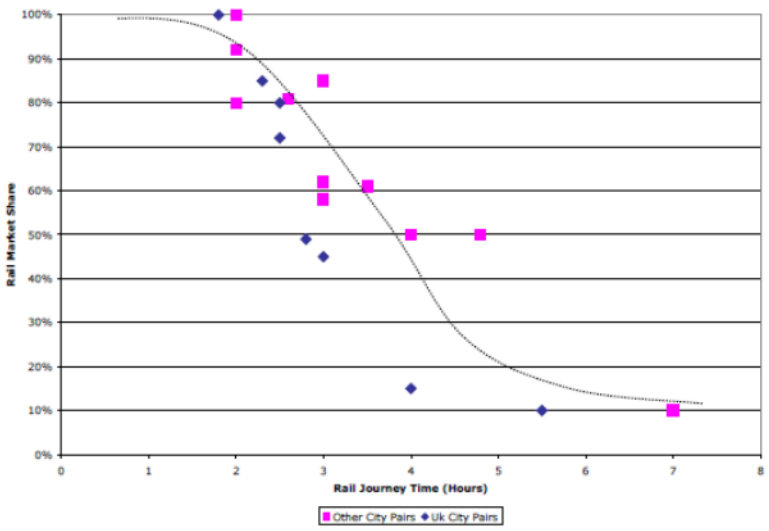
6.1. Modal Share

To estimate the high-speed rail mode share in 2026 and 2033, the total rail journey time from each market considered to each European destination was calculated (including a 30 minute interchange at Ebbsfleet where applicable). The rail market share was then estimated using Figure 6.1 to determine the proportion of demand that a new high-speed rail service will abstract from air. This proportion was then applied to the total market (i.e. air and rail) in order to provide an estimate of the annual rail market. This approach assumes that the frequency of rail services is broadly equivalent to that of air. However, a significant limitation of this approach is that it does not account for any generated demand as a result of an improvement to the rail service.

[9] International services could also be operated to/from East Midlands/Yorkshire/Northeast England. This travel market currently avoids the 'Euston Road' problem through the opportunity for transfer between HS1 and the classic rail network within the St Pancras/Kings Cross station complex. There would be further demand on offer if these markets were also provided with direct international high-speed services which we have not assessed as part of this report.

Figure 6.1 Rail/air mode shares by rail journey time

Source: MVA/SNCF



6.2. Options Assessed

Two basic service concepts have been tested in the market analysis of international service demand:

- an interchange provided for travellers from HS2 at Ebbsfleet (or Stratford) enabling them to switch from domestic - only HS1 – HS2 services to Eurostar international services (and in due course other operators) that are assumed to continue to operate to/from St Pancras International; and
- direct international services from HS2.

There is a fundamental problem with the latter arrangement in that the commercial value (and benefit) of direct international services diminishes the further within the UK the service is provided *unless the trains involved are able to carry domestic passengers too*. For the latter to be possible, a number of border control issues would have to be overcome. These are the subject of ongoing research and will be the focus of a separate Greengauge 21 report in due course. No conclusions are being sought at this stage on the best arrangements for the international markets assessed here – rather the objective is to assess the size of market demand for each option.

The domestic feeder service option provides a better alternative than either walking Euston Road or interchanging between domestic and international services at Old Oak Common.

International services operating just to/from Old Oak Common would not be able to offer the full frequency and range of destinations available on HS1 services from St Pancras International. Interchanging at Old Oak Common would also require additional international station infrastructure and border control facilities to be provided at the site, with both capital and operating cost implications.

6.3. Europe – West Midlands/North West England

The West Midlands/North West England region has been defined as per the domestic demand analysis (see Appendix B, Table B.3 and Figure B.3 for the model zones included). The 2011 base year demand and mode share for trips between Europe and the West Midlands and North West England are presented in Table 6.1. HS rail in this case represents trips using Eurostar on HS1 between London and Europe with an interchange to domestic services between London and the West Midlands/North West.

Table 6.1 2011 Base Year Demand and Mode Share

2011 Base Year	Air	HS Rail	Total
Paris	703,000	168,000	**871,000**
Lille	-	24,000	**24,000**
Belgium*	298,000	48,000	**346,000**
Holland+	1,167,000	-	**1,167,000**
Cologne	42,000	-	**42,000**
Frankfurt	458,000	-	**458,000**
Total Demand	**2,668,000**	**240,000**	**2,908,000**
% Mode Share	**92%**	**8%**	**100%**

*Belgium consists of Brussels, Antwerp and Liege; +Holland consists of Amsterdam and Rotterdam

Source: Eurostar, CAA

Table 6.2 2026 and 2033 Total Demand (Air & Rail combined)

Forecast Year	2026	2033
Paris	1,335,000	1,679,000
Lille	37,000	47,000
Belgium	530,000	667,000
Holland	1,787,000	2,245,000
Cologne	65,000	82,000
Frankfurt	702,000	883,000
Total Demand	**4,456,000**	**5,603,000**

Total air and rail demand in 2026 and 2033 is shown in table 6.2. The impact of the HS2-HS1 link in 2026 and 2033 was modelled both with an interchange with international services at Ebbsfleet (where an interchange of 30 min was assumed) and without an interchange i.e. direct through services (see Table 6.3 to Table 6.6). The impact of through services is to increase the overall rail mode share for this market from 34% to 40% in 2033.

With Ebbsfleet interchange

Table 6.3 2026 Rail journey time, estimated rail market share and demand (with Ebbsfleet interchange)

	Journey time	% Rail share	Estimated rail demand 2026
Paris	3 hr 50 min	50%	**668,000**
Lille	3 hr 05 min	100%	**37,000**
Belgium	3 hr 25 min	62.5%	**331,000**
Holland	6 hr 05 min	12.5%	**223,000**
Cologne	7 hr 30 min	10%	**7,000**
Frankfurt	8 hr 30 min	5%	**35,000**
		Total	**1,301,000**
		Rail Mode Share	**29%**

Table 6.4 2033 Rail journey time, estimated rail market share and demand (with Ebbsfleet interchange)

	Journey time	% Rail share	Estimated rail demand 2033
Paris	3 hr 35 min	60%	**1,007,000**
Lille	2 hr 50 min	100%	**47,000**
Belgium	3 hr 10 min	67.5%	**450,000**
Holland	5 hr 50 min	15%	**337,000**
Cologne	7 hr 15 min	10%	**8,000**
Frankfurt	8 hr 15 min	5%	**44,000**
		Total	**1,893,000**
		Rail Mode Share	**34%**

With through services

Table 6.5 2026 Rail journey time, estimated rail market share and demand (with through services)

	Journey time	% Rail share	Estimated rail demand 2026
Paris	3 hr 20 min	62.5%	**834,000**
Lille	2 hr 35 min	100%	**37,000**
Belgium	2 hr 55 min	75%	**398,000**
Holland	5 hr 35 min	17.5%	**313,000**
Cologne	7 hr 00 min	12.5%	**8,000**
Frankfurt	8 hr 00 min	7.5%	**53,000**
		Total	**1,643,000**
		Rail Mode Share	**37%**

Table 6.6 2033 Rail journey time, estimated rail market share and demand (with through services)

	Journey time	% Rail share	Estimated rail demand 2033
Paris	3 hr 05 min	70%	**1,175,000**
Lille	2 hr 20 min	100%	**47,000**
Belgium	2 hr 40 min	82.5%	**550,000**
Holland	5 hr 20 min	18.5%	**415,000**
Cologne	6 hr 45 min	13.5%	**11,000**
Frankfurt	7 hr 45 min	10%	**66,000**
		Total	**2,264,000**
		Rail Mode Share	**40%**

6.4 Europe – Stratford

Analysis of the Europe to Stratford market assumes that the Stratford station catchment is:

- East London and Docklands; and
- Essex and Suffolk.

Table 6.7 shows the demand and mode share for base year trips between Stratford and Europe, where HS rail represents trips using Eurostar on HS1 between London St Pancras and Europe and include an interchange in central London for the Stratford catchment.

Table 6.7 2011 Base Year Demand and Mode Share

2011 Base Year	Air	HS Rail	Total
Paris	191,000	1,292,000	**1,483,000**
Lille	-	186,000	**186,000**
Belgium	57,000	372,000	**429,000**
Holland	501,000	-	**501,000**
Cologne	76,000	-	**76,000**
Frankfurt	156,000	-	**156,000**
Total Demand	**981,000**	**1,850,000**	**2,831,000**
% Mode Share	**35%**	**65%**	**100%**

Table 6.8 2026 and 2033 Total Demand (Air & Rail combined)

Forecast Year	2026	2033
Paris	2,564,000	3,303,000
Lille	322,000	413,000
Belgium	744,000	959,000
Holland	850,000	1,104,000
Cologne	127,000	164,000
Frankfurt	276,000	362,000
Total Demand	**4,883,000**	**6,305,000**

The impact of HS2-HS1 in 2026 and 2033 was modelled assuming direct through international services to/from North/Midlands/Heathrow with a station call at Stratford (see Table 6.9 and Table 6.10).

Table 6.9 2026 Rail journey time, estimated rail market share and demand

	Journey time	% Rail share	Estimated rail demand 2026
Paris	2 hr 15 min	90%	2,308,000
Lille	1 hr 30 min	100%	322,000
Belgium	1 hr 50 min	95%	465,000
Holland	4 hr 30 min	30%	255,000
Cologne	5 hr 55 min	15%	19,000
Frankfurt	6 hr 55 min	12.5%	35,000
		Total	**3,404,000**
		Rail Mode Share	**70%**

Table 6.2 2033 Rail journey time, estimated rail market share and demand

	Journey time	% Rail share	Estimated rail demand 2033
Paris	2 hr 15 min	90%	2,973,000
Lille	1 hr 30 min	100%	413,000
Belgium	1 hr 50 min	95%	647,000
Holland	4 hr 30 min	30%	331,000
Cologne	5 hr 55 min	15%	25,000
Frankfurt	6 hr 55 min	12.5%	45,000
		Total	**4,434,000**
		Rail Mode Share	**70%**

6.5 Europe – Heathrow

Heathrow demand was based on the CAA data. Only terminating passengers were included (47% of total) as it was assumed – for simplicity - that inter-lining passengers would not switch to high-speed rail.

Table 6.3 2011 Base Year Demand

2011 Base Year	Demand to/from Heathrow
Paris	676,000
Lille	-
Belgium	243,000
Holland	663,000
Cologne	69,000
Frankfurt	692,000
Total Demand	**2,343,000**

Source: CAA

Table 6.4 2026 and 2033 Total Demand

Forecast Year	2026	2033
Paris	921,000	1,084,000
Lille	-	-
Belgium	331,000	390,000
Holland	903,000	1,063,000
Cologne	94,000	111,000
Frankfurt	943,000	1,110,000
Total Demand	**3,192,000**	**3,758,000**

The impact of HS2-HS1 in 2026 and 2033 was modelled assuming direct through-services to/from Heathrow (see Table 6.13 and Table 6.14).

Table 6.5 2026 Rail journey time, estimated rail market share and demand

	Journey time	% Rail share	Estimated rail demand 2026
Paris	2 hr 35 min	85%	**783,000**
Lille	1 hr 50 min	95%	**-**
Belgium	2 hr 10 min	90%	**298,000**
Holland	4 hr 50 min	22.5%	**203,000**
Cologne	6 hr 15 min	15%	**14,000**
Frankfurt	7 hr 15 min	10%	**94,000**
		Total	**1,392,000**
		Rail Mode Share	**44%**

Table 6.6 2033 Rail journey time, estimated rail market share and demand

	Journey time	% Rail share	Estimated rail demand 2033
Paris	2 hr 35 min	85%	**921,000**
Lille	1 hr 50 min	95%	**-**
Belgium	2 hr 10 min	90%	**351,000**
Holland	4 hr 50 min	22.5%	**239,000**
Cologne	6 hr 15 min	15%	**17,000**
Frankfurt	7 hr 15 min	10%	**111,000**
		Total	**1,639,000**
		Rail Mode Share	**44%**

6.6 Generated demand

As previously noted this analysis of international demand excludes any assessment of generated demand as a result of the improvements to rail services. An indication of the levels of generated demand that could be expected can be based on consideration of demand elasticities. For demand to the nearest European destinations - Paris and Brussels - demand generation in the region of 15% to 20% might be expected. For destinations further away such as the Netherlands and Germany, only a minimal demand uplift (up to 5%) might be expected.

7. Conclusions

There is substantial demand for the HS1 – HS2 connection. The demand for which the connection was first envisaged (international direct high-speed services) represents a relatively small proportion of this overall demand. What this work identifies is a much larger market for domestic high speed rail services operating across London. The implications of the scale of demand identified, and the issues arising with direct international services have implications for how the HS2 and associated infrastructure is developed. We make an initial exploration of how these implications might be best addressed later in this chapter.

7.1 National services

Because of the multiple stations on HS1, serving East London and Docklands and Essex and beyond (*via* Stratford), the M25 and north and Mid Kent (*via* Ebbsfleet) and East Kent and East Sussex (*via* Ashford), services using a HS1 – HS2 connection have the potential to address a substantial catchment area. In terms of demand, it equates to 45% of the

level of demand emanating to/from central London, or a quarter of the demand to/from the whole of Greater London.

Whereas Euston is the best station for central London – and also for much of Greater London – the combination of markets that can be served through the HS1 stations suggest that HS1 – HS2 services will attract a lot of new demand to high-speed rail, as shown in Table 7.1. The total demand shown would exceed the capacity of a HSR service operating twice each hour in each direction in the forecast year of 2033.

Table 7.1 Summary of domestic high-speed demand over a HS1 – HS2 connection by market (2033)

Market	**2033 Annual demand**	**2033 Daily one-way demand**
HS1 – HS2 demand (direct to/from Midlands/North)	13,540,000	18,500
HS1 – HS2 demand (via interchange at Old Oak Common)	13,695,000	18,700
HS1 – HS2 demand (direct to/from Heathrow (no interchange at Old Oak Common))	4,504,000	6,200
Total all markets	**31,739,000**	**43,500**

A significant proportion of the demand would interchange at Old Oak Common on to Crossrail and other services. It should be noted that in the summary table above, these onward connections are assumed to include a direct connection to Watford/Milton Keynes from Old Oak Common which has not yet been approved. Excluding this connection would remove about half of the forecast interchange traffic at Old Oak Common. Even so, the value and function of Old Oak as an all-day interchange on HS2 would be much enhanced if the HS1 – HS2 connection is used to provide the type of services examined in this report.

There is also evidence that the demand for services over the HS1 – HS2 link would be drawn from a much wider set of transport modes than is projected to arise on HS2's Euston services. The sources of demand vary according to the market segments under consideration – as is shown in Table 7.2 below.

Table 7.2 Change in rail market share

Market	2011 rail mode share (Classic)	2033 rail mode share (Classic and high-speed)	Change
Kent - West Midlands / North West England	17%	40%	+23%
Essex / Suffolk - West Midlands / North West England	13%	36%	+23%
East London / Docklands - West Midlands / North West England	72%	85%	+13%
Kent / Essex & Suffolk / East London / Docklands - Thames Valley / Heathrow / West of England / South Wales	31%	42%	+11%
Kent / Essex & Suffolk / East London & Docklands - North West London / Milton Keynes	29%	36%	+7%
Kent / Essex & Suffolk / East London & Docklands - Heathrow	54%	68%	+14%
Kent / Essex & Suffolk / East London & Docklands - East Midlands / Yorkshire & Humber	9%	17%	+8%

The increase in rail share is between 7% and 23%, which is a remarkably high transfer. This is because complex cross-London journeys by existing ('classic') rail are augmented by the offer of direct cross-London services. This provides a real alternative to travel around London on congested roads, typically, the M25. Shift from other modes bring wider benefits, not just to the HS1 – HS2 link, but also to HS2 as a whole. It would appear likely that domestic services using the HS1 - HS2 link, if added to the central London services on HS2, would strengthen the overall business case for HS2.

7.2 International Demand

The demand analysis summarised above excludes consideration of the potential use of domestic services operating from HS2 onto HS1 to provide convenient access to international HSR services. In practice, a twice hourly service from places such as Manchester and Birmingham to an interchange station such as Ebbsfleet (which already

has border control facilities in place and segregated arrangements for international passengers) for onward connection to continental Europe would attract demand and would offer a better option than either:

(i) Expecting passengers to 'make their own way' between Euston and St Pancras International; *or*

(ii) Using Old Oak Common as an interchange point.

The value of interchange at Ebbsfleet is that it enables interchange onto the full range of pre-existing international services and frequencies terminating at London (St Pancras). It is possible that the choice of interchange station on HS1 could change as the service pattern on the route evolves. Providing for interchange at Old Oak Common would be reliant on there being entirely separate Old Oak Common international services. These in practice are unlikely to materialise for commercial and capacity reasons and would require separate platforming with border control facilities at Old Oak Common.

The scale of international passenger demand that could make use of a HS1 – HS2 link and its services is shown in Table 7.3. Overall there is sufficient demand for limited frequency direct international services, both to Heathrow and the Midlands/North. High-speed rail's attraction to the longer distance travel markets tails off sharply in this analysis, as can be seen. Heathrow is as attractive a destination as a combination of Midland and Northern locations.

Table 7.3 Summary of international demand

Market	**2033 Annual demand *mppa***	**2033 Daily one-way demand**
Europe – Midlands/Northern England	1,893,000	2,600
Europe – Stratford	4,434,000	6,100
Europe – Heathrow	1,639,000	2,200

In the analysis of international demand, whether by interchange (at Ebbsfleet) or by direct services, it was assumed that service frequency matches that on offer by the air mode. The interchange at Ebbsfleet in effect adds a thirty minute journey time penalty over a direct service. The impact of this in the analysis is not as substantial as might be expected. With an interchange at Ebbsfleet, rail is expected to capture 29% of the available market

in 2026, rising to 34% in 2033; with direct services instead, the market share is forecast to be 37% in 2026 rising to 40%.

The important conclusion is that a regular interval fast connecting service to a convenient same station interchange that is already served by international services to/from London will not only carry significant domestic demand, it will also achieve significant penetration of the international air/rail market for travel to near continental destinations.

7.3 Implications for infrastructure and for HS2 plans

While the work presented here does not itself represent a business case for the HS1 – HS2 connection, for the first time it does set out how the HS1 – HS2 connection could be expected to support services for which there would be strong demand and very widely spread benefits.

Instead of being seen primarily as a connection for direct international services, the analysis here points to the need to examine fully the role of the HS1 – HS2 link in supporting longer distance cross London domestic services, for which demand is forecast to be substantial. International services using the HS1 – HS2 link can then be considered as an overlay, a supplement to using Ebbsfleet as an interchange with international services.

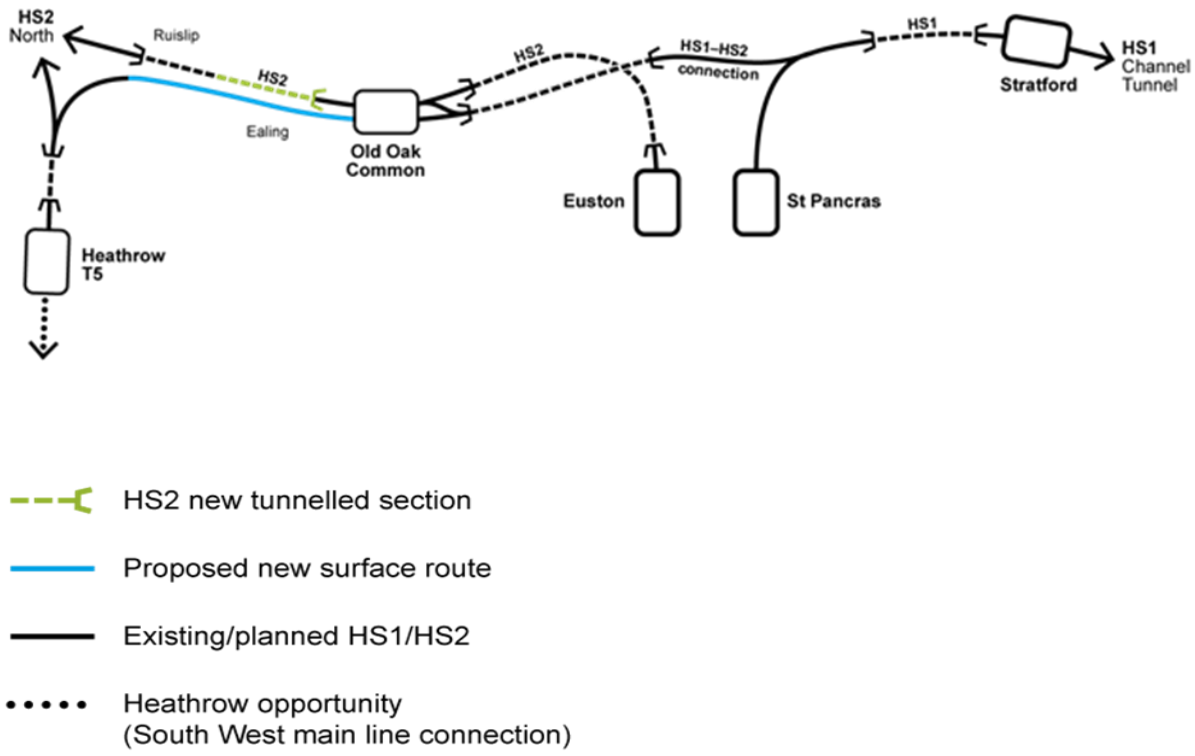
The question arises as to whether the single track connection that forms the current plan for a HS1 – HS2 link is sufficient. It is not possible to answer this without a thorough and detailed examination of how the two high-speed lines would work with through services at varying frequency levels. The evidence suggests that there is demand for perhaps a 4 train/hour service (in each direction). This is unlikely to be accommodated easily on a single track arrangement.

Another issue is the risk of overloading HS2 by the combination of demand for services from Euston and from the HS1 – HS2 connection. The recent decision by HS2 Ltd to adopt a preferred solution that entails a continuously tunnelled section of route form North Ealing (just east of Old Oak Common) to Ruislip creates one possible way to mitigate this risk that is worth mentioning.

A potential solution to this problem would entail creating a connection at Old Oak Common on to the existing (UK gauge) railway that uses the surface corridor through West London that has now been abandoned for use by HS2 itself. The railway in contention – part of the former Great Western Main line between Paddington and Birmingham – would

need to be re-instated as a double track railway; it is currently single track and carries a residual once-daily train service. Provided this section of route remained at UK loading gauge, the difficulty that reportedly arose with the HS2 scheme – the need for extensive bridge rebuilding – would be avoided. This concept is illustrated in Figure 7.1 below.

Figure 7.1 Sustaining a HS1 – HS2 connection and protecting HS2 capacity



The key point shown in Figure 7.1 is the scope to connect HS1 directly to Heathrow without operating over HS2 itself. The route would be constrained to UK gauge trains (such as Eurostars or the planned HS2 classic compatible HS2 trains or indeed the Class 395 services that operate the 'Javelin' service across Kent). Speeds through the section marked in blue above ('proposed new surface route') would not operate at high-speed, any more than is planned or is practicable for the HS1 – HS2 link itself. At Heathrow, interchange with services using the new Western rail access to the airport would be possible as well as continuation southwards to connect with the South Western Main Line[10].

[10] See Heathrow Opportunity, Greengauge 21, 2011

As planned, the HS1 – HS2 connection is designed to accommodate EU-gauge high-speed trains. This entails a proposed widening of the viaduct at Camden Market and other measures. It is not clear whether there would be a good business case for this specification if it were to be tested against a UK-gauge only solution. In respect of international passenger demand, the number of services that would be accommodated is likely to be relatively small, and there is an established fleet of suitably equipped trains (Eurostar) that could meet the need (assuming they are relieved of St Pancras Eurostar services at some stage). In respect of domestic services, the demand levels are, on the other hand, sufficiently high that the section of HS2 between Old Oak Common and Heathrow junctions is unlikely to be able to readily accommodate them along with all of the Euston service demand – leading to the suggestion set out in Figure 7.1. As noted, this suggestion only works with a UK-only gauge solution.

While restricting the gauge of such a central part of the future national HSR network could and should not be taken lightly, the evidence suggests it is an approach that should be considered. If that is the case, it would be much more feasible to establish at least the Primrose Hill – St Pancras (north) section of the HS1 – HS2 route as double track. The question would remain about the efficacy of constraining the Primrose Hill – Old Oak section to a single track tunnel, and, with a higher service frequency (largely of domestic trains) the arrangements at Camden Road junction may need to be expanded.

The ideal solution, in any event, would remain one in which European gauge trains are not precluded, so that future Eurotunnel/HS1-compatible train fleets are able to operate over the connection and onwards to/from HS2 destinations.

7.4 Summary of Benefits

The HS1 – HS2 link would offer a wide set of benefits:

- Cross-London passenger demand would be taken out of congested central London interchanges;
- Domestic services operating over the link would provide high quality access at Ebbsfleet to international services provided by Eurostar (and in future planned by Deutsche Bahn) to France, Belgium, Netherlands and Germany from all locations served by HS2;
- A viable alternative to the M25 for longer distance journeys would be provided, especially for those travelling to/from Kent and Essex;
- The growth areas of East London and Docklands would be provided with access to HSR at an existing HSR station (Stratford);

- A new geography would get direct benefit from HS2 services: Essex, East/South East London, Kent, parts of Suffolk and East Sussex;
- Heathrow could be accessed directly by HSR from the continent (or in future, if an Estuary airport is built, accessible from HS1, links could be provided between the two airports);
- The high levels of transfer to HS1 – HS2 services suggest a high level of benefits per passenger carried and significant relief to congested parts of the national transport network;
- The role and value of the Old Oak Common as a (domestic) interchange is strengthened and diversified;
- The demand for existing London international HSR services would be strengthened, improving the economics of these services and the value of HS1; and
- The overall business case for HS2 is likely to be strengthened by the addition of a HS1 – HS2 connection.

8. Recommendations

Adding services from HS1 expands the benefits of HS2. It removes the limitation of having the southern focus of the scheme entirely on serving central London. It means that Phase 1 of HS2 can offer better connectivity from the Midlands and the North, not just to London, but also to the wider south east and to continental Europe. The connection therefore needs to be seen as an integral part of the Phase 1 plans for HS2.

There is a need to examine the business case for a good resilient connection, based on domestic demand with an overlay of some international services.

The potential value of Ebbsfleet for good interchange from HS2 to a full range of international services needs to be examined, along with the alternatives at Stratford and Ashford.

The potential value of Stratford in serving the East London market needs to be examined further. It may also serve as an alternative London 'terminal' at times of major (emergency) service disruption at Euston, provided the HS1 – HS2 link is built with sufficient capacity.

The strengthened role of Old Oak Common as an interchange between HS2 (and HS1) with Crossrail needs to be examined. The further benefit identified in having Crossrail extended to serve West Coast Main Line destinations to Milton Keynes should be progressed and the

need to create a connection with the surface corridor between North Ealing and Northolt needs to be examined as a high priority.

Annex A

Consultants' Brief

A.1 Background

Greengauge 21 is planning to conduct a research study into the potential use of the HS2-HS1 link currently proposed by Government to be constructed in Phase 1 of the HS2 project. The work will address the following specific questions:

- What is the broad level of domestic travel demand between Stratford/ Ebbsfleet/ Ashford and Old Oak Common/ Birmingham/ Manchester/ Sheffield/ Leeds/ Newcastle/ Liverpool? This will be addressed by consideration of the wider demand potential between Kent/East London & Docklands/East Anglia and West Midlands/North West/ Yorkshire/ North East and Scotland etc
- What is the passenger demand for a direct international services between locations such as Leeds and Manchester/Birmingham/Old Oak/Stratford (and Lille/Paris)?
- What is the range of services that might be provided via the HS2 – HS1 link?
- How might the services be provided cost-effectively and in a way that addresses international security/border control issues?

Specialist input on transport demand analysis is required for the project, which is the subject of this brief. Additional expertise is being commissioned separately on border security issues and the final report will be developed and published by Greengauge 21.

Sponsorship for the work is currently being sought from a number of public sector organisations and sufficient interest has been expressed that Greengauge 21 is confident the work will proceed.

A.2 Scope of demand analysis

There are three types of passenger service that could operate over a HS2 – HS1 link:

(a) Direct international services between the Midlands/North and Europe;
(b) Domestic inter-regional services; and
(c) Services which provide a combination of the two service types.

Service type (a) is unlikely to support more than a low daily frequency. It needs to be considered as a possible addition to others service types. Service type (c) has to provide for secure border control/security, on which subject a separate parallel preliminary investigation is in hand. Service type (b) appears not to have been considered by HS2 Ltd to date, and the main focus of the work is to make a preliminary assessment of the scale

of the travel markets that could be addressed under this heading.

A.3 Domestic inter-regional travel markets

With a robust HS2 – HS1 link in place, from 2026 there would be scope to operate regular hourly or better services such as Ashford – Ebbsfleet – Stratford – Old Oak Common – Birmingham Interchange – Crewe/Manchester Airport/Piccadilly (with the service north of Birmingham Interchange getting a speed up under HS2 Phase 2 plans).

This would serve the following travel markets:

a. Kent – W Midlands/North West England;
b. Essex/Suffolk – W Midlands/North West England;
c. East London/Docklands – W Midlands/North West England;
d. Kent/Essex & Suffolk/East London/Docklands – Thames Valley/Heathrow/West of England/South Wales (via Old Oak Common interchange); and
e. Europe (Paris/Brussels/Lille and in future, Frankfurt/ Koln/ Amsterdam/ Rotterdam/ Antwerp) – Midlands/North West (via interchange on HS1, say at Ebbsfleet).

If additional connectivity is provided at Old Oak Common as proposed by TfL (and Network Rail), then these flows can be added:

f. Kent/Essex & Suffolk/East London/Docklands – NW London/Milton Keynes.

If the Heathrow connections are provided post-Davies Commission in HS2 Phase 2, then there is also scope for:

g. Kent/Essex & Suffolk/East London/Docklands – Heathrow services.

And when Phase 2 HS2 is complete, services could also operate:

h. Kent/Essex & Suffolk/East London/Docklands – East Midlands/Yorkshire

Greengauge 21's requirement is to identify the scale of each of the travel markets identified in paragraphs 7-10 above. The flows concerned are primarily domestic for which an analysis at county and region level is needed, together with an assessment of the 'East London' and NW London travel markets. If consultants are able to provide a more disaggregated analysis that relates more closely to an assessment of station catchments, it should be proposed as an addition.

For each relevant market (flow), we want an assessment of:

i. the total travel market (in mppa) in a suitable base year (such as 2011), a main travel mode breakdown (for which car/rail/other will suffice); and
ii) the same for 2026 and 2033.

For comparative purposes, we would like a similar breakdown for the total and modal markets for travel between Greater London and each of West Midlands, East Midlands, North West, and Yorkshire/Humber. If it is possible to provide the same for a suitable definition of 'central London' then that may be proposed as an additional deliverable.

A4. International markets

The scope above includes an international travel market at §7 (market e) above. This can be assessed as an air travel market (i.e. ignoring other travel modes such as rail, coach and car) for 2011 and 2026 using the latest DfT/CAA projections and evidence.

A typical through HSR service in the international sector might operate Manchester/ Birmingham Interchange/Stratford – Lille/Paris. The economics of such a service depend on a set of flows only some of which have been considered in HS2 Ltd's assessments to date. On the basis of existing practices, the flows to be considered would be not only those listed above, but also:

a. Stratford - Lille/Paris/Brussels/Antwerp/Rotterdam/Amsterdam/Koln/Frankfurt; and
b. Paris (or Amsterdam or Frankfurt) together with intermediate European locations as noted above and Heathrow

Greengauge 21 requires estimates of these international markets, based on air flows, for 2011, 2026 and 2033. If consultants are able to provide data/evidence on these markets by other travel modes, they may be offered as an addition.

Greengauge 21 would welcome commentary from consultants on the following areas, based on the data and projections as described above:

- The relative scale of the markets that could be served by HS2 – HS1 rail services in comparison with the services planned to operate between various Midland and Northern destinations and central London

- Views based on relevant experience on the likely market share that a HSR service in these markets could attract assuming 2 tph (domestic services) and an appropriate frequency for international services, together with any assessment about induced/generated levels of demand that might be expected.

Annex B
Demand Forecasting Model

B.1 Car Base Year Updates

The 2007 car demand matrix was derived from the Department for Transport (DfT) National Transport Model (NTM). To update the demand for 2011, analysis of the DfT's most recent National Road Traffic Forecasts (NRTF) was undertaken which suggested that national car travel had reduced slightly between 2007 and 2011. The DfT's publication of Road Traffic Statistics provided a direct comparison of actual car travel (in billion vehicle kilometres) by region between 2007 and 2011 and this was used to produce a matrix of scaling factors in order to create the 2011 car demand matrices. The same factors were applied to both the business and leisure demand matrices to maintain the distributional detail of the purpose splits as derived previously from the NTM. Car costs and GJTs as derived from the NTM for the 2007 base year were left unchanged for the 2011 base year. The journey times include an allowance for congestion at the base year level, and since the overall level of travel had dropped marginally between 2007 and 2011 it was assumed that the level of congestion had not materially changed.

B.2. Rail Base Year Updates

Each of the model origin-destination flow pairs in the rail demand matrix were classified according to the rail market serving that flow:

- Long-distance (excluding Virgin West Coast Main Line services);
- Regional;
- London and South East;
- Virgin West Coast Main Line (WCML); and
- International (Eurostar).

A distinction was made for Virgin WCML flows to account for the additional demand generated by the step-change in service following the introduction of their Very-High Frequency (VHF) initiative in December 2008 in which the frequency was increased from 2 tph to 3 tph on the principal WCML routes, as well as faster journey times.

The four-year increase in passenger demand for each domestic market was sourced from ATOC and from Eurostar for international services (Table B1). These growth rates were then applied to the 2007 base rail demand matrix to generate the 2011 matrix.

Table B1 Passenger demand growth by market, 2007/08 to 2011/12

Market	Long-Distance	Regional	LSE	Virgin WCML	Eurostar
Passenger demand (m)					
2007/08	82.1	285.8	828.4	21.8	8.3
2011/12	95.1	340.9	993.9	30.2	9.7
Growth (%)	**15.8**	**19.3**	**20.0**	**38.7**	**17.4**

Source: ATOC, Eurostar

Rail GJTs were left unchanged from the original model i.e. 2007 values for all flows except for those served by Virgin WCML services. For these flows, the impact on GJT was derived by assuming the additional demand growth observed on WCML services above that observed on other long-distance services was solely due to the impact of VHF on the GJT. Using this demand growth and a long-distance GJT elasticity of -0.9 (as per PDFH v5), an implied GJT reduction of -18% was derived which was then applied to all WCML flows.

B.3 Air Base Year Updates

The base year matrix for air demand was obtained by sourcing demand data for 2011 from the Civil Aviation Authority (CAA) with provides demand between airport pairs. For certain flows, demand is zero owing to the withdrawal of certain domestic services e.g. Leeds /Bradford – London Heathrow (a service that was in fact re-instated in 2012).
As per rail, air GJTs were left unchanged from 2007 with the exception of those services which have since been withdrawn; in these cases the GJT was set to a large value (9,999) to exclude air from the subsequent mode choice calculation.

B.4 Growth Factor and Parameter Updates

The base car, rail and air demand are grown forward using a variety of growth factors and parameters to generate demand in the forecast years. Where updates were available, these factors have been revised as per

Table B2.

Table B2 Growth factor and parameter updates

	Update
Population growth	Base year and forecast year population updated using TEMPRO v6.2 to derive population growth factors
GDP per capita growth	GDP growth rates updated using latest WebTAG values (Unit 3.5.6, October 2012)
Employment growth	Base year and forecast year employment updated using TEMPRO v6.2 to derive employment growth factors
Car demand growth	Updated using 2011 NRTF based on NTM results
Car operating costs growth	Updated using latest WebTAG values (Unit 3.5.6, October 2012)
Values of time	2002 values updated to 2010 values from WebTAG (Unit 3.5.6, October 2012)
Growth in values of time	Updated using latest WebTAG values (Unit 3.5.6, October 2012)

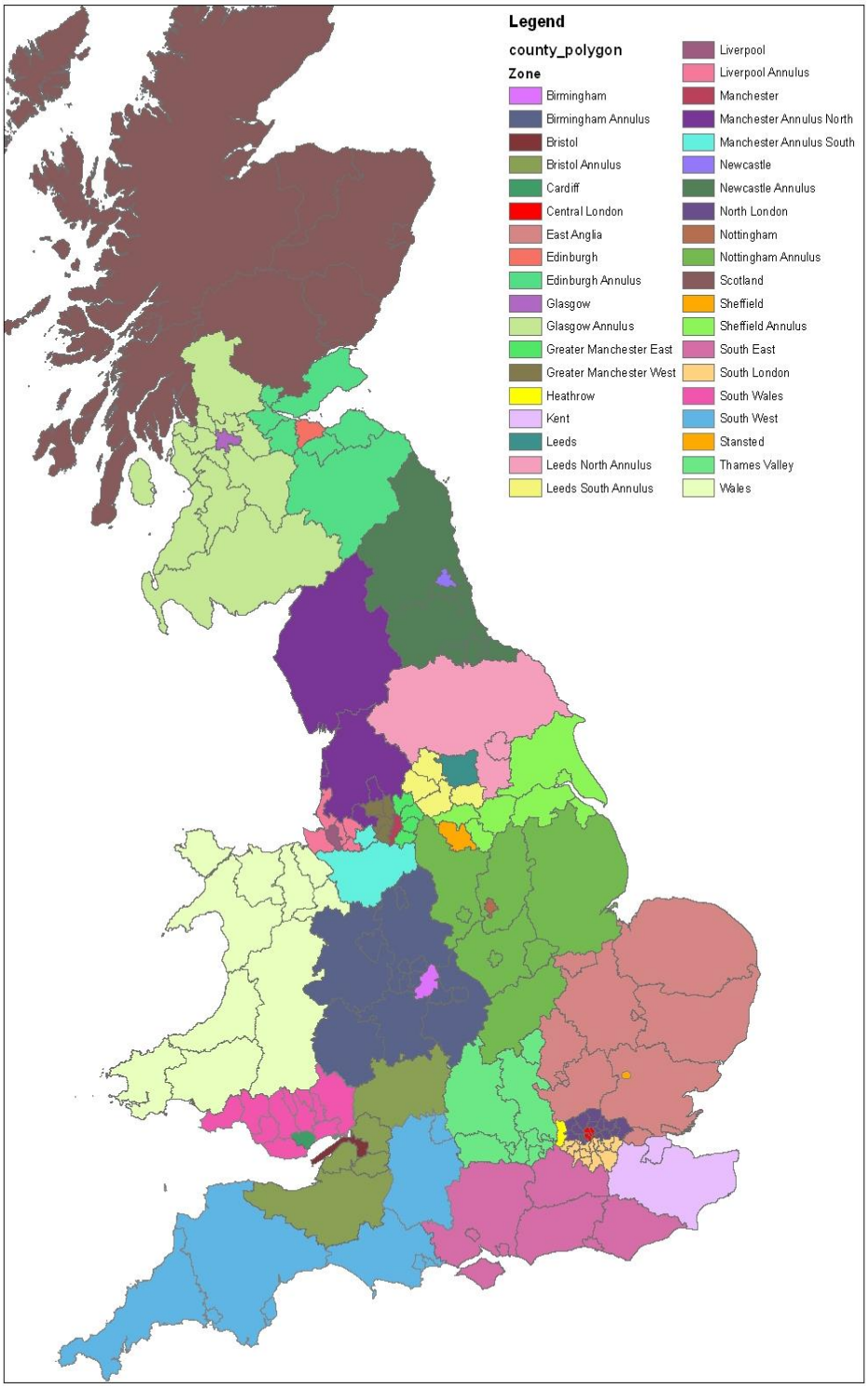
B.5 Model Zones

The model disaggregates travel demand according to 39 zones which cover England, Wales, Scotland and Europe. The zoning reflects the intercity nature of the market for high-speed rail and distinguishing between city centres and annuli allows differential access times to be reflected. The model zoning system focuses on UK cities served (directly or with an interchange) by HS rail; each of which has at least one annulus which covers the area immediately surrounding the city. The purpose of the annulus is to account for differences in travel behaviour and mode share between trips from the city centre and those from its hinterland. For example, trips beginning in the city centre may be more likely to use rail for a trip due to easier access to the city centre station. The Europe zone is used to model travel between the UK and European destinations which are likely to become more attractive once high-speed rail is introduced. Demand has been split into business and leisure travel. For the purposes of modelling, commuting trips have been grouped with business trips.

The model zones form a 39 by 39 matrix of movements between zones (1,521 origin destination pairs). Flows have been assumed to be one way therefore for example the

Manchester to London flow demand has an equivalent London to Manchester demand (as symmetry is expected for annualised demand values). A map and list of the model zones is shown in Figure B2

Figure B2 Model zones



B.6 Zonal Disaggregation outside of Greater London

This commission is concerned with demand to and from specific areas, either at a county or regional level. Outside of Greater London, these areas generally mapped directly to one or more model zones. For example, the West Midlands region is represented by the Birmingham and Birmingham Annulus model zones. For certain areas (Essex/Suffolk, Thames Valley and Milton Keynes), a direct mapping to a model zone or zones was not possible. In these cases, zones were mapped to county level by pro-rating zonal demand according to population which was sourced from 2011 Census data (Table B3).

Table B3 Model zone to county/region mappings

County/Region	Model Zone(s)	Proportion of Zonal Demand
Kent	Kent	100%
Essex/Suffolk	East Anglia	42%
West Midlands	Birmingham	100%
	Birmingham Annulus	100%
North West England	Greater Manchester East	100%
	Greater Manchester West	100%
	Manchester	100%
	Manchester Annulus North	100%
	Manchester Annulus South	100%
	Liverpool	100%
	Liverpool Annulus	100%
Milton Keynes	Thames Valley	11%
Thames Valley	Thames Valley	89%
West of England	Bristol	100%
	Bristol Annulus	100%
South Wales	Cardiff	100%
	South Wales	100%
East Midlands	Nottingham	100%
	Nottingham Annulus	100%
Yorkshire	Sheffield	100%
	Sheffield Annulus	100%
	Leeds	100%
	Leeds North Annulus	100%
	Leeds South Annulus	100%

B.7 Zonal Disaggregation within Greater London

Within Greater London a more detailed disaggregation was sought to provide an accurate representation of trip distributions for trips from and within London as specified in the commission. This disaggregation was derived with the use of data from the London Transportation Studies (LTS) model authorised for use in this study by kind permission of Transport for London (TfL).

The LTS model is a multi-modal model which provides an accurate representation of car, public transport and active mode trip movements to/from/within the Greater London Authority (GLA) area and other regions within the M25. LTS demand matrices were manipulated and analysed to produce a trip distribution which corresponded to the Greengauge 21 model data. The following assumptions were made:

- LTS demand matrices were annualised using standard LTS annualisation factors to scale period demand to be comparable to GG21 annual demand matrices;
- 2011, 2026 and 2031 LTS demand matrices were used where 2031 is a proxy to the required 2033 forecast year;
- LTS matrices for 'in work time' and 'out work time' were used to produce the trip distribution for business and leisure demand respectively; and
- the trip distribution for the 'no HS2' or 'no HS2-HS1' case was applied to all scenarios as the LTS model does not currently include high speed rail schemes.

The LTS demand matrices were mapped outside the GLA to the Greengauge/MVA model zones. Where Greengauge model zones did not match LTS boundaries exactly proportions were created using 2011 Census Output Area population data contained within the respective overlapping regions. This provided information on where trips originating in London, at a detailed disaggregate level, are going to within and outside of the GLA.

This data was finally aggregated to create the market interest areas within and outside London as specified in the commission. It should be noted that the LTS trip distribution within the GLA was adopted wholly, without retaining the trip distributions inherent from the four constituent Greengauge 21 model London zones. This process was used as LTS trip movements were thought to be more accurate than those in the Greengauge model at GLA level, and also it provided better disaggregation between Hillingdon borough (in the North West London market) and Heathrow.

B.8 Base Case Inputs

B.8.1 No HS2 Inputs

In the absence of any high-speed services, the base case inputs were based on current Classic rail journey times, frequencies and interchange assumptions. For key routes such as London to Birmingham, the current journey time, frequency and number of interchanges were sourced from published HS2 Ltd documents. For other routes outside of Greater London, the information was sourced from National Rail Enquiries (based on average off-peak values). For journeys within Greater London, for example, from Stratford to London Euston, the information was sourced from Transport for London's journey planner.

B.8.2 HS2 Only Inputs

HS2 inputs have been sourced from published HS2 Ltd documents. Two sets of inputs were required:

- Phase 1 from 2026 in which the high-speed line will run as far as Birmingham; Classic compatible high-speed services will then extend northwards to Manchester and Leeds; and
- Phase 2 from 2033 in which the high-speed line will extend to Leeds and Manchester resulting in faster journey times.

B.8.3 HS2-HS1 Inputs

To derive the inputs with the HS2-HS1 link in place, the following assumptions were made:

- high-speed journey times from Stratford International to HS2 destinations are as those from London Euston **+10 minutes**
- high-speed journey times from Ashford International to HS2 destinations are as those from London Euston **+41 minutes** (based on the 10 minutes additional journey time to Stratford, plus an additional 31 minutes which is the current Stratford – Ashford journey time on Southeastern HS1 services);
- a high-speed frequency of 2 tph from Ashford/Ebbsfleet/Stratford.

Worked Example

To illustrate how journey time savings and differences in frequencies and interchanges have been derived, the Kent to Birmingham flow is shown as an example. The modelled

station for the Kent zone is Ashford and for the Birmingham zone, Birmingham New Street (for Classic Services) and Birmingham Curzon Street (for HS2 services).

HS2 only

Under the HS2-only scenario, the benefit compared to Classic will only be realised over the London to Birmingham portion of the journey as passengers from Ashford will still need to interchange in London as currently. Given the model is only concerned with *changes* in GJT, for this scenario only this portion of the journey is considered (Table B4).

Table B4 Kent – Birmingham Classic and HS2 inputs

	Journey Time (min)	**Frequency (tph)**	**Interchanges**
London Euston – Birmingham:			
Classic	84	3	0
HS2	49	3	0
Difference (HS2 – Classic)	**-35**	**0**	**0**

Source: HS2 Ltd

HS2-HS1

Under the HS2-HS1 link scenario, the benefit will be realised from the start of the journey due to the direct services from Ashford. The entire journey is therefore considered (Table B5).

Table B.5 Kent – Birmingham Classic and HS2-HS1 inputs

	Journey Time (min)		**Interchanges**
Ashford – Birmingham:			
Classic	170	2	2
HS2-HS1	90	2	0
Difference (HS2 – Classic)	**-80**	**0**	**-2**

Source: National Rail Enquires, Southeastern, MVA/Greengauge 21 assumptions

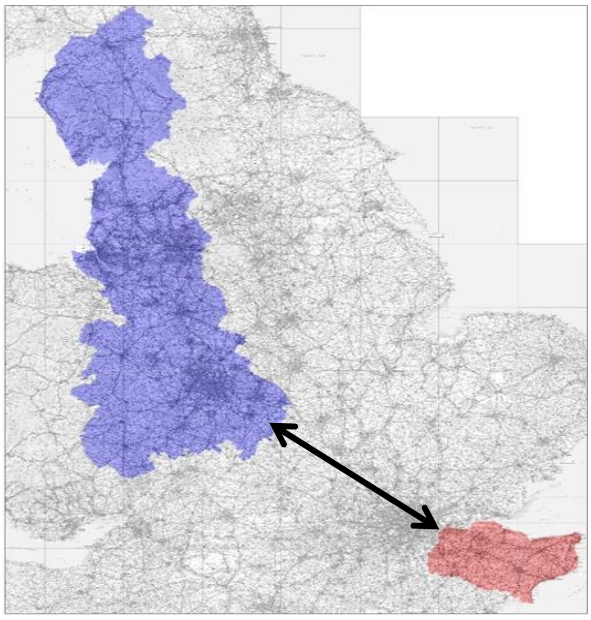
Annex C

Demand for cross London domestic HSR services

C.1 Kent – West Midlands/North West England

The scope of the Kent to/from West Midlands and North West England market is shown in the Figure C1.

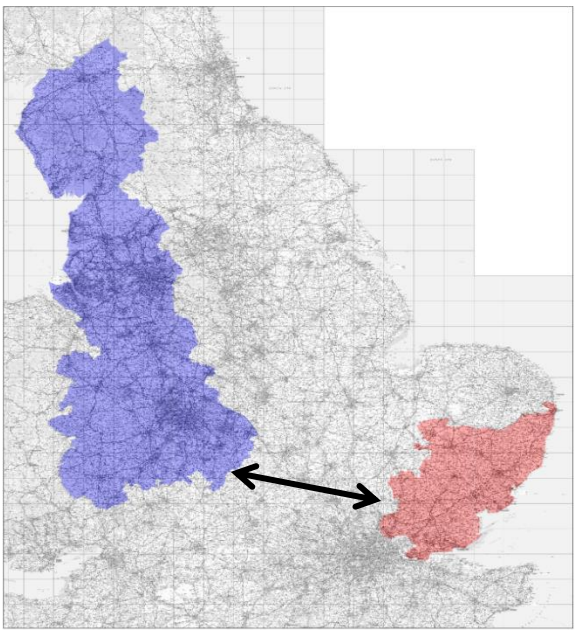
Figure C1.



C.2 Essex/Suffolk – West Midlands/North West England

The scope of the Essex and Suffolk to/from West Midlands and North West England market is shown in the Figure C3.

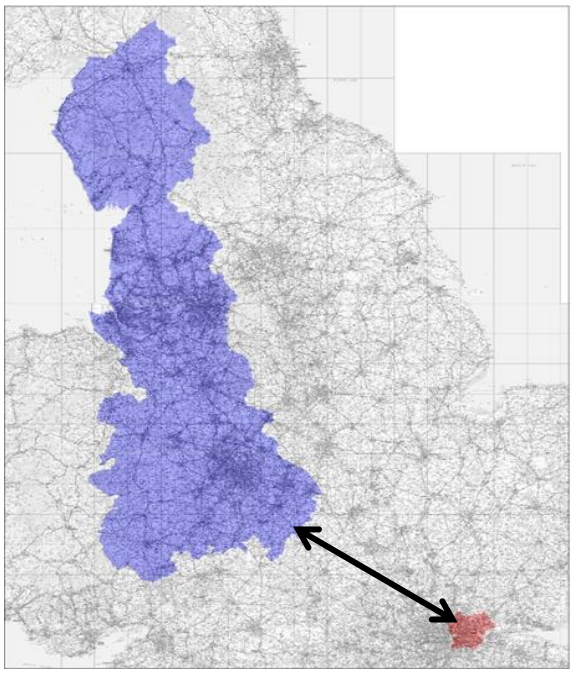
Figure C3



C.3 East London/Docklands – West Midlands/North West England

The scope of the East London/Docklands to/from West Midlands and North West England market is shown in the Figure C4.

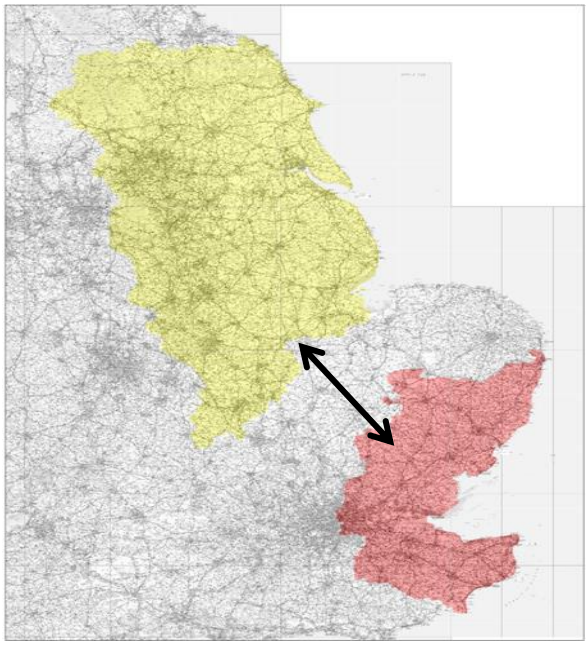
Figure C4



C.4 Kent/Essex/Suffolk/East London/Docklands services – East Midlands/Yorkshire

The scope of the Kent/Essex/Suffolk/East London/Docklands to/from East Midlands and Yorkshire market is shown in the Figure C5.

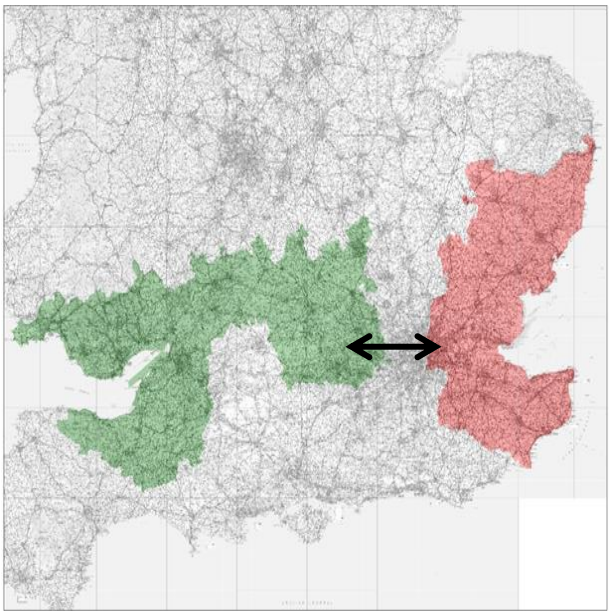
Figure C5



C.5 Kent/Essex/Suffolk/East London/Docklands – Thames Valley/Heathrow/West of England/South Wales

The scope of the East London/Docklands to/from West Midlands and North West England market is shown in the Figure C6

Figure C6



C.6 Kent/Essex/Suffolk/East London/Docklands – North West London/Milton Keynes

The scope of the Kent/Essex/Suffolk/East London/Docklands to/from North West London and Milton Keynes market is shown in the Figure C7

Figure C7