Trans-Pennine Tunnel Study

Stage 3 Report

Department for Transport

highways england

TRANSPORT FOR THE NORTH

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1. Executive Summary

1.1 Overview

1.1.1 For too long, the UK has been overly dependent on growth in London and the south east. In realisation of this, one of the key aims of the Government's emerging Industrial Strategy will be to address this imbalance and drive improved productivity and growth across the whole country. Completing the 'missing link' in the strategic network between Manchester and Sheffield could trigger a step change in economic performance for the north. The Trans-Pennine Tunnel Study (TPTS) has conducted an initial examination of the feasibility of providing such a link.

1.2 The Case for Intervention

1.2.1 The North of England is home to 15 million people – nearly a quarter of the UK's population – and generates £304 billion in economic output[1], accounting for only a fifth of the nation's GVA (Gross Value Added).

1.2.2 It has abundant natural and physical assets, and its educational institutions are among the best in the country[2]. Despite this, the north continues to lag behind London and the south east, the region's physical assets (its cities, institutions) are under-utilised and it is losing skilled workers to the more prosperous south.

1.2.3 Poor connectivity and relative underinvestment in the north has contributed to the region's economic underperformance. Previous studies have shown connectivity between Sheffield and Manchester to be limited and worse than comparators across the North. The distance between Manchester and Sheffield is around 40 miles, but despite this, the journey between the two cities takes 75 minutes in uncongested conditions, with an average journey speed below 35 mph. This makes it comparatively the poorest connected of the city region pairs in the UK, resulting in a low number of existing movements between the two (See Figure 1-1). Furthermore, the majority of the better connected local authorities in England and Wales are found in the south east, with only 4 (out of 50 nationally) in the north west, and none east of the Pennines[3].

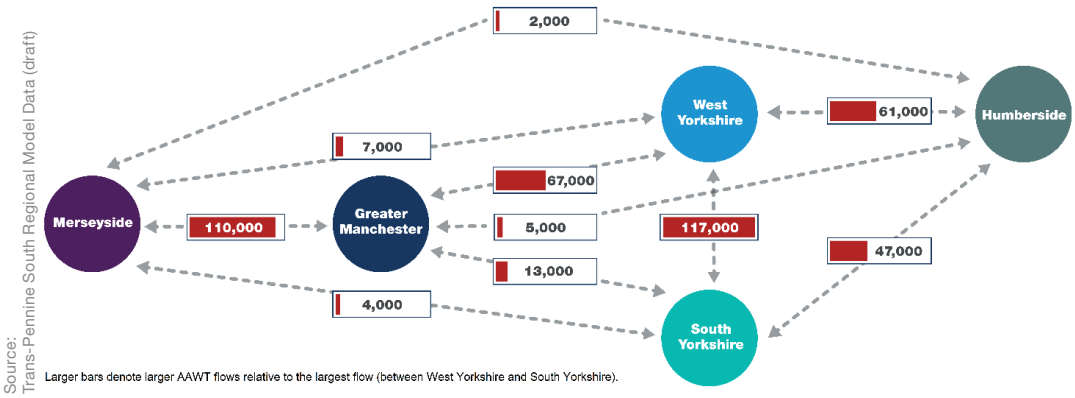


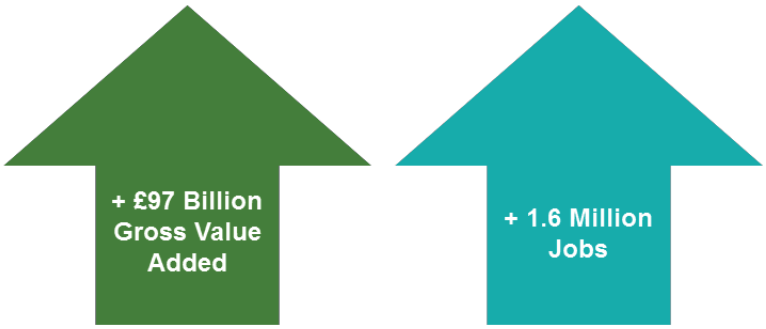
Figure 1-1 – Existing Trans-Pennine Movements (Average Annual Weekday Traffic, 2015), all trips

1 ONS. Statistical bulletin, regional gross value added (income approach), December 2014
2 Two of the top 10 universities in the UK for 2015/16 are located in the north of England (Manchester ranked 8th and Durham 9th). Source: The Times Higher Education World University Rankings 2015, September 2015
3 ATOC. Accessibility Statistics, 2010

1.2.4 Whilst recent years have seen significant investment in north-south routes across the UK, the M62 is the only motorway standard, east-west route in the north of the country and has well documented capacity issues[4].

1.2.5 A similar trend of poor connectivity is seen across the rail network, whereby journeys by rail between the northern city regions are also relatively slow and less frequent. These challenges have contributed to a legacy of poor connectivity in the north which continues to limit economic linkages across the region and restricts its combined potential for growth[5].

1.2.6 The Northern Powerhouse Independent Economic Review (NPIER)[6] demonstrates that with the right level of investment, there is potential for a transformational uplift in economic growth in the north to equal growth levels of the UK average (including London). It highlights that better connectivity in the north's towns and cities is essential to creating a transformed integrated economy. The review shows that, if the north is supported by the right level of investment, there could be a step change in growth of an additional £97 billion GVA and 1.56 million additional jobs, of which 850,000 would otherwise not exist.



1.2.7 The Sheffield City Region has ambitions for boosting economic growth, through the creation of 70,000 jobs, 6,000 new businesses, 10,000 new homes and increasing GVA by 10% (or £3 billion). Greater Manchester aims to deliver an additional 120,000 new jobs over the next 20 years.

1.2.8 The case for change is therefore based on the interrelated transportation and economic needs of the North. A new strategic route between Manchester and Sheffield has the potential to:

- improve the ability for people to travel between these two major cities
- promote growth (improving jobs, skills and employment opportunities)
- improve capacity of the transport network
- improve safety for all road users
- offer greater resilience
- reduce the impact of traffic on the high-quality environment of the Peak District National Park (PDNP)

4 This study, and the other two northern strategic studies (Northern Trans-Pennine and Manchester North West Quadrant) focus heavily on attempting to improve east-west movements

5 Strategic Economic Plans (SEPs) for Manchester and Sheffield outline ambitious plans for growth in the number of jobs and businesses

6 TfN Northern Powerhouse Independent Economic Review

1.2.9 Importantly, if the wider policy towards creating a Northern Powerhouse is successful, the constraints on connectivity between Manchester and Sheffield and their impact on the wider transport network in the north will hold back growth across the region.

1.3 A Tunnel Solution

1.3.1 The Government's Road Investment Strategy (RIS)[7] published in 2015 highlighted the need to improve capacity and connectivity between Sheffield and Manchester[8] in order to facilitate and promote economic growth as part of the Northern Powerhouse initiative, stating that: "*such a connection could have a dramatic impact on the economy of the North, particularly in combination with plans for high speed rail links*".

1.3.2 The RIS went on to state that: "*the invaluable landscapes and ecological significance of the PDNP rule out a surface link. The only credible solution may be to construct a tunnel under the central part of the Pennines. This carries with it the potential to bring important environmental improvements to the PDNP*".

1.3.3 In July 2015, the Department for Transport (DfT) and Transport for the North (TfN) jointly commissioned Highways England to produce a strategic study assessing the feasibility of a new strategic highway route (including a tunnel under the Pennines) connecting Sheffield and Manchester – the TPTS.

1.3.4 The delivery of such a bold concept would have a transformational impact on both travel in the north and across the UK and could be a catalyst to explore further improvements in east-west connectivity, including linking the international ports on Merseyside and Humberside.

1.4 Emerging Findings

1.4.1 The study has identified that delivering a new strategic link between Manchester and Sheffield, involving a significant length of tunnel, would be achievable. The geology of the Pennines and modern tunnelling techniques mean that the construction of a new road tunnel, would be feasible.

1.4.2 The length of the new strategic link connecting Sheffield and Manchester could be between 24 and 26 miles, depending on the final route selected. This link could comprise a tunnel section of between 12 and 20 miles in length, a number of above-ground structures including bridges, retaining walls and earthworks, as well as the need to improve the existing highway infrastructure. The tunnel section would be longer than any tunnel in the UK and would be longer than most other road tunnels in Europe, making it an exemplar of its kind.

7 DfT Road Investment Strategy: Investment plan and statement of funds available, March 2015
8 When we refer to Sheffield and Manchester in this report we refer to their respective city regions

1.4.3 A review of best practice for the operation and maintenance of a strategic link, particularly one with long tunnel sections, has been undertaken, looking at comparable schemes across the world. The review demonstrated that the operation and maintenance of such a scheme would also be viable. Transport technology is evolving at a rapid pace and it is expected that there will be considerable change between now and the potential scheme opening year. Ensuring that the scheme would be, as far as is possible, future proofed, is an important issue to address as the scheme develops.

1.4.4 DfT and TfN continue to investigate the opportunities for rail solutions across the north with teams from Network Rail and HS2 due to report in winter 2016. As part of this study, opportunities for synergies with rail have been assessed, concluding that additional tunnel bores would be necessary to accommodate heavy rail and that the inclusion of light rail within the road tunnel would be unlikely to be appropriate.

1.4.5 Potential options for a strategic link have been developed. In line with government guidance, and in collaboration with stakeholders, an incremental sifting process was followed, resulting in the identification of a shortlist of five better performing route options[10]. (See Figure 1-2).

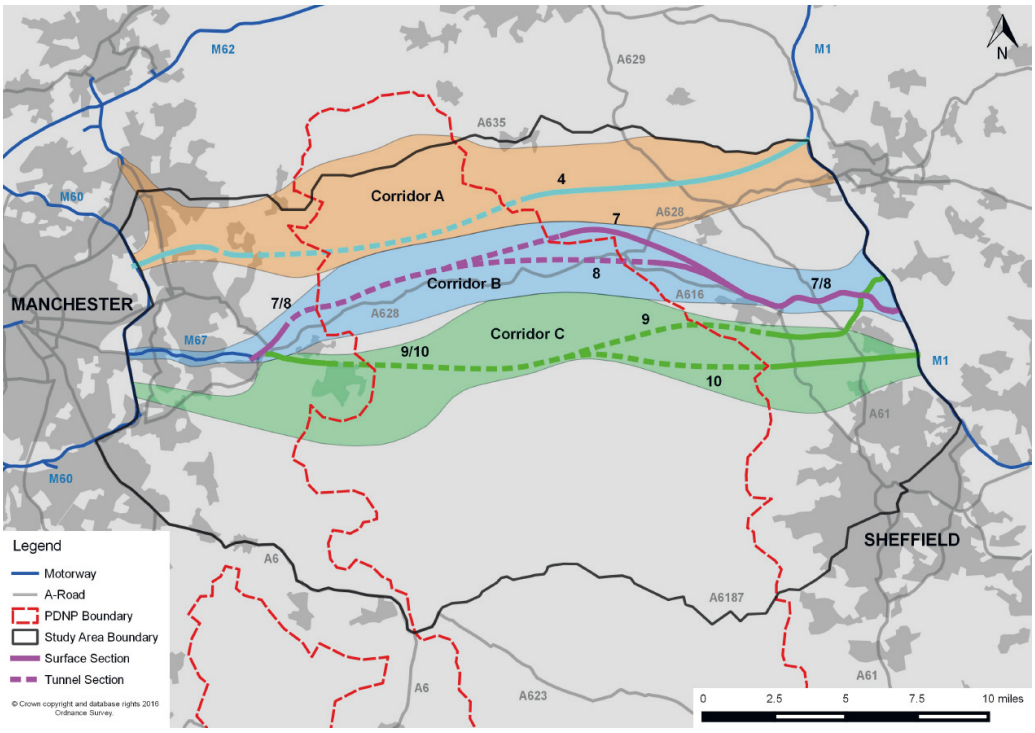


Figure 1-2 – Better Performing Route Options

1.4.6 It is anticipated that a new link could initially attract up to 35,000 vehicles a day and deliver significant benefits, such as improved journey times, a saving of up to 30 minutes for both passenger and freight traffic between Manchester and Sheffield, with potential knock-on implications for travel times on other parts of the network. A tunnelled solution would offer increased reliability and resilience for road users, including overcoming the challenges associated with adverse weather events.

10 Please note, these options have been developed solely for the purposes of this initial study into the feasibility of delivering a TPT solution. These are not actual preferred routes that will be taken forward to construction. Subsequent stages will investigate potential options in further depth

1.4.7 Environmentally, the analysis undertaken demonstrates that the traffic relief across existing trans-Pennine routes, could offer improvements to the PDNP, in terms of the impact on landscape, air quality and biodiversity – albeit the impacts of the route as a whole may have some adverse environmental impacts.

1.4.8 Initial analysis demonstrates that there would be large economic benefits associated with delivering a new strategic link between Manchester and Sheffield. However, current limitations, primarily associated with the availability of suitable traffic models and the emerging nature of the wider economic impacts appraisal methodology, mean that many of the benefits that are likely to result from the implementation of such a transformational scheme have not been accounted for at this stage – it is likely that the large benefits identified at this stage would increase further.

1.4.9 Order of magnitude cost estimates have been developed for the five indicative route options. Estimated costs, using "today's" prices (Q1 2014 price base) range from £6.5 billion (Route Option 4) to £10.1 billion (Route Option 10). Allowances for project risk and unscheduled items could increase these further by another £1.3 billion to £1.5 billion.

1.4.10 As a result of its unique nature, aligned with the extensive time frame associated with the development, construction and operation of the scheme, allowances will need to be made in the future for inflation and portfolio risk. These are currently not included within the cost estimates.

1.5 Next Steps

1.5.1 The budget announcement on 16 March 2016 announced that £75 million of the £300 million identified in the Transport Development Fund will go toward accelerating three strategic studies focused on improvements in northern England, including the TPTS.

1.5.2 The analysis to date has demonstrated that there are anticipated to be large, wide reaching benefits associated with the development of a new strategic link. This funding will help undertake the additional analysis which is needed in order to be able to both fully capture the benefits of a Trans-Pennine Tunnel (TPT) and estimate the anticipated costs more accurately. Key to this will be making use of the soon to be completed Trans-Pennine South Regional Traffic Model, as well as incorporating the outputs from a wide range of other strategic and regional studies.

2. Introduction

2.1 Background

2.1.1 As part of its RIS: Investment Plan, December 2014 (RIS)[12], the DfT announced that it would be exploring the feasibility of a major new road link under the Pennines between Sheffield and Manchester and outlined the requirements for a strategic study, the TPTS. The RIS anticipates that such a connection could provide dramatic benefits to the economy of the north, particularly in combination with planned high speed rail links. A tunnelled route was considered necessary, rather than a surface link, in order to protect the invaluable landscapes and ecologically significant areas of the PDNP. In July 2015, the DfT and TfN jointly commissioned Highways England to undertake the TPTS, believing that the development of such a corridor could improve the economic prosperity of both cities and the wider Northern Powerhouse region.

2.1.2 The Northern Transport Strategy[13], published in March 2015, commits to developing the next generation of major road schemes to dramatically improve east-west connectivity and fully supports the TPTS. The update to this strategy, published in March 2016[14], continues to support the TPTS and identified the TPT as one of the key priorities for investing in the future Strategic Road Network (SRN) in the north. Also in March 2016, the National Infrastructure Commission (NIC) published its report outlining strategic advice on regional connectivity challenges in the north[15]. In this report they presented the 'Pennine challenge', which highlighted the lack of capacity for east-west connections and noted that, as well as improving connectivity, the proposed strategic link would provide an additional strategic route across the Pennines, including a new route for freight traffic.

2.2 Study Area

2.2.1 The TPTS explores road-based solutions for a new route between Manchester and Sheffield. At the outset, it is important to note that the mandate for this strategic study specifically focuses on the development of the case for a new strategic highway route and does not include analysis of strategic alternatives, including consideration of rail alternatives. The evidence collated by Highways England has demonstrated that in order to meet its strategic aim and objectives, improvements to the trans-Pennine SRN are required. The RIS notes that there are limited east-west road links available and given the invaluable landscape and ecological significance of the PDNP a surface link has been ruled out, and consequently a tunnel scheme is suggested.

12 DfT. Road Investment Strategy: Investment plan and statement of funds available, December 2014
13 TfN. The Northern Powerhouse: one agenda, one economy, one North – a report on the Northern Transport Strategy, March 2015
14 TfN and DfT, Northern Transport Strategy Spring Report, March 2016
15 National Infrastructure Commission, High Speed North, March 2016

2.2.2 As part of the Northern Powerhouse agenda, different schemes are being considered to deliver the connectivity required to make the north a strong and interconnected single economic area, with the overall aim to support the ambition of a Northern Powerhouse. Each scheme is being developed to address specific local challenges, whilst improving different types of connectivity across corridors and modes. As part of this study, potential synergies with rail and/or light rail within a single multi-modal corridor have been considered. Furthermore, opportunities for combining this study with solutions involving rail have been considered.

2.2.3 The study area (Figure 2-1) is bounded to the west by the M60 Manchester orbital motorway and to the east by the M1 motorway. It is bounded to the north by the town of Holmfirth and extends south to Chapel-en-le-Frith. North and south of these two boundaries, any potential new routes would become significantly less direct and therefore also significantly less desirable, as they would not capture enough traffic from the existing routes. A wider study area, which includes and extends beyond the entire Northern Powerhouse area, has been used to consider the economic and traffic impacts of the scheme.

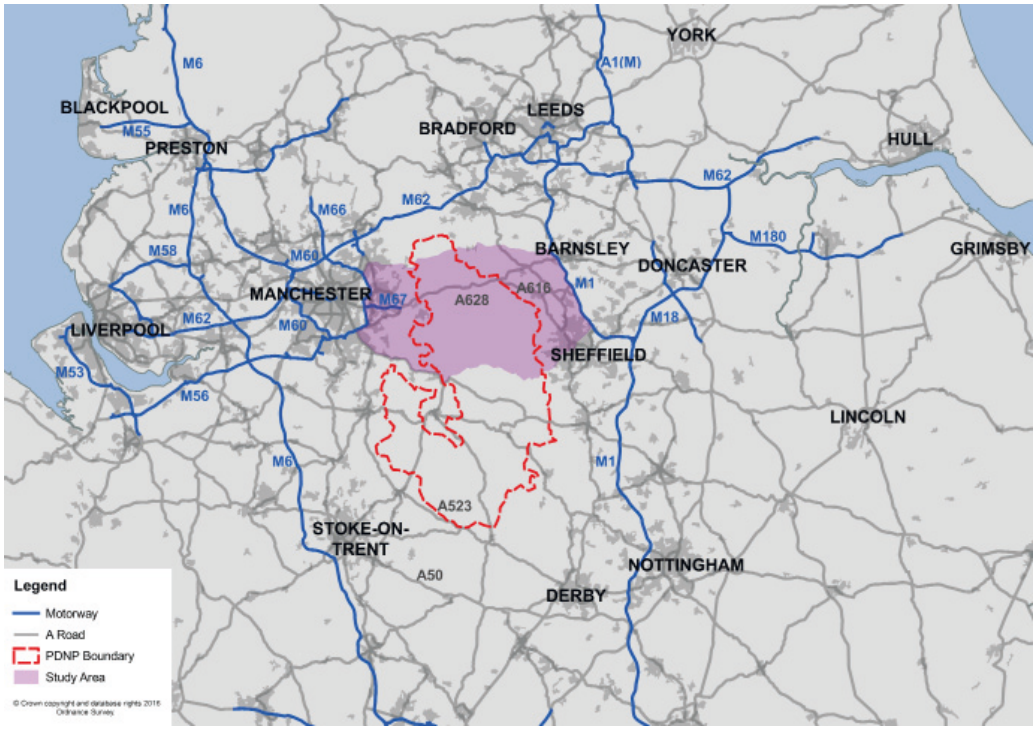


Figure 2-1 – Geographic Scope of Study

2.3 TPTS Approach

2.3.1 The TPTS has been conducted in three key stages including:

- **Stage 1** – Review of existing studies and initial examination of the potential case for a new strategic road link across the Pennines, and the construction viability.
- **Stage 2** – Further assessment of the design, construction, operation and maintenance considerations associated with a TPT.
- **Stage 3a** – Initial identification of potential route corridors between Manchester and Sheffield for the new link. Sifting of these corridors using industry standard tools in order to short-list corridors worth looking at in more detail.
- **Stage 3b** – Potential options developed within short-listed corridors, and more detailed sifting of options in order to identify short-listed options.
- **Stage 3c** – Further appraisal of the short-listed route options.

2.4 Purpose of Report

2.4.1 This report summarises the findings of the initial investigation into the feasibility of a strategic road link between Manchester and Sheffield, with a significant length of tunnel under the Pennines, confirming that the construction and operation of such a link would be viable. The report also provides indicative estimates of the costs associated with building such a scheme, as well as the potential magnitude of benefits, based on 5 potential route options which have been generated.

3. The Case for the New Strategic Link

3.1 Introduction

3.1.1 The north of England is a major contributor to the UK economy – home to over 15 million people, 6.4 million jobs and has an economic output of around £304 billion GVA[16].

3.1.2 The region's economic potential is however constrained by relatively poor transport connectivity within and between major conurbations creating barriers to trade and inefficiencies in the working of markets.

3.1.3 A legacy of relatively poor transport connectivity and underinvestment in transport infrastructure in the north of England has arguably contributed to a persistent and entrenched performance gap between the north and the rest of England. The consequence of this long term imbalance is that London and the south east have become a magnet for investment, business and skilled workers, whilst much of the rest of the country lags behind, with the former industrial powerhouses of the north being among the worst performers.

3.1.4 The Government and TfN[17] have indicated that an improved transport corridor between Manchester and Sheffield has the potential to improve the economic prosperity of both cities and the wider northern region, and that a step-change in transport investment is required to reduce these barriers to growth.

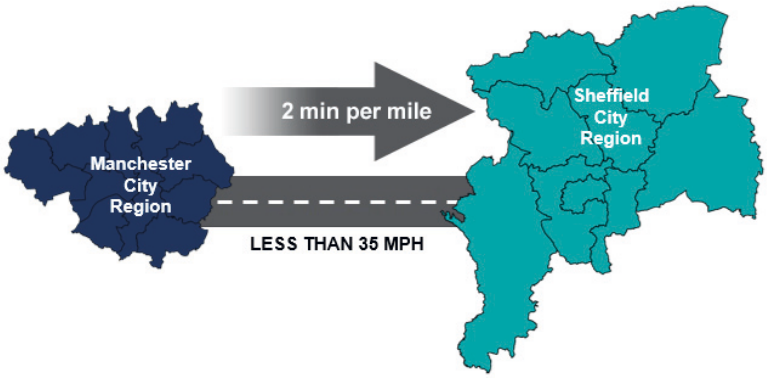
3.1.5 In order to clearly articulate the strategic narrative for investment, there is a need to understand the current constraints and opportunities faced by the north, and to understand how this improvement would impact on economic performance at a local, regional and national level. The following sections present the transport and economic challenges and opportunities relevant to investment in a trans-Pennine strategic link between Manchester and Sheffield. The two sets of challenges and opportunities are clearly linked with improved transport connectivity, enabling households and businesses to participate in a wider range of economic activities which in turn generate market efficiencies and economic growth.

16 The North is defined as North East, North West and Yorkshire and the Humber regions – HM Treasury
17 TfN, The Northern Powerhouse: One agenda, One economy, One North – A report on the Northern Transport Strategy (2015)

3.2 Transport Challenges and Opportunities

3.2.1 Unlike the rest of the UK, economic activity in the north of England is dispersed across a wide geography but is also concentrated within five dominant conurbations including: Greater Manchester, West Yorkshire, South Yorkshire, Merseyside and the north East. These conurbations are located in relatively close proximity, however poor connectivity across cities and modes acts as a constraint to growth. This means economic interactions are costly and there is less potential for gains from economic scale and agglomeration benefits that could boost productivity.

3.2.2 Poor connectivity and relative underinvestment in the north has contributed to the region's economic underperformance. Previous studies have shown connectivity between Sheffield and Manchester to be limited and worse than comparators across the North. The distance between Manchester and Sheffield is around 40 miles, but despite this, the journey between the two cities takes 75 minutes in uncongested conditions, with an average journey speed below 35 mph.



3.2.3 This makes it one of the poorest connected, city region pairs in the UK, resulting in a low number of existing movements (See Figure 3 1). Furthermore, the majority of the better connected local authorities in England and Wales are found in the south east, with only 4 (out of 50 nationally) in the North West, and none east of the Pennines[18].

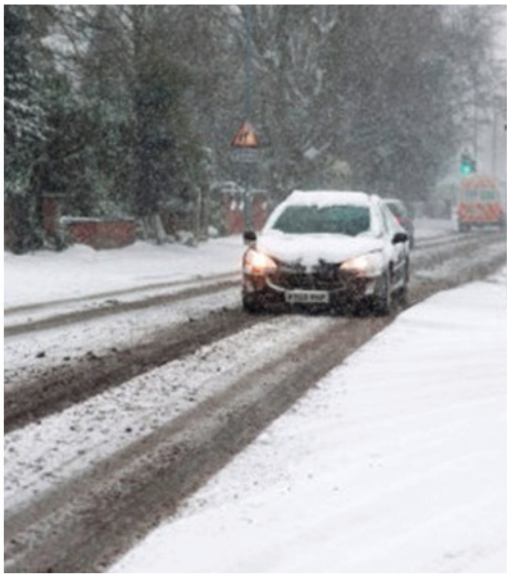
3.2.4 A similar trend of poor connectivity is seen across the rail network, whereby journeys by rail between the northern city regions are also relatively slow and less frequent[19]. These challenges have contributed to a legacy of poor connectivity in the north which continues to limit economic linkages across the region and restricts its combined potential for growth[20].

3.2.5 In 2015, the DfT published its Trans-Pennine Routes Feasibility Study[21] which identified a range of challenges and priorities for transport connections between the Sheffield and Manchester City Regions including:

- delays and network stress on existing key routes
- road traffic collisions and safety, which have been identified for decades as a significant challenge for trans-Pennine routes, leading to problems of journey-time reliability and maintenance

18 ATOC. Accessibility Statistics, 2010
19 Rail connectivity is being investigated as part of the DfT Trans-Pennine Rail Study
20 Strategic Economic Plans for Manchester and Sheffield outline ambitious plans for growth in the number of jobs and businesses
21 Highways England, Trans-Pennine Routes – Feasibility Study (2015)

- frequency of road closures due to severe weather and the topography of the Pennines (The trans-Pennine strategic routes experience a road closure every 11 days on average, with two-thirds of these being longer than 2 hours. 77% of these closures are the result of either road traffic collisions or bad weather)
- operational challenges such as the poor asset condition, lack of technology, lack of information provided to travellers and those operational issues specific to a single carriageway road
- limited road connectivity between South Yorkshire and Greater Manchester, restricting business interactions and opportunities for increasing economic activity
- capacity and capability constraints of the road network, limiting the potential for road freight growth due to delays, poor reliability and network resilience



3.2.6 These challenges have contributed to a legacy of poor connectivity in the north which continues to limit economic linkages across the region and restricts its combined potential for growth. Looking at the pattern of total trips between northern city regions (as shown in Figure 3-1) the levels between Manchester and Sheffield are low.

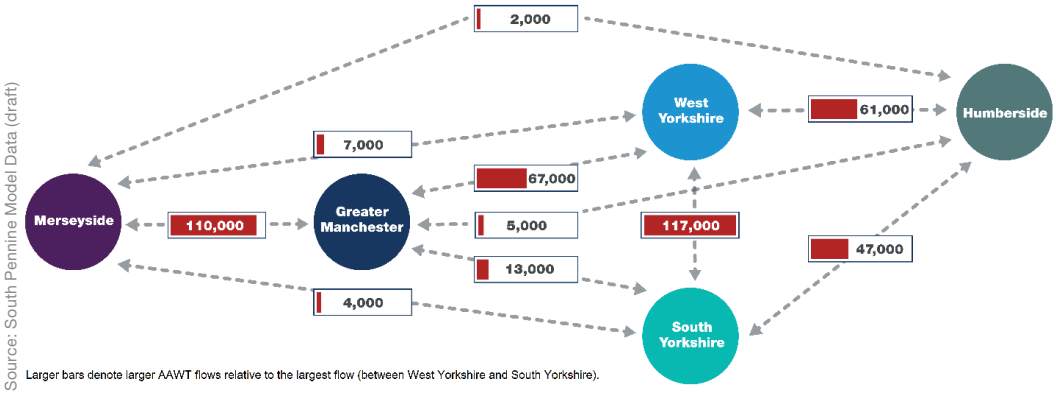


Figure 3-1 – Existing Trans-Pennine Movements (Average Annual Weekday Traffic 2015)

3.2.7 The comparatively low levels of movements between Manchester and Sheffield (of which the vast majority are commuting trips), has adversely impacted trade between these cities. A study[27] by EKOS Consulting on behalf of the Sheffield and Manchester City Councils, based on a survey of businesses, found that:

- Sheffield's suppliers are more commonly located in London and internationally, than in Manchester
- the majority of businesses in Sheffield identified local competitors within South Yorkshire rather than in Manchester
- Manchester is not a common market place for Sheffield companies, with 7 out of 10 businesses stating that no sales or income were generated in Manchester

3.2.8 Linked to the points made above, poor transport connectivity has hindered the potential benefits from greater integration of urban areas across the north, but it is not the only cause. Recent research into regional agglomeration[23] found that the extent to which cities are integrated is largely dependent not only on proximity, but also their size. Evidence from the recent publication from the Centre for Cities, 'Building the Northern Powerhouse – Lessons from the Rhine-Ruhr and Randstad', confirmed that the Rhine-Ruhr and Randstad perform better than their respective national averages not only due to the strength of their transport links but also to their strongly performing core cities driving economic performance.

3.2.9 The recently published Northern Powerhouse NPIER[24] highlights the agglomeration benefits associated with increased city size enabled by improved transport connectivity. These agglomeration effects matter not only to the magnitude of improvements in economic performance, but also to the spatial distribution of economic activity.

22 EKOS Consulting, Joint Economic Study: Manchester and Sheffield, 2008

23 The theory of agglomeration is based on the concept that individuals and firms benefit from being in closer proximity to each other, resulting in positive externalities such as in knowledge spill overs, which lead to productivity benefits. Transport investment influences the scale of agglomeration and therefore impacting productivity by reducing travel costs and affect how 'near' firms are to each other and their input and labour markets

24 Transport for the North, Northern Powerhouse Independent Economic Review (2016)

3.2.10 The NPIER report also highlights recent evidence focused on evaluating inter-city connectivity in the North, such as the Frontier Economics[25] report for the NIC which estimated a 1.1-2.6% increase in wages as a result of a 10% increase in accessibility as a result of transport investment in the north[26].

3.2.11 The research mentioned above concluded that the main drivers of agglomeration are transport connectivity and economic complementarity. The findings from this research show that mutually beneficial specialisations of cities, limits potentially wasteful competition, encouraging integration and cooperation.

3.2.12 In summary, the north is fragmented by poor transport links between key settlements and the economy as a whole is failing to gain the agglomeration benefits to improve productivity across the region. Better transport connectivity can help to promote a higher employment rate by improving access to centres of employment, and it can help to promote higher productivity by improving the attractiveness of an area for investment. This can improve access to markets, increase the pool of workers available to work in higher productivity urban locations, and increase the effective scale of cities and the associated benefits of agglomeration.

3.3 Economic Challenges and Opportunities

3.3.1 It is important to understand the economic landscape to understand whether there is capacity for improved transport connectivity to impact economic performance. Economic activity in the north of England is dispersed across a wide geography but concentrated within 5 dominant conurbations (Greater Manchester, Leeds, Sheffield, Liverpool and the north east) – characteristics attributable to that of a 'poly-centric regional economy'[27]. The five conurbations noted above provide jobs for 4.2 million workers and generate £201 billion in economic output, are home to 10.1 million people (a sixth of the total population of the UK) and accounts for 66% of the GVA[28] generated in the north[29].

3.3.2 Located within relatively close proximity, the five northern city regions combined cover an area of around 5,400 square miles which is significantly greater than that of Greater London which is around 620 square miles. Table 3-1 provides a summary of the population and employment size for each of the five dominant northern city regions, and their output measured as GVA. The table also includes Humber, recognising the importance of Hull and the Humber Ports to both the regional and national economies. Figure 3-2 provides a graphical illustration of this data.

25 Frontier Economics (2016), Assessing the productivity benefits of improving inter-city connectivity in Northern England. A report prepared for the National Infrastructure Commission

26 SERC LSE (2009) Strengthening the economic linkages between Leeds and Manchester. Report to Northern Way, report dated November 2009

27 Collections of historically distinct and both administratively and politically independent cities located in close proximity and connected through infrastructure

28 Business Survey and Register of Employment 2014 data – city regions defined as existing or potential Combined Authorities

29 Census population data (2011)

City Region	Population	Jobs	Total GVA (£bn)	GVA% of UK total
Greater Manchester	2.7m	1.2m	57	4.6
Leeds City Region	2.2m	1.0m	47	2.9
Sheffield City Region	1.8m	0.7m	33	2.0
Liverpool City Region	1.5m	0.6m	28	1.8
North East Combined Authority	1.9m	0.8m	35	2.2
Humber	0.9m	0.4m	16	0.9
6 City Regions	**11.0m**	**4.7m**	**216**	**14.4**
London	8.2m	4.7m	364	22.6

*Note: population data sourced from Census 2011 tables.
Source: Office for National Statistics GVA tables; 2011 Census

Table 3-1 – Employment and Population in Northern City Regions, 2014

Figure 3-2 – Employment and Population in Northern City Regions, 2014

3.3.3 Although the population in the northern city regions is greater than London, they have lower employment levels and contribute less than 13% output to the UK economy, with London contributing over 20%. This differential is a result of a combination of factors hindering economic performance.

3.3.4 TfN has recently published an NPIER[30] of the Northern Powerhouse which involved assessing the prosperity and productivity gaps in the North. Findings show the north's 'performance gap' (measured by GVA per capita)' is persistent and entrenched, averaging about 25% against the rest of England, and having been on a downward trend since the early 2000s. Furthermore, the gap has widened since the 2008-09 economic recession.

30 Transport for the North, Northern Powerhouse Independent Economic Review: Workstream 1 – Productivity, 2016

3.3.5 In addition to the transport challenges discussed earlier, it is important to understand the combination of interrelated factors restricting growth across the region in order to identify the opportunities for growth. These include the post-industrial recovery, migration and skills retention, investment in the north, transport connectivity and agglomeration. A brief summary of the factors is set out as follows:

- ***Post-Industrial Recovery:*** The economic landscape of the north has changed significantly throughout history and coming through a period of industrial decline, the cities of the North have experienced significant industrial shifts from manufacturing to business and professional services. Currently across the north there is a concentration of less productive sectors, which to some extent shows the lower levels of productivity across the region.
- ***Investment in the North:*** Investment in those areas which boost the economy, such as science, technology and infrastructure, is considerably lower in the north than in other regions of the UK. In the case of transport infrastructure, in projects that involve public sector spending (solely or in partnership with the private sector), spend per head of population is £2,596 in London but just £5.01 per head in the North East, £99.19 in the North West and £160.26 in Yorkshire and Humber[31]. The overall pattern of planned capital investment in transport infrastructure is largely unchanged, with more than 89% allocated to projects in London and the south east.
- ***Migration and Skills Retention:*** The north has a higher share of people with lower skills, and a lower share of people with higher skills which has worsened in the post-recession period. This means that the economies of the North are left with spare productive capacity, resulting in higher levels of unemployment (7.3% in Greater Manchester and 7.7% in Sheffield, compared to the national average of 6%) and higher levels of outward migration. The north's skills gap is an important factor driving the gap in economic performance, as it influences both productivity and the employment rate. This is not aided by enhanced economic opportunities which draws skilled labour and investment to the more prosperous south. Migration patterns are depriving the north of much needed skilled labour. This is despite the fact that much of the highly skilled workforce in the UK is educated in the universities of the north.

3.3.6 Figure 3-3 shows relatively high levels of net migration to the London and the south east, particularly among younger demographics.

31 Figures quoted from IPPR North (2013). Still on the wrong track: An updated analysis of transport infrastructure spending (http://www.ippr.org/publications/still-on-the-wrong-track-an-updated-analysis-of-transport-infrastructure-spending)

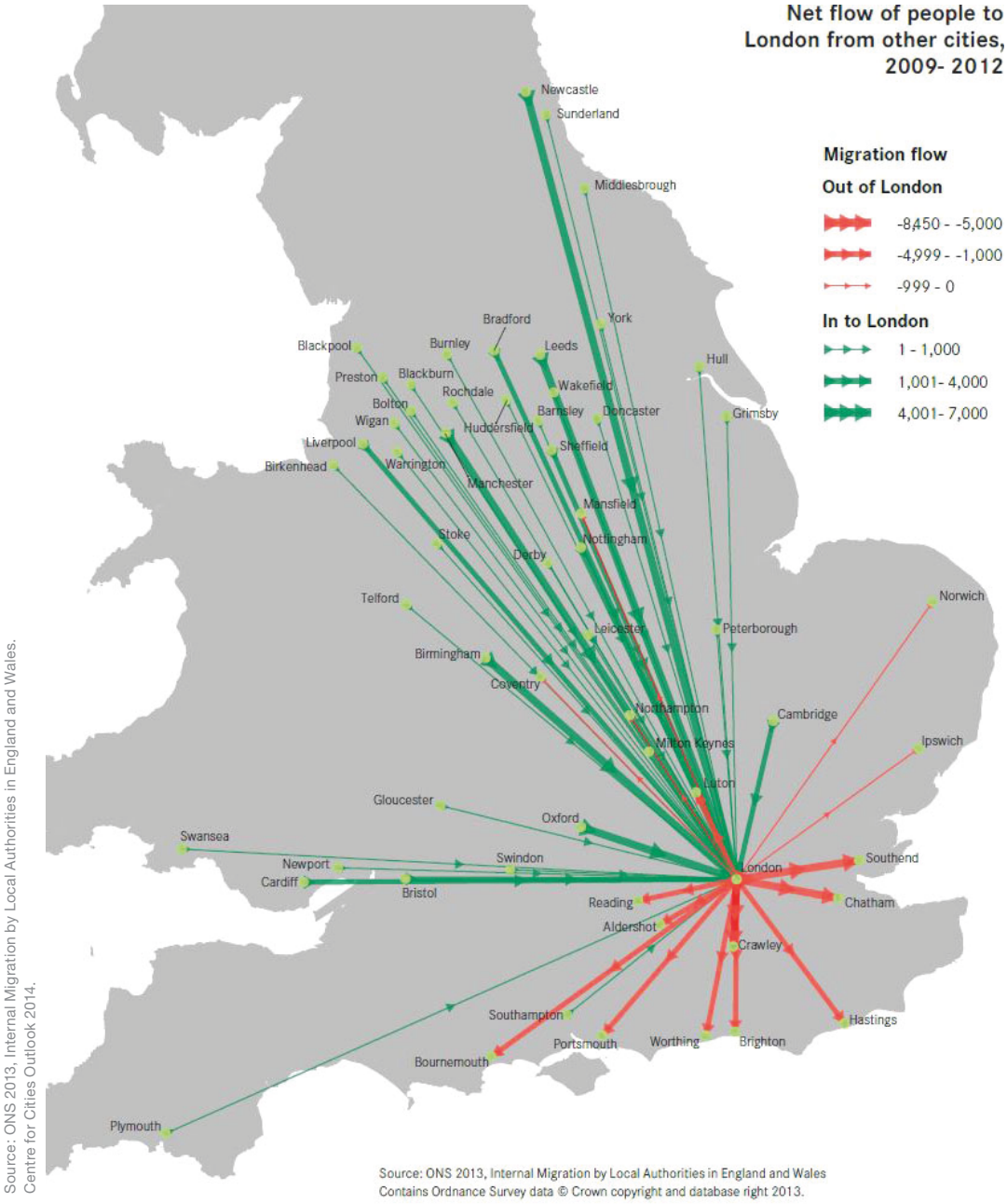


Figure 3-3 – Net Migration Flows in the UK, 2009 to 2012

3.3.7 There is a unique opportunity for the UK to address the economic challenges and issues through a combined strategy of investments to reduce the gap in performance and rebalance the economy. This is core to the Government's economic strategy and an agreed priority with civic leaders across the north. A summary of the potential economic opportunities are as follows:

- The **northern cities** have experienced significant industrial shifts from manufacturing to business and professional services. As these jobs tend to locate in city centres, the main five urban centres of the north have become the growing centres of economic activity, providing jobs for residents in the wider city region and beyond.
- **Existing industrial strengths** within the manufacturing sector is still key to the economies of the north maintaining its rank as the largest exporting sector for the UK.

- Growth of **high growth sectors** such as Knowledge Intensive Business Services (KIBS) sectors have seen the fastest growth in employment in northern cities, while the other parts of the city regions have seen decline. This is a particularly prevalent trend for Sheffield and Manchester, which are concentrating on growing existing assets and capabilities within the financial and professional services, advanced manufacturing, life sciences and healthcare and materials sectors; all of which are expected to drive employment growth over the coming years.
- The north has **underutilised resources** (in labour, land and capital) manifested through a number of channels, including pressures on housing affordability and congestion in London. At a time when London and the south east are experiencing housing shortages and cost rises, the north has available land supply and potential to relieve pressure on other parts of the UK. Accordingly, there is also spare physical capacity as the north has ample land supply, but population and employment centres are scattered and poorly connected. The primary reason for the underutilisation of land supply in the north is that investment and development is less attractive in these regions.
- The **skills gap** between London and the rest of England that currently prevails across the main five city regions of the north creates a significant opportunity for increased productivity through graduate retention. As well as this, greater connectivity means a higher chance to find the right skills and to generate knowledge spill-overs that enable businesses to become increasingly more innovative and productive.

3.3.8 There is a clear role for transport infrastructure to transform connectivity in the north reversing trends of underinvestment, increasing attractiveness and unlocking the economic potential of the northern city regions. However, we recognise that in supporting the north's ambition to become the Northern Powerhouse there is a need for transport investment as well as other policy interventions to help boost the economies of these regions.

3.4 Impact of Doing Nothing

3.4.1 As outlined in the previous sections, the north is fragmented by poor transport links between key urban centres, with the link between Manchester and Sheffield being a significant limitation on east-west connectivity across the north. This impacts the economy as a whole by limiting the regions ability to benefit from agglomeration and stronger economic linkages, which has the potential to improve productivity across the region.

3.4.2 In the absence of large transport infrastructure investments, transport connectivity will get worse as demand for road travel continues to grow. Large scale growth is planned in the urban areas on either side of the South Pennines area. Traffic forecasts, set out in the Trans-Pennine Routes Feasibility Study – Stage 1 report indicate that for existing routes across the Pennines, traffic is set to grow by 8-11% from 2015 to 2019 and 28-37% up to 2034, depending on the individual route. It is anticipated that this will result in longer journey times and further capacity constraints, increasing pressures on other areas of the SRN, not only impacting labour market and business-to-business interactions, but also severely impacting freight connectivity to major international gateways.

3.4.3 In this context, doing nothing is likely to involve increasing constraints and challenges to business productivity as a result of worsening transport connectivity. This will negatively affect the attractiveness of the north as a place to invest and as a place for graduates and skilled workers to start and progress their careers. Overall, this would have a negative impact on economic performance, causing ongoing imbalances in the UK economy.

3.4.4 The consequence of not addressing the transport and economic challenges faced in the North will put rising pressures on the rest of the country – especially London and the south east – with the potential to constrain overall national growth.

Strategic Benefits

3.4.5 Travelling by road between Sheffield and Manchester currently involves driving on single carriageway roads across the Pennines, which in some sections, are severely congested, resulting in long and unreliable journeys. In addition, reliability and resilience of the existing routes are poor. A tunnelled solution would offer increased reliability and resilience for road users travelling between the two cities. The tunnel would overcome challenges of adverse weather and other operational resilience issues, such as the availability of alternative routes. A new strategic link would dramatically change connectivity between two of the most important cities in the north, with the potential to generate large economic benefits.

3.4.6 A new road link across the Pennines is expected to lead to approximately a 30 minute time savings for all road trips travelling between Manchester and Sheffield. Time savings of this magnitude are likely to induce changes to patterns of economic activity and bring significant benefits to both cities as well as the wider region.

3.4.7 Figure 3-4 illustrates the ways in which transport investment, such as the TPT strategic link, could impact the economy and drive economic performance. The flow highlights how direct impacts from a new strategic link could create market efficiencies leading to investment and relocation decisions which in-turn can lead to changes in productivity and economic growth.

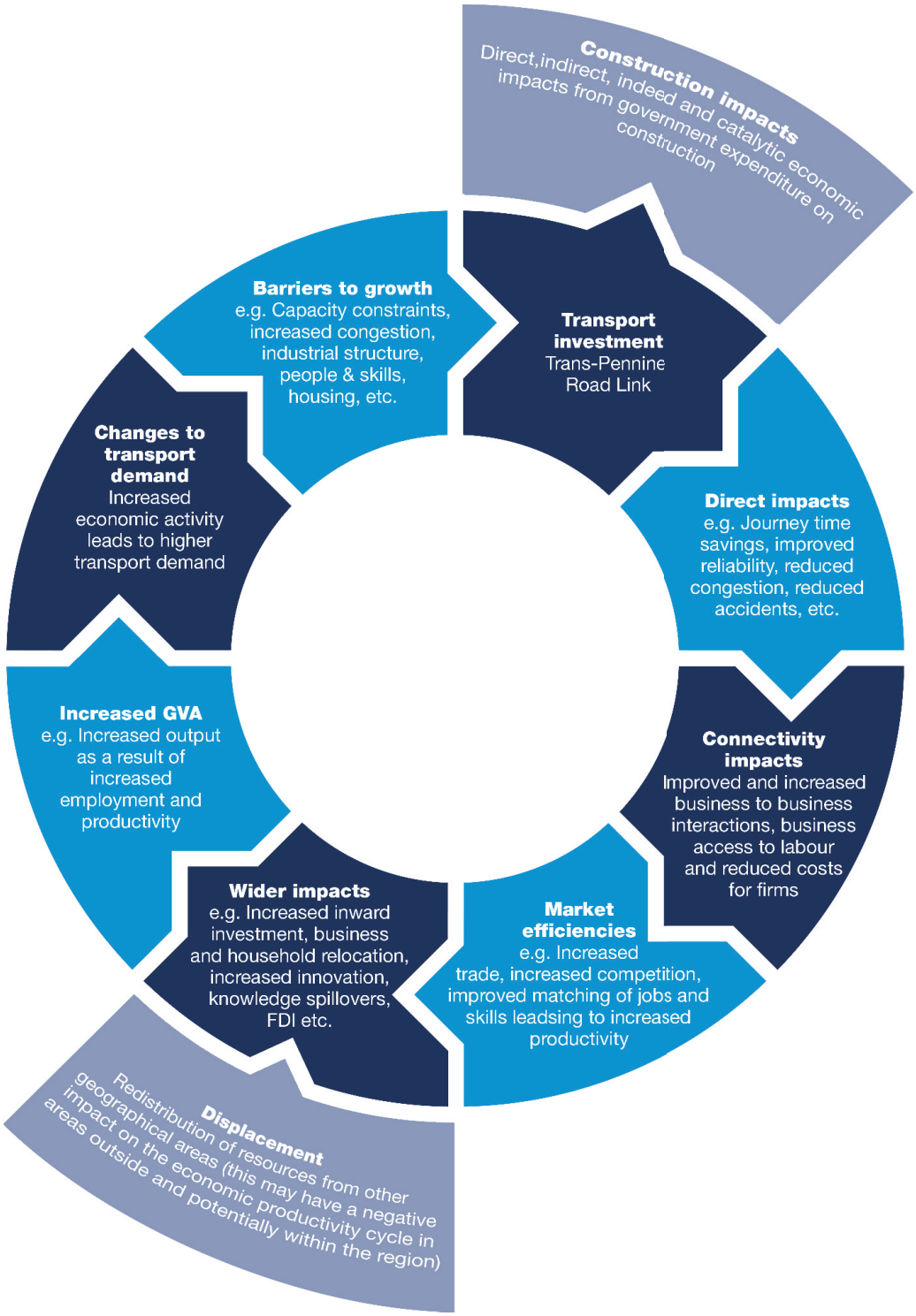


Figure 3-4 – Transport Connectivity and Economic Performance

3.4.8 A transformational scheme, such as the TPT strategic link would result in relatively large changes in travel times and costs, which may induce households and businesses, including logistics companies, to change their behaviour as they look to exploit the new and enhanced opportunities. These changes would provide direct benefits to users as well as having the potential to correct existing market failures or inefficiencies arising from barriers to movement.

3.5 Strategic Fit of TPT with Policy Objectives

3.5.1 A new road link between Manchester and Sheffield via a tunnel under the Pennines fits with overall national policy, as it would:

- Bring two of the major urban centres in the North (Sheffield and Manchester) effectively closer through significantly reducing journey times, as well as relieving congestion on other routes, impacting positively on productivity in the north through agglomeration benefits – as per Her Majesty's Treasury (HMT's) 'Fixing the Nation' and the governments emerging Industrial Strategy.
- Impact on the spatial patterns of investment and employment in the north through closing one of the most challenging gaps in connectivity in the region – as per HMT's *Reducing the Deficit and Rebalancing the Economy*.
- Contribute to a single economic area in the North through enabling more commuting and trade between Sheffield and Manchester – as per the vision for a Northern Powerhouse and DfT's *Northern Transport Strategy*.
- Provide capacity and much needed connectivity between two major cities, as well as improve east-west connectivity – as per the DfT's *Strategic Objectives*.
- Contribute to the aspirations of the northern regions to transform connectivity in the North and maximise economic benefits – as per the *Northern Way* and the *One North* vision.

4. Building and Operating a Tunnelled Solution

4.1 Introduction

4.1.1 The design, construction and operational factors associated with providing a strategic link between Manchester and Sheffield, including a significant length of road tunnel under the Pennines, have been investigated as part of this study. A range of technical specialists from both the UK and other countries have developed a set of key considerations, drawing on best practice examples from across the world.

4.1.2 A number of assumptions relating to the technical considerations of the proposal include the following:

- The strategic link would be designed to dual, two-lane motorway standards (including variable message signs, above ground incident detection system and CCTV).
- The assumed operating speed for the strategic link is at least 60 mph (based on the Government's 'mile a minute' objective).
- The new strategic link would need to connect with the motorways at the edges of the study area (M60 and M1).
- Local communities would need to be able to connect to the surface sections of the strategic link to allow them to realise benefits of the project.
- The new strategic link would open approximately 20-25 years from now and the tunnel would be designed for an operational life of 120 years.

4.2 Design Considerations

4.2.1 The new strategic link, connecting the SRN in the vicinity of Sheffield and Manchester, could be between 24 and 26 miles in length (depending on the final route option selected). This link could comprise of a tunnel section of between 12 and 20 miles, a number of above-ground structures including bridges, retaining walls and earthworks, as well as the need to improve the existing highway infrastructure.

4.2.2 The relatively long length of tunnel and the presence of the PDNP, present a number of design considerations, including:

- Environmental impact
- The driver/customer experience
- Safety
- Fire and incidents
- Emergency access
- Maintainability and tunnel operation
- Ventilation
- Vehicle recovery
- Network resilience

4.2.3 The design of the strategic link needs to consider the expected traffic flow when the scheme would become operational. Initial forecasting estimates have indicated an average weekday traffic flow of up to 35,000 vehicles on the proposed link, based on its assumed opening date. The number of lanes provided on the link would need to cater for this level of use as well as future-proofing for additional capacity requirements as well as operational and safety aspects.

4.2.4 It is anticipated that the proposed route would be to motorway standard and would need to have a minimum of two lanes and a hard shoulder in each direction. Other features of the proposal would include incident detection, CCTV and provision for variable speed limits.

4.2.5 The proposed design of the tunnel would be twin-bore, providing a separate tunnel for traffic travelling in either direction, with service access below the carriageways.

4.2.6 In terms of tunnel safety, specific systems and considerations include:

- Communications and monitoring systems operated via a dedicated control room, including variable message signs, signal control, public address systems and incident detection systems.
- Provision for broken down vehicles.
- Lighting to aid the driver experience and ensure visibility in the tunnel during normal operation and emergencies.
- Ventilation systems, to deal with vehicle emissions and, in the case of fire, to direct hot smoke away from tunnel users.
- Firefighting capability, particularly with regard to response times.
- Provision of cross passages (for pedestrians to escape incidents and get to safe areas) and cross overs (for vehicles) to allow passage between the tunnel bores (required in cases of emergency and maintenance of the tunnel bores).

4.2.7 Design of the strategic link would also need to consider the synergies with rail. Construction and operational advantages could be achieved by delivering a tunnel for use by both rail and road based traffic meaning a much larger tunnel diameter than is currently feasible. However, there are also risks that delays in delivering the different aspects could impact delivery timings. Additionally, the different operational requirements of the two modes would likely require different construction alignments and possible different entry/exit portals, meaning the benefits of a parallel tunnel alignment are not fully realised.

4.2.8 Light rail systems are well developed in both Manchester and Sheffield, so the theoretical possibility of connecting the two is a consideration. However, light rail generally only offers significant benefits for short journeys with closely spaced stops, and a journey between the two cities is substantial which we consider would not make it attractive to passengers travelling directly between the two cities. Furthermore, light rail may share road space with road traffic and, if provided, may adversely impact on the safe operation of the road network.

4.2.9 Ultimately, any design must adhere to the relevant legal and regulatory requirements of road and tunnel design standards. Discussions and approvals will continue to be required with the relevant highway authorities.

4.3 Construction Considerations

4.3.1 The construction would be constrained by working in, around and under the PDNP as well as interfacing with the existing road network, difficult terrain and climatic conditions.

4.3.2 The construction of the surface sections would need careful consideration, as they would tie in with the large conurbations at both ends of the route. The impacts on these communities, such as severance and local access, will be considered as the scheme design progresses, as will the impacts on the environment, including drainage and water courses. Consideration would need to be given to issues such as soft ground conditions, contamination, historical mine workings and the interface with existing infrastructure. The impacts on the local road network and implications of new junctions will continue to be explored in determining a preferred route option.

4.3.3 For the construction of the tunnel section, a mechanised method using Tunnel Boring Machines (TBMs) is widely accepted as the preferred option for constructing long tunnels due to the speed of advancement, whereby up to 100 metres per week can be progressed in good ground conditions.

4.3.4 In terms of geology, the bedrock of the Pennines largely comprises of millstone grit which is generally suitable for constructing large-diameter tunnels, and there have been previous tunnels constructed through the Pennines in this area (for example, the Woodhead railway tunnel). The high level of consistency in ground conditions across the study area will make it easier to choose appropriate tunnelling methods.

4.3.5 In addition to geology, the other main issues considered are historical mining works and ground gases. However, initial investigations anticipate that these can be mitigated during the planning, design and construction phases of the project as a tunnel route can be selected whereby this risk is low or negligible.

4.3.6 A significant volume of excavated material would be generated by all potential route options, with current estimates range from 10 to 15 million cubic metres (the equivalent of 4,000 to 6,000 Olympic-sized swimming pools).

4.3.7 There are opportunities to reuse some of the material within the scheme, however, given that much of the scheme would be a tunnel, there is limited above ground construction where reuse of material would be possible. Designers will consider how the reuse, recycling and recovery of materials can be incorporated into the design and ultimately reduce waste to landfill. Further work will determine if off-site reuse can be complemented by generating or contributing to existing local reclamation projects, quarry restoration, ecological sites, etc., as well as other major projects such as HS2. A further potential option would be to work with existing aggregate companies located within the Peak District to sell excavated/tunnelled material from the scheme.

4.3.8 Transportation of excavated material could be undertaken by lorry, however, a number of the route options also provide the possibility of removing excavated material by rail, which would help to alleviate the impact of increased lorry traffic at portal areas and on the wider road network.

4.4 Operations and Maintenance Considerations

4.4.1 A review of best practice for the operation and maintenance of a strategic link, particularly the tunnel section, has been undertaken. This review involved looking at comparable schemes across the world (including schemes in China, Norway and Switzerland) to better understand the requirements for safe and efficient operation of a tunnel, similar to that being proposed for the TPT (see Table 4-1).

	Zhongnanshan Tunnel (China)	Lærdal Tunnel (Norway)	Gotthard Tunnel (Switzerland	Yamate Tunnel (Japan)	Rogfast Tunnel (Norway)
Length	11 miles	15 miles	10 miles	11 miles	17 miles
Operating speed for traffic	Not known	50 mph	50 mph	37 mph	Not known
Number of lanes	2 tubes (2 lanes in each tube)	1 tube (1 lane in each direction)	1 tube (1 lane in each direction)	2 tubes (2 lanes in each tube)	2 tubes (2 lanes in each tube)
Hard shoulder	Yes	No, but includes 3 caverns and emergency niches every 500 metres	No	No	Yes

Table 4-1 – Comparable Schemes Review

4.4.2 Based on this initial examination it was concluded that it would be feasible to operate a tunnel of this size.

4.4.3 As part of the review of best practice, the following priorities have been identified:

- Promoting safe tunnel operation at all times in order to reduce the likelihood of incidents occurring.
- Training of control room staff to ensure positive control of evacuation routes.
- Ensuring that efficient co-ordination and communication with the emergency services and local highway authorities would be in place at all times.
- Minimising damage to the tunnel structure.
- Mitigating potential traffic congestion and limiting delays to the travelling public by controlling speed and headway between vehicles.
- Establishing operational procedures to deal with incidents and evacuation and educating users of the procedures.
- Identification of hazardous loads - this would follow a similar practice used in other tunnels - eg. Dartford.

4.4.4 Safety and security is a key issue of the proposed link and restriction or prohibition of vehicles and/or hazardous loads will be given early consideration in the operational requirements of the tunnel to enhance safety. It would not be desirable for all road users to be allowed to use the strategic link for safety and operational reasons. This applies particularly to a tunnel, where for instance it wouldn't be desirable to have non-motorised users. Incident management systems that facilitate early detection of issues and appropriate response levels would be included.

4.4.5 The tunnel would need to be positively managed with appropriately trained personnel. Appropriate intelligent transport systems would be required to monitor traffic conditions across the whole link (including the tunnel) to manage traffic flow, identify incidents and provide information for customers. As a minimum, these would include monitoring systems and variable message signs, but may also use floating vehicle detection (using real-time electronic fleet data to identify traffic flows) and wireless communications linked directly with the technology in motor vehicles.

4.4.6 The tunnel would have a service building at each vehicle entry/exit point. These would house the tunnel control centre and the tunnel maintenance facility, and provide an area for emergency services to assemble if responding to incidents.

4.4.7 Maintenance of the tunnel is a key consideration. Operational safety systems that reduce the need to access the tunnel for maintenance and inspections would be included in the design. For example, provision of a service tunnel could reduce the requirement to close the tunnel for maintenance, as maintenance teams would be able to access engineering systems, sign controllers, cabling etc. Maintenance plans would be developed to reduce the impact on traffic and the PDNP, which would result from a closure or reduced operations of the tunnel. The plan would set out strategies for undertaking routine maintenance, including the use of tunnel cross passages to establish short sections of contraflow and the use of automatic traffic management systems.

4.5 Planning for the Future

4.5.1 The proposed strategic link would be likely to open 20-25 years from now, and in line with current design standards on highway structures it would have an operational design life of 120 years (see Figure 4-1).

Figure 4-1 – Scheme Timeline

4.5.2 This long construction and operation timeframe is anticipated to coincide with the greatest ever period of innovation within the motor vehicle industry, as well as a change in travel patterns and travel behaviour, and other wider changes including changing social mobility, concentration of populations back into cities and changes to goods distribution models. It is important that any potential solution takes into account these changes. Technology will play a developing role, ensuring that the scheme is fit for purpose over its whole life. Emerging technologies in vehicle design, highway design, operations and network information are all important considerations.

5. Selecting Options

5.1 Stages 1 and 2

5.1.1 The*TPTS Interim Report*[32] published in November 2015, reported the findings from Stages 1 and 2 of the study, concluding the following:

- The scale of the problems are significant and that there is a clear strategic case for the scheme, which is aligned with central and sub-national Government policy.
- The economic benefits of the scheme, resulting from time savings and the improved resilience of the route, together with wider and more significant benefits in productivity, labour markets, land use and investment, could be significant.
- The construction of a new strategic route between Manchester and Sheffield would be technically viable.
- The operation and maintenance of this new road link – which includes extensive tunnel sections – would also be viable.

5.1.2 This initial work established the scale of the problems, the challenges ahead, and the need to do something.

5.1.3 In addition, the following study objectives were identified during these early stages of the study, in collaboration with stakeholders:

Objective 1	*To provide a safer, faster, and more resilient road connection between Manchester and Sheffield, creating more capacity and an additional east west connection.*
Objective 2	*To fulfil the aims of the Northern Transport Strategy to deliver a scheme that will contribute to the transformation of the economy in the North.*
Objective 3	*To protect and improve the natural environment by reducing through traffic in the PDNP and by getting the right traffic onto the right roads.*
Objective 4	*To support wider socio economic needs and leave a long term legacy of improved road connectivity, better access to labour markets, wider employment opportunities, better land use, and more effective integration between transport modes.*

5.1.4 These objectives have been used to guide the work in the subsequent stages of the study.

32 Highways England, Interim Report, November 2015

5.2 Stage 3

5.2.1 Based on the positive findings from the first two stages, the study team developed potential indicative options for a strategic link, aiming to identify a short list of better performing options to address and solve the problems and challenges identified in the earlier stages of the study[33].

Corridor Assessment

5.2.2 In collaboration with stakeholders, an initial five corridors were identified as shown in Figure 5-1. A set of viability assumptions were developed in order to guide the development of corridors, and to act as a high-level check to ensure that any proposed corridors met key study criteria. The viability assumptions were:

- It fits the project scope; that is, a strategic link connecting Manchester and Sheffield under the Pennines.
- It is largely within the study area boundary.
- It does not involve construction of a surface route within the PDNP and its wider setting.

5.2.3 These viability assumptions were debated and challenged by both the study team and stakeholders in order to ensure that they were appropriate, and that they did not prematurely rule out any corridors that were worthy of assessment.

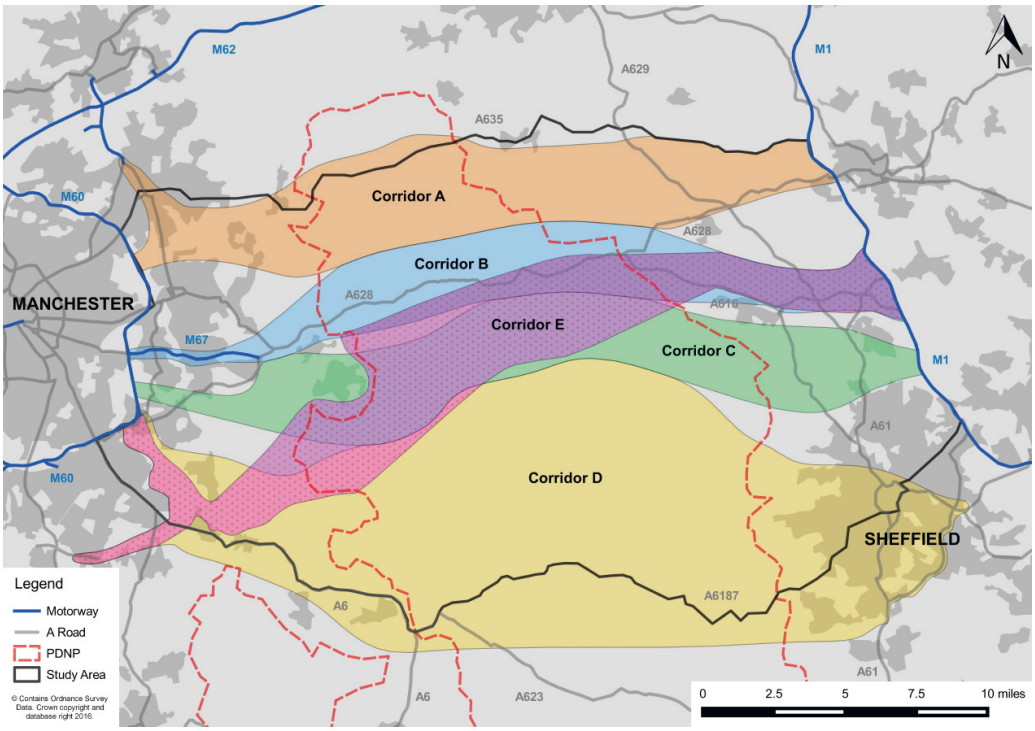


Figure 5-1 – Trans-Pennine Corridor Options

33 Please note, these options have been developed solely for the purposes of this initial study into the feasibility of delivering a TPT solution. These are not actual preferred routes that will be taken forward to construction. Subsequent stages of the study will investigate potential options in further depth

5.2.4 An initial sifting exercise was undertaken in order to identify whether any corridors were more suitable as a route for the new strategic link than others. The outcome of the initial sift demonstrated that Corridor B, along the existing route of the A628/A616, and to a lesser extent Corridors A and C, had greater advantages over the other corridors, including that construction may be easier and take less time. The initial sift also concluded that Corridors D and E scored less well in terms of meeting the objectives of the study, and should not be prioritised for further assessment, within this particular study, for the following reasons:

- Corridor D fails the viability test that the route "does not involve construction of a surface route within the PDNP and its wider setting".
- Corridor D has additional environmental challenges, for example heritage features, ecological designations and noise issues that would make delivery more difficult.
- Corridor E is estimated to deliver materially less economic benefits and less additional output to the UK than the other corridors.
- Time savings within Corridor E would be lower than for the other corridors.
- Corridors D and E could have longer tunnel lengths than Corridors B and A, whilst offering no discernible benefits in terms of connectivity, wider journey times or economics.
- A longer tunnel would cost substantially more, and be proportionately less likely to provide a business case for investment. This would also mean more embedded carbon, greater maintenance costs per annum, more excavated material to dispose of and more ventilation shafts to be constructed within the PDNP.

Route Option Assessment

5.2.5 As Corridors A, B and C were identified as the better performing corridors, route options within these three corridors were identified, including ideas suggested by stakeholders. 36 route options were identified, and following a consolidation process that involved identifying routes with similar characteristics (for example, same start and end points, similar lengths and alignments) these were refined down to 12 distinct route options.

5.2.6 The 12 route options were then subject to a more detailed sifting exercise, in order to develop a shortlist of route options which could be assessed during Stage 3c of the study. Based on the analysis, it was considered that, whilst in some areas the differentiation was marginal in places, there were sufficient strengths and weaknesses between the 12 route options to refine down to five short-listed route options. The analysis concluded that Route Options 7, 8, 9 and 10 were the better performing options in terms of the following:

- These 4 routes present the best fit in terms of providing a greater degree of beneficial impacts, particularly in terms of the strategic case and the impacts on the economy.
- The 4 routes have the fewest adverse impacts environmentally and have some positive impacts within the PDNP.
- These 4 routes are seen to be more deliverable and acceptable to the public.

5.2.7 The analysis also concluded that one option was worthy of further consideration on the basis of its anticipated relative cost. In this case, Route Option 4 had some merit because of its cost relative to options with the same or higher score.

5.2.8 Therefore Route Options 4, 7, 8, 9 and 10 are those which were taken forward for further analysis in the final stage of the study. These are shown in Figure 5-2.

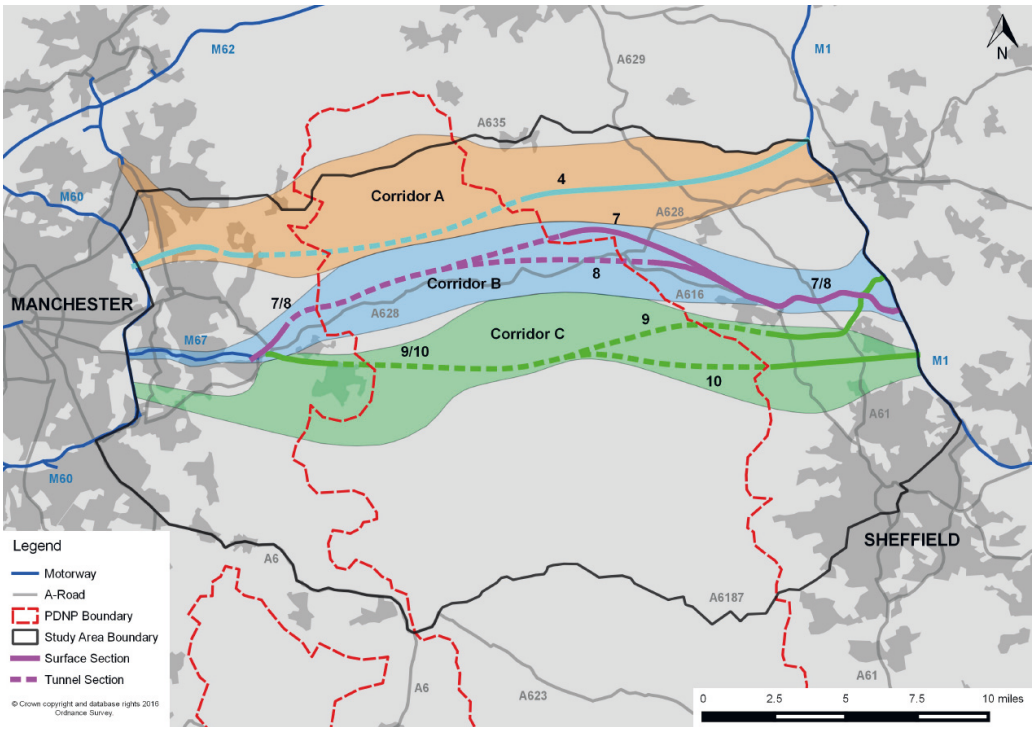


Figure 5-2 – Better Performing Route Options

5.2.9 Further detail on the work and analysis undertaken as part of these stages of the study can be found in the *Updated Interim Report*[34] published on the 18 August 2016.

34 Highways England, TPTS Updated Interim Report, August 2016

6. Further Analysis and Appraisal

6.1 Approach

Refinement of Options

6.1.1 The initial alignments for the surface and tunnel sections of the five short-listed route options were reviewed to ensure that any option put forward was buildable. The geotechnical, environmental and topographical elements were assessed and the alignments for each option refined.

Traffic Forecasting

6.1.2 In the absence of a suitable strategic highway traffic model to appraise the route options (the Highways England Trans-Pennine South Regional Traffic Model would be an appropriate tool, but this is currently under development), a high level spreadsheet based approach was adopted, using a set of key drivers for traffic growth to determine a high level strategic traffic forecast for each route option. Using this approach, high-level forecasts were provided that enable the strategic and economic case and the design considerations to be assessed. This is a standard industry approach undertaken whenever a suitable traffic assignment model is not available.

6.1.3 The spreadsheet approach, however, did not capture the impacts on the wider network. As it is important to understand the traffic relief to the local network (and associated local benefits), two existing models, one for Manchester and one for Sheffield were used to test the impacts on the existing network.

Economic Appraisal

6.1.4 The standard approach to transport appraisal is based on welfare economics[35] and looks to capture the social value of economic performance impacts, whereby the starting point is the estimation of direct benefits to users of the transport network. These benefits look to capture the impact (costs and benefits) to the individuals and firms affected by changes in the generalised travel costs as a result of the intervention, plus or minus externalities such as accidents, noise, carbon emissions, option values and other effects.

6.1.5 Whilst major transport schemes can generate large savings in transport costs, they can also make new trips patterns possible and change activities and perceptions within a local area. This can lead to behavioural change both in the labour and land markets in particular, which can then have exponential rather than incremental effects on the local economy by improving existing market failures and generating positive economic spill overs. This means that in practice the total economic benefit of a transport investment can be significantly greater, or indeed less.

35 Welfare economics is a branch of economics that uses microeconomic techniques to evaluate well-being (welfare) at the aggregate (economy-wide) level.

Environmental Appraisal

6.1.6 An initial qualitative assessment of the potential environmental impacts has been undertaken for:

- Noise
- Air Quality
- Landscape
- Townscape
- Historic Environment
- Biodiversity
- Water Environment

6.2 Emerging Results

Potential Impacts

6.2.1 The analysis of the five route options undertaken during Stage 3c of the study has demonstrated that there would be significant benefits associated with their implementation. All of the route options would align strongly with Objective 1, offering 'mile a minute' journeys between Manchester and Sheffield, and time savings of up to 30 minutes, a vast improvement over existing routes.

6.2.2 Early analysis has demonstrated that there would be large economic impacts associated with the implementation of any of the five route options. Benefits of this magnitude would go some way to meeting both Objectives 2 and 4. However, the current appraisal approach is limited by the absence of a suitable traffic model and further limitations associated with the emerging nature of the approach to valuing wider economic impacts. It is the view of the study team that this early analysis has potentially, significantly underestimated the value of implementing such a scheme and that further analysis and modelling work needs to be undertaken to fully understand and define the wider economic benefits.

6.2.3 The environmental analysis has demonstrated that the traffic relief across existing trans-Pennine routes, could offer improvements to the PDNP, particularly in terms of the impact on the landscape, air quality and biodiversity – in line with Objective 3.

Cost Estimates

6.2.4 Order of magnitude construction cost estimates have been produced for each route option[36]. The estimated base cost[37] for each of the route options is broken down as shown in Table 6-1.

36 Cost estimates are at a 2014 Quarter 1 price base

37 Includes: project risk, unscheduled items and uncertainty allowance. Excludes: portfolio risk and inflation over the construction spend profile

Cost element	Route option costs (£bn)				
	4	7	8	9	10
Estimated Cost	6.5	7.0	7.4	8.1	10.1
Project Risk, Uncertainty and Unscheduled Items	1.3	1.3	1.3	1.4	1.5
Total	**7.8**	**8.3**	**8.7**	**9.5**	**11.6**

Table 6-1 – Breakdown of scheme cost estimates (2014 Q1 prices excluding inflation)

6.2.5 Table 6 1 demonstrates that Route Option 4 is anticipated to be the lowest cost option, with a base cost estimate of £6.5 billion. This rises to £7.8 billion with the addition of project risk, uncertainty and unscheduled items. The total cost estimates for Route Options 7, 8, 9 and 10 are 6%, 12%, 22% and 49% higher than that of Route Option 4 respectively.

6.2.6 Estimates of portfolio risk and inflation over the construction spend profile are not included in the breakdown within Table 6-1. These will need to be included as the scheme progresses. It is anticipated that, given the infancy of the project and uncertainty surrounding the accuracy of the design at this stage, the proportion of additional risk could be high. Similarly, there could be a large proportion attributable to inflation to reflect the significant timescales anticipated with the development and construction of any potential new link.

6.3 Limitations of Adopted Approach

6.3.1 The analysis uses a spreadsheet based model to forecast traffic levels, not a full transport model. The nature of the spreadsheet based approach means that not all responses are considered. Of particular note is the fact that the likely increase in the proportion of commuter trips and the impact on employment and housing as commuter's access to Manchester and Sheffield centres improves, cannot be captured. This is anticipated to be a significant impact. Use of Highways England's Trans Pennine South Regional Transport Traffic Model will enable much fuller analysis to be carried out.

6.3.2 Furthermore, the appraisal considers the impact of the TPT in isolation from the other schemes being considered as part of a wider Northern Transport Strategy. The tunnel is just one component of a set of multi-modal solutions and policy interventions, and failure to understand the cumulative impact of all interventions may mean that a significant proportion of benefits are not being accounted for.

7. Conclusions

7.1 Next steps

7.1.1 The budget announcement on 16 March 2016 announced that £75 million of the £300 million identified in the Transport Development Fund will go toward accelerating three strategic studies focused on improvements in Northern England, including the TPT strategic link.

7.1.2 Whilst the adopted appraisal approach at this stage of the study is proportionate and provides the correct level of assurance, as the study progresses it will be necessary to increase the depth of the appraisal. Key areas for development include:

- **Making Use of a Trans-Pennine South Regional Traffic Model** – As previously outlined, the programme timescales combined with the lack of availability of a suitable modelling tool meant that the study team had to develop a bespoke modelling framework by combining multiple model and data sources. This approach has been successfully used to demonstrate that the scheme would deliver substantial benefits and warrants further analysis. The emerging Trans-Pennine South Regional Traffic Model will be available in early 2017 and it is proposed that undertaking further analysis with this suitable model would be beneficial, allowing an increased level of assurance and more accurate consideration of the level of benefits. The model will bring together separate geographies (coast to coast) and combine highway and rail models under one framework.
- **Economics** – The current appraisal approach includes impacts associated with changing land use scenarios, linked to the outputs from the spreadsheet model. When the Trans-Pennine South Regional Traffic Model becomes available, a new link will need to be developed with the land use modelling, to allow more accurate forecasting of the impacts of land use change on traffic levels.
- **Tolling** – The evidence gathered in the current study indicated that, as it stands, tolling this strategic link would not meet the agreed objectives of the study. Any further economic analysis would need to look at this issue in more detail.
- **Environmental Impacts** – Currently, the environmental impacts are based on a high level desktop assessment identifying known constraints and issues from readily available constraints data. As the study progresses, more detailed research and investigation with regard to the environmental conditions and constraints will require surveys and environmental monitoring to be undertaken to gather further evidence. This would also include carrying out consultations with relevant environmental bodies and organisations.
- **Scheme Costs** – Order of magnitude cost estimates have been produced for each route option. As the engineering certainty around the scheme design increases, the cost estimates will be considered in more detail and revised to increase the level of cost certainty. In addition the operating and maintenance costs associated with each option will be investigated further.
- **Interaction with Other Studies** – There are a number of other studies being undertaken, the outputs of which need to be considered in detail, as they are likely to impact on the development of the TPT scheme (see Figure 7-1).

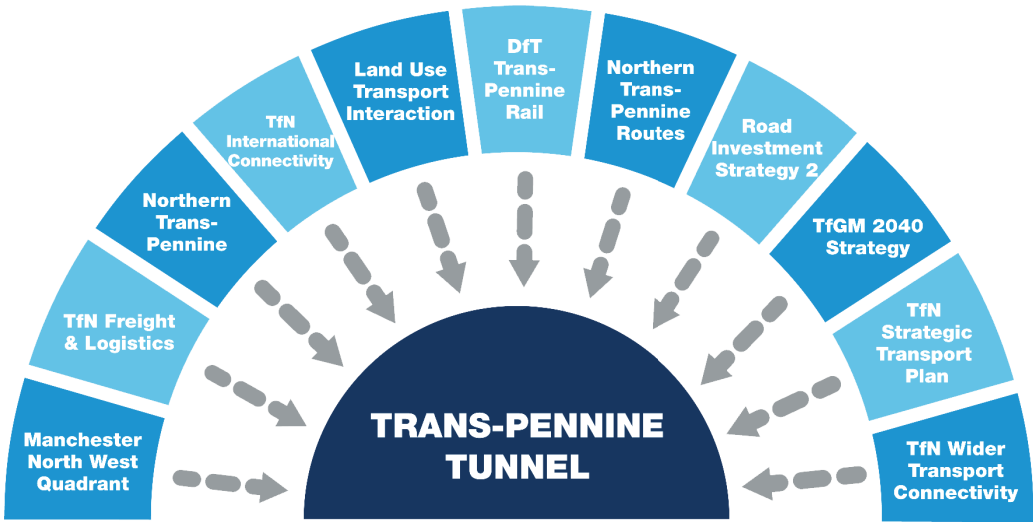


Figure 7-1 – TPTS Interaction with Other Studies/Strategies

- Enabling Works – The provision of the TPT strategic link would provide a benefit for travel across the Pennines. However, it is recognised that there may be issues experienced at the tunnel portals where the new link would tie in with the existing highway network. At these locations, further improvements may be required to the existing highway network, and the requirement and extent of these enabling works will require further investigation.
- Review of Best Practice Worldwide – The study team will continue to look at examples of similar schemes worldwide, in order to draw on any lessons learnt and stay at the forefront of developments in technology that could impact on the construction and operation of a long road tunnel.
- Stakeholder Engagement – Stakeholders will continue to be closely involved in subsequent stages of the study. Engagement events and face-to-face briefings will be scheduled to keep stakeholders informed of progress and seek their input into the study process.
- Future Technology – Further consideration of emerging technologies, through the use of a future technology scenario planning tool, is needed to plan how developments in technology will impact on the design, construction, operation and the further appraisal of the strategic link route options.

7.2 The Case for a New Strategic Link

7.2.1 Manchester and Sheffield are two major conurbations in the north – just 40 miles apart but physically separated by the Pennines. A combination of poor standard roads, where usability is determined largely by the weather and the lack of alternative routes, restricts economic interactions between these two cities. In addition to the local economic impacts, the restricted connectivity has wider implications for surrounding areas creating an east-west divide within the north.

7.2.2 The case for change is therefore based on the interrelated transportation and economic needs of the north. A new strategic route between Manchester and Sheffield has the potential to:

- improve the ability for people to travel between these two regions
- promote growth (improving jobs, skills and employment opportunities)
- improve capacity of the transport network
- improve safety for all road users
- offer greater resilience
- reduce the impact of traffic on the high-quality environment of the PDNP

7.2.3 Importantly, if the wider policy towards creating a Northern Powerhouse is successful, the constraints on connectivity between Manchester and Sheffield and their impact on the wider transport network in the North will hold back growth across the region.

7.3 Initial Feasibility of a Tunnel Scheme

7.3.1 Initial analysis has indicated that there would be large economic benefits associated with delivering a new strategic link between Manchester and Sheffield. However, current limitations, primarily associated with the availability of suitable traffic model and the emerging nature of the wider economic impacts appraisal methodology, mean that many of the benefits that are likely to result from the implementation of such a transformational scheme have not been accounted for at this stage – it is likely that the large benefits identified at this stage will increase further.

7.3.2 Order of magnitude estimates for the 5 indicative options, demonstrate a construction cost ranging from £6.5 billion to £10.1 billion. With the addition of project risk and unscheduled items, this could rise to between £7.8 billion to £11.6 billion, using “today’s” prices (Q1 2014 price base).

7.3.3 The reduced traffic in the PDNP would have a positive impact on landscape, air quality and biodiversity which would bring opportunities for increasing its attractiveness to visitors.

7.3.4 Further analysis is needed in order to be able to fully capture the benefits of a TPT strategic link, estimate the anticipated costs more accurately and understand the environmental impact.

Glossary

AAWT – Annual Average Weekday Traffic

Agglomeration –The theory of agglomeration is based on the concept that individuals and firms benefit from being in closer proximity to each other, resulting in positive externalities such as in knowledge spill overs, which lead to productivity benefits. Transport investment influences the scale of agglomeration and therefore impacting productivity by reducing travel costs and affect how 'near' firms are to each other and their input and labour markets.

ATOC – Association of Train Operating Companies

CCTV – Closed Circuit Television

DfT – Department for Transport

GVA – Gross Value Added

HMT – Her Majesty's Treasury

HS2 – High Speed 2

IPPR – Institute for Public Policy Research

KIBS – Knowledge Intensive Business Services

LUTI – Land Use Transport Interaction

MNWQ – Manchester North West Quadrant

NPIER – Northern Powerhouse Independent Economic Review

NIC – National Infrastructure Commission

Northern Powerhouse – "The Northern Powerhouse is the bringing together of the northern cities, creating modern high speed transport links between those cities, making sure that they have strong civic leadership, bringing investment to them, and as a result creating a North of England that is greater than the individual parts." Rt Hon George Osborne MP, Building a Northern Powerhouse, Chengdu, China, 24 September 2015

ONS – Office for National Statistics

PDNP – Peak District National Park

Q1 – First quarter of a 12-month period

RIS – Road Investment Strategy sets out investment plans up to 2021

SEP – Strategic Economic Plan

SERC – Spatial Economics Research Centre

SRN – Strategic Road Network

TBM – Tunnel Boring Machine

TfGM – Transport for Greater Manchester

TfN – Transport for the North

TPT – Trans-Pennine Tunnel

TPTS – Trans-Pennine Tunnel Study

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