ATKINS

Strategic Alternatives to HS2 Phase 2b

Department for Transport

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1. Executive summary

1.1. Requirement and Remit

HM Treasury "Green-book" guidelines require that proposals for investment are tested against alternative options before any formal decision is made[1]. To augment previous work into the alternatives to HS2, in May 2016, the Department for Transport (DfT) commissioned Atkins to design and assess potential strategic, alternative, rail based options to building Phase 2b of High Speed 2 (HS2). These are known as the strategic alternative (SA) options.

Atkins were remitted to develop and appraise possible rail alternatives to HS2 Phase 2b, updating previous work undertaken by Atkins on Strategic Alternatives in 2013[2] to take account of:

- Recent design development work by Network Rail on some schemes (including 140 mph/225 kph running on the ECML with the "L2E4" scheme);
- The decision to construct Phase 2a (to Crewe) which lengthens the western leg of HS2; and
- Changes to the list of schemes on the current rail network "committed" by Government.

The alternatives consist of packages of infrastructure upgrades and other interventions. The SA options have been designed to deliver higher speed journey times and deliver similar train frequencies to HS2 Phase 2b. It is recognised that because all the SA options rely on some upgrading of the existing network they cannot exactly replicate the extra functionality of HS2 but have been designed to deliver something approximately equivalent.

During this commission HS2 Ltd proposed some potential changes to the HS2 consulted route in the South Yorkshire area to provide direct services to Sheffield Midland station. At the time of undertaking this work no formal decision had been made and no amended HS2 train service specification (TSS) made public, therefore the SA options were developed as alternatives to the HS2 "consulted" route (via Meadowhall) only. We have however considered the proposed South Yorkshire alignment when designing the SA options.

DfT has requested that Atkins undertake an assessment of the SA options (compared to HS2 Phase 2b) against the strategic objectives of HS2 and Phase 2b in particular. In addition to Value for Money and Affordability, this involves considering:

- Additional network capacity generated that could be used for other future services,
- On train/seating capacity and crowding,
- Reliability and punctuality,
- Disruption and
- Environmental impact.

The SA options have typically been worked up to pre-GRIP level - a low level of engineering certainty, which means cost estimates are also inherently more uncertain. The design development of railway schemes progress from GRIP 0 to GRIP 5 in terms of certainty, with single option design being achieved at the end of GRIP 3. HS2 Phase 2b is generally considered to be close to or at the end of GRIP 3 in terms of design development and therefore is proportionally more certain in terms of design and cost. While higher levels of "optimism bias" and other elements have been included within the SA costs in accordance with DfT standard practice to reflect this, it should be noted that very significant cost increases have been seen recently on some other rail projects between GRIP2 and GRIP3. In reviewing the cost estimates, Network Rail have suggested that it would be appropriate to present a range of costs around the central estimates shown, with the suggested range asymmetrically skewed towards higher costs.

[1] [1] HM Treasury (2003), *The Green Book: Appraisal and Evaluation in Central Government*, 2011 revised edition. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf [Accessed: 15/09/16]

[2] Atkins (2013), *HS2 Strategic Alternatives: Final Report*, Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/253456/hs2-strategic-alternatives.pdf [Accessed: 22/09/16]

1.1.1. Exclusions

The remit for this study was specifically to examine alternatives to the HS2 Phase 2b scheme and not optimisation of the HS2 network. Therefore Atkins were not remitted to look at alternative network shapes to the "Y" network (examined previously by DfT), tilt or double-decker (high speed) trains or changes to fares or demand management (to be consistent with HS2 Ltd methodology).

1.1.2. Strategic Alternative options

All options rely on Phase 2a having been built to Crewe. HS2 Phase 2b therefore involves less work on the Western leg (82km) than on the Eastern leg (198km). As a result the SA options are based on a single, similar option on the west for all options (although there are some slight variations to account for the knock on impact of choices on the ECML, MML and Cross Country services), with the different options on the east reflecting the different ways of reaching Edinburgh, Leeds and Nottingham via upgrades to the existing infrastructure. All of the options require a new link from HS2 Phase 1 to the existing Birmingham-Derby line, which also has to be electrified and upgraded.

Table 1-1 Table showing key differences by routes between HS2 Phase 2b and the SA options

Key destinations	Route option to Edinburgh	Route option to Leeds	Route option to Nottingham	Route option to WCML destinations	General comments
Option 1	Via ECML	Via ECML	Via new link to HS2 Phase 1	Via upgrades to WCML north of Crewe	Requires greatest volume of upgrades to existing network, mainly ECML
Option 2S	Via ECML	Via new link to HS2 Phase 1 and short new section of HS2 M18 route	Via new link to HS2 Phase 1	Via upgrades to WCML north of Crewe	Requires some upgrades mainly to facilitate extra ECML trains to Edinburgh
Option 2L	Exactly as option 2S (via ECML)	Exactly as 2S except uses a longer new section of HS2 M18 route	Exactly as 2S (via new link to HS2 Phase 1)	Exactly as 2S (via upgrades to WCML north of Crewe)	As per 2S but with longer new line section to Leeds
Option 3	As per HS2, via HS2 and WCML north of Preston	As for 2S	Via new link to HS2 Phase 1	Via upgrades to WCML north of Crewe	Least conventional upgrades
Option 4	Via ECML	As for 2S	Via an upgrade of the Midland Main Line north of Kettering	Via upgrades to WCML north of Crewe	As per 2S but Nottingham via upgraded MML

In developing these options Atkins has taken account of "committed" or assumed infrastructure schemes and other enhancements. A list of "committed" schemes has been developed, consulted upon with Network Rail and agreed with DfT. Without these schemes the SA options would have been more expensive and have lower benefit cost ratios (BCRs). Similarly if some parts of the SA schemes were to be built as part of other projects, then subject to the capacity requirements of those other projects, the total cost of the SA options would be less expensive and likely to have better BCRs.

1.2. Methodology

A long-list of schemes was developed from previous commissions (mainly 2013). As far as possible the schemes were refreshed but some schemes needed to be redesigned to take account of changes, some schemes added and others removed. Atkins then distilled those schemes into four packages that were required to operate the proposed SA TSS (with some "spare" capacity). These form the core basis of the 5 SA options tested.

Over a period of a few months, these options were discussed at a series of workshops chaired by DfT and including representatives of both Network Rail and HS2. To make the study consistent with the assessment of HS2 Phase 2b, HS2 Ltd models and methodologies were used where possible. Standard industry approaches and templates, as advised by Network Rail, to journey times, capital cost estimation and disruption analysis were used, with the disruption assessment undertaken by Network Rail. Whilst this approach is consistent with standard guidance, the SA options are inevitably less well developed than HS2 Phase 2b.

Because the level of design development of the SA options is significantly lower than that of HS2, there is a greater risk that unknown factors may cause the SA capital costs to rise. The costs in this report have been based on an estimate of the direct costs of each scheme using quantities from the engineering diagrams and unit rates agreed with Network Rail. They were then put into a Network Rail mandated template and increased to take account of indirect costs, "other costs" including disruption and optimism bias. These factors have been agreed with DfT. Wherever possible the approach has been cross-checked with HS2 Ltd for consistency.

One other consequence of the programme for the SA work is that there was no time to optimise the specification and the schemes. Normally as projects evolve, schemes are design developed, and costs and demand are modelled, the options are amended to improve the project. That process is on-going with HS2 and may equally improve the BCRs for HS2 Phase 2b.

1.3. Results

1.3.1. Appraisal

The appraisal results are set out below.

Table 1-2 Appraisal summary

2016 Present Value (£bn)	Option 1 (Max ECML)	Option 2S (ECML-HS2 mix, short M18)	Option 2L (ECML-HS2 mix, long M18)	Option 3 (Max HS2, short M18)	Option 4 (Nottingham MML, short M18
Benefits	27.1	29.4	29.8	29.6	28.2
Revenues	15.2	16.6	16.8	16.9	15.9
Operating costs	12.7	9.6	9.5	11.8	10.6
Capital costs	13.0	15.6	16.9	11.8	14.4
HS2 rolling stock capital costs	2.2	2.4	2.4	3.1	2.5
Wider Economic Impacts	7.9	7.8	8.0	7.9	7.9
NPV (excluding WEI)	14.2	18.4	17.8	19.9	16.7
NPV (including WEI)	22.1	26.2	25.8	27.8	24.6
BCR (excluding WEI)	**2.1**	**2.7**	**2.5**	**3.0**	**2.4**
BCR (including WEI)	**2.7**	**3.4**	**3.1**	**3.9**	**3.1**

WebTAG guidance suggests that schemes with a BCR of greater than 2.0 are considered high value for money. However, please note that the results and the ranking of the options from this necessarily high level and complex analysis are very sensitive to key input assumptions.

Network Rail notes that given the early development of the works the indicative cost estimates have significant potential for variance, and as such believes that costs for the capital cost estimates are better considered as ranges. These latest estimates were not received in time to be included in the appraisal and are included for information and context only.

1.3.2. Journey times

The alternatives deliver significantly faster journey times than the "do minimum" (with HS2 Phase 2a) to many of the key HS2 destinations. However, HS2 creates faster journey times between London and Leeds, Manchester, Newcastle, Toton (for Nottingham and Derby) and Sheffield that are typically about 10 minutes faster than the SA options. There are fewer differences to the other HS2 destinations although to compensate for slower running speeds the SA options rely on changes to the stopping pattern and/or the removal of splitting and joining of HS2 services. HS2 delivers transformative faster journey times between cities in the North and the Midlands in line with the economic priorities of Transport for the North and Midlands Connect which seek to support growth in knowledge-based sectors, increasingly located in major cities. The SAs cannot match this connectivity, with journey times between Birmingham and the major cities in the North that are typically between 15 and 30 minutes slower than HS2 Phase 2b 2013 consulted route.

Key destinations where there is a difference between broadly comparable HS2 and SA service options are shown in the table below.

Table 1-3 Table showing typical journey times between HS2 Phase 2b and SA options

Destination	Journey time[3]	HS2 time from London[4]	SA time from London	HS2 time from Birmingham	SA time from Birmingham
Leeds	With stops	1:22	1:48 – 1:59	0:54	1:07 – 1:43
	Non-stop	1:15[5]	1:30/1:35		
Manchester	With stops	1:11	1:20	0:41	1:10
	Non-stop	1:08	1:17		
Newcastle	With stops	2:19		2:03	2:29 – 2:54
	Non-stop		2:26		
Nottingham	Non stop	0:52 (Toton)	1:12	0:20 (Toton)	0:37 – 0:42
Sheffield	With stops	1:09 (Meadowhall)	1:23 – 1:31	0:37	0:52 – 0:58

1.3.3. Network capacity

Atkins used its professional judgement to assess whether the proposed infrastructure investments were considered sufficient to robustly operate each SA option. This was reviewed and refined though discussions with DfT, HS2 Ltd and Network Rail. No timetabling was undertaken. In recognition of this and the risk that additional schemes may be required a sensitivity test has been undertaken showing the potential impact if extra schemes were required.

[3] Journey time services on HS2 (in both Phase 2b and SAs) labelled 'non-stop' include a stop at Old Oak Common.
[4] HS2 journey times have been calculated using the Train Service Specification in the Economic Case modelling for the 2013 consulted route via Meadowhall.
[5] HS2 Ltd advise that a London-Leeds service would take 1:15 if the Toton stop assumed in the business case was removed. This would require a change to the modelled train service specification.

In most cases where the SA options have had to invest in infrastructure schemes at key bottlenecks to facilitate the extra trains or speeds required by the SA TSS, the schemes typically also generate some additional "spare" capacity. In addition the SA options build an extended freight route on the ECML (and a much shorter freight route on the WCML) which frees further capacity. In comparison HS2 generates "spare" capacity both on its own network and on the conventional network because the number of conventional trains on the existing intercity routes are fewer than currently, as services switch to using the high speed line.

In summary, therefore, both HS2 and the SA options create extra ("spare") capacity on the national network for other services. However, only HS2 creates extra capacity for potential additional high speed services on the high speed line on the eastern and western legs north of Birmingham. In effect they extend Phase 2a into a new national network. It is this network that is being considered for additional train services by stakeholders such as Transport for the North and Midlands Connect.

1.3.4. Seating capacity

The SA options operate more seats than the "do minimum" and will operate fewer seats than HS2 to some key HS2 destination cities. The Strategic Alternative options roughly match or slightly better the train frequencies of HS2 Phase 2b. However HS2 will operate significantly longer trains (400 metres in length) than the SA options to the key destinations of Manchester, Leeds, Sheffield Meadowhall and Toton. Although the SA options vary, typically they operate longer trains (260 metres) all day than assumed in the HS2 demand model (200 metres) to other destinations including York, Newcastle, Liverpool, Glasgow and Edinburgh, and more trains to Derby and Nottingham (rather than Toton). The SA trains would not be capable of being lengthened without further infrastructure investment. DfT have advised Atkins that no final decision has yet been taken about HS2 train lengths.

The table below shows the number of seats per hour (taken from HS2 Ltd.'s demand model) on direct trains from London to key HS2 destinations (high speed and intercity).

Table 1-4 Number of seats provided into key cities from London per hour, for all High Speed and residual services

Destination city	HS2 Phase 2b (consulted route)	SA option 1	SA option 3
Toton/Derby + Nottingham	5,208	5,074	4,524
Leeds	3,361 (3,911[6])	2,444	3,471
York	3,177 (2,627[6])	1,598	2,209
Newcastle	2,322	2,444	2,444
Edinburgh	1,711	1,833	2,016
Manchester	3,768	2,860	2,613
Liverpool	1,100	1,430	1,430

For both the SA options and HS2 Phase 2b we have shown the maximum number of seats in an hour where train lengths vary across the day. More information and detailed footnotes are provided in the main report.

Atkins have also completed a comparison of seat kilometres operated for high speed services and intercity services on the WCML, ECML and MML. The results show that SA options operate between 94-98% of the seat kilometres operated by HS2.

[6] There are choices to be made about the exact split of capacity between York and Leeds. The alternative figures show the capacity provided with 3 400m trains per hour to Leeds. Atkins agree that this configuration would be possible.

1.3.5. Punctuality and reliability

The appraisal of the SA options captures the reliability benefits of new infrastructure in the same way as the appraisal of HS2, and this has been taken into the demand model. However, in total, the additional network resilience that will derive from having a new line built to modern standards of resilience will be less for the SA options than HS2 because there will be less new line.

No benefit has been claimed by HS2 or by the SA options for the punctuality and reliability benefit on the existing network from infrastructure investment proposed by the SA options and from released capacity from HS2, and no benefit has been claimed for any increase or reduction in the splitting/joining of services. The SA options will typically be less punctual and less reliable than HS2 on the HS2 trunk sections as SA options require 10 more trains per hour from London and Birmingham in each direction to run off HS2 and on to the conventional network.

1.3.6. Disruption

Network Rail has undertaken an assessment of the disruption impact of constructing the SA options. This assessment is described in more detail in the body of this report.

All the SA schemes are in an early stage of development and so the disruption impact is likely to be subject to change. However, it has been estimated by Network Rail that in summary, across the whole network, the SA options would each take:

- Between 1,500 and 2,000 weeknight closures;
- Approximately 360 “equivalent Sunday” closures; and
- Around 100 full weekend or extended weekend closures.

However, in summary, in Atkins’ professional view, the total disruptive impact of the SA options do not make them undeliverable and an estimate of the approximate financial impact has been included within the overall costs. Standard overlays for the cost of disruption and compensation have been included within the capex estimates for the SA options. For some schemes where there is significant “on network” works this may be too little but for other schemes, particularly larger schemes where the amount of “on network” work is relatively small, the overlay may be too great.

1.3.7. Environment

A high level environmental assessment was made of each Strategic Alternative scheme to check that no location has been proposed that would pose a particular environmental challenge. Some environmental risks may materialise given the low level of current design development.

1.4. Conclusions

According to WebTAG guidance, the strategic alternative options can be considered to be high value for money. The infrastructure schemes provide significant improvements in journey times and capacity against the base case.

The total benefits provided by the alternatives are less than for HS2 Phase 2b. Phase 2b generates more rail demand and benefits more passengers. In accordance with standard appraisal guidance, the demand for HS2 Phase 2b and the alternatives is capped in the modelling in 2036, only 3 years after Phase 2b is due to open. The impact of this cap on the benefits of Phase 2b is likely to be greater than on the alternatives.

The alternatives provide sufficient capacity for the TSS modelled but do not match the ultimate capacity of Phase 2b. If, in the very long term, rail demand continues to grow in line with the trend of the last 20 years, then, even if the full HS2 scheme is built, there may be elements of the SA schemes that are still worth considering in their own right to increase the overall capacity of the UK rail network even further, for example, on the ECML and on the northern end of the WCML.

The effectiveness of the SA options varied across the network. On some route sections in particular the alternatives struggled to match HS2 Phase 2b:

- **Manchester route**: No conventional alternative option was identified that could connect Manchester to HS2 that was not unreasonably disruptive. It proved even more difficult to increase train speeds significantly, and in the alternatives services from Birmingham can only be accommodated at Victoria, not Piccadilly. The alternatives effectively relied on using the existing routes into

Manchester which are acknowledged to be highly capacity-constrained and do not offer the levels of reliability that high speed passengers might reasonably expect.

- **Leeds route**: Similarly no conventional alternative could be found to serve Leeds that was not unnecessarily expensive or disruptive, or that could deliver sufficient benefits in terms of speed. Options 2-4 – which rely on building the HS2 M18 route – perform significantly better than option 1 (which is based on upgrading the existing East Coast Main Line). This strongly suggests that high speed offers the most appropriate solution to Leeds.

Midlands Connect and Transport for the North propose to use capacity created on HS2 Phase 2b as a first step to transforming the economies of the Midlands and the North. This would rely in particular on some sections of the HS2 route that would not be built under the alternatives. It follows, therefore, that the aspirations of Midlands Connect and Transport for the North would be more expensive or difficult to achieve with the alternatives.

In total the alternatives provide fewer seats and fewer "seat-kilometres" than HS2 Phase 2b.

The alternatives do not deliver the transformative journey times of HS2 Phase 2b particularly for connections between Birmingham, Manchester and Leeds. The alternatives are typically 10 minutes slower to/from London and 15 to 30 minutes slower to/from Birmingham. The alternatives also struggle to provide the same journey times between cities on the Eastern leg of HS2 Phase 2b (East Midlands, Sheffield, Leeds and Newcastle).

The design development of the alternatives is lower than for HS2 Phase 2b. Whilst an industry-appropriate factor has been included for this within the cost modelling, including in the application of a higher optimism bias and in indirect costs, there remains a cost estimate risk because of the lower level of design development. The cost increases seen on some recent rail programmes suggests than this risk is not insignificant.

The alternatives generate similar levels of improvements in performance on the national network as HS2 Phase 2b. However, Phase 2b sees 10 fewer high speed trains per hour operating over both the conventional and the high speed network in each direction as they can stay entirely on high speed infrastructure, and as a result the high speed network is likely to be less reliable and punctual with the SA options than with HS2 Phase 2b as more delay is expected to be imported from the classic network onto Phase One of HS2.

Both HS2 and the strategic alternatives will require work on the national network that will inevitably cause some disruption to existing train services. The calculations setting out the disruption impact of the SA options are set out in the main report but the total impact is not thought to be so great as to prevent the SA options from being constructed.

Finally, it is worth noting that the appraisal technology and techniques used in this assessment and in calculating the BCRs are in line with standard industry practice, and were developed originally to test enhancements to the existing rail network. These work well with the alternatives. However, in Atkins' opinion, they do not capture the beneficial impact of more transformative schemes such as HS2 Phase 2b as well. In comparing HS2 and the SAs, the overall strategic case is as important as the value for money assessment.

2. Introduction

Phase 2b of High Speed 2 (HS2) consists of both an Eastern Leg and a Western Leg. The Eastern Leg has two branches and runs from the Phase 1 line near Birmingham to Leeds and to the East Coast Main Line (ECML) at Church Fenton, south of York. The Western leg also has two branches, running from Crewe to Manchester and Golborne, south of Preston on the West Coast Main Line (WCML). Collectively these are referred to as Phase 2b, completing the "Y"-shaped network of HS2. Following the opening of Phase One to Birmingham in 2026 and Phase 2a to Crewe in 2027, Phase 2b would open in 2033.

HM Treasury (Green Book[7] Guidelines) require that proposals for investment are tested against alternative options before any formal decision is made. Noted as a Cost-Effectiveness Analysis, this involves comparing the costs of alternative ways of producing the same or similar outputs. This work involves testing how far upgrades to the existing rail network might deliver the functionality and benefits of HS2 Phase 2b, and the benefit-cost ratio (BCR) of such an approach. It follows on from a previous assessment completed by Atkins which looked at strategic rail alternatives to HS2 Phase 2a. Each previous major HS2 decision has been preceded by a study examining alternatives involving upgrading the conventional network, for example, in 2013 DfT commissioned Atkins to examine alternative options to the whole HS2 network[8], and in 2015 to examine alternatives to Phase 2a[9].

In May 2016, the Department for Transport (DfT) commissioned Atkins to design and assess potential alternative rail options to building HS2 Phase 2b.

This report describes the work undertaken by Atkins to develop and assess the SA (alternative) options to HS2 Phase 2b, and is structured as follows:

- **Chapter 3** describes the background and remit of the work provided to Atkins by the Department for Transport;
- **Chapter 4** outlines the context including summarising HS2 Ltd.'s proposals;
- **Chapter 5** provides information on the option development process in more detail and outlines the alternative options;
- **Chapter 6** sets out the methodology used for each aspect of the analysis;
- **Chapter 7** outlines the results including:
  - journey times comparison;
  - capital cost estimates for each SA option;
  - operating costs for each SA option;
  - the impact of each SA option on network capacity impacts;
  - on-train capacity comparisons between the SA options and HS2 Phase 2b;
  - the impact of each option on operating performance;
  - any disruption caused by the construction of the SA options;
  - a high level assessment of the environmental impacts; and,
  - forecasts of demand, revenue and benefits in order to undertake an economic appraisal consistent with the Government's standard WebTAG guidance and the appraisal of HS2.
- **Chapter 8** summarises the main conclusions from this assessment.

[7] HM Treasury (2003), *The Green Book: Appraisal and Evaluation in Central Government*, 2011 revised edition. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf [Accessed: 15/09/16]
[8] Atkins (2013) *HS2 Strategic Alternatives: Final Report*, Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/253456/hs2-strategic-alternatives.pdf [Accessed: 06/10/16]
[9] Atkins (2015) *Rail Alternatives to HS2 Phase 2a*, Available online: https://www.gov.uk/government/publications/hs2-rail-alternatives-to-phase-2a [Accessed: 21/09/16]

3. Study remit

3.1. Overview

Atkins were remitted to develop and test strategic rail alternatives to HS2 Phase 2b. Each would consist of a package of infrastructure upgrades and other interventions to deliver lower journey times (as fast as practical using the conventional network) and deliver similar train frequencies to HS2 Phase 2b. It is recognised that as the strategic alternative (SA) options rely on some upgrading of the existing network they cannot exactly replicate the extra functionality of HS2 but have been designed to deliver something approximately equivalent.

In effect the remit was for this work to be an update of Atkins' previous commissions from the DfT, notably in 2013 and 2015. Atkins were remitted to develop and appraise possible rail alternatives to HS2 Phase 2b taking into account recent developments, which includes:

- Recent design development work by Network Rail on some schemes (including 140 mph/225 kph running on the ECML with the "L2E4" scheme);
- The decision to construct Phase 2a (to Crewe) which lengthens the western leg of HS2; and
- Recent franchise commitments;
- Changes to the list of schemes on the current rail network "committed" by Government.

The vast majority of the schemes were therefore taken from previous SA commissions (particularly the 2013 report) with the exception of L2E4 (140 mph running on the ECML) which was based on a separate study commissioned by Network Rail and undertaken by Arup. The schemes were checked and refreshed where necessary to ensure that there was an adequate engineering understanding before the costs were estimated and the operational impact taken in to account.

DfT requested that Atkins undertake an assessment of the SA options against the strategic objectives of HS2 and Phase 2b in particular. In addition to Value for Money and affordability, this involves considering:

- Additional network capacity generated that could be used for other future services;
- On train/seating capacity and crowding;
- Reliability and punctuality;
- Disruption; and
- Environmental impact.

3.2. Assumptions

For this study the key assumption is that HS2 Phases 1 and 2a have been built. All the SA options are based on a maximum of 16 high speed trains per hour (tph) using the trunk HS2 route to London Euston (the same as HS2).

During this commission HS2 Ltd published potential changes to the HS2 consulted route in the South Yorkshire area to provide direct services to Sheffield Midland station. At the time of undertaking this work no decision had been made and no amended HS2 train service specification (TSS) made public, therefore the SA options were developed as alternatives to the HS2 "2013 consulted" route (via Meadowhall) only. We have however considered the proposed South Yorkshire alignment when designing the SA options.

3.3. Exclusions

The remit of this work was to update the previous alternatives studies in light of recent developments. Other specific requirements were:

- The SA options considered should be alternatives to the whole Phase 2b network, i.e. providing capacity and connectivity benefits to both Eastern and Western leg destinations together, and not any scenarios that involved some of the four high speed branches being built individually.
- The alternatives were to be based on the existing Y-network shape of HS2 and not test alternative network shapes, as this has previously been examined by DfT.

- SA options were not to rely on extended sections of new track – except for the Derwent Link/M18 scheme. Any decision around Sheffield (whether HS2 runs to Meadowhall or is served by a conventional upgrade to and on the Midland Main Line (MML) has no impact on SA as all the SA options test using the existing network to serve Sheffield Midland (city centre).
- Alternatives were not to consider tilt or double-decker trains, as comparable work has not been completed for the HS2 services.
- Alternatives were not to make any changes to assumptions regarding fares or demand management, so as to remain consistent with HS2 economic case modelling.

4. Context

4.1. Overview

As proposed, HS2 Phase 2b involves completing both parts of the Y network, to Manchester and Golborne Junction (south of Wigan) on the Western Leg and to Leeds and the North East via Sheffield and the Midlands on the Eastern Leg. Phases 1 and 2a up to but not including Crewe Hub are considered to be committed for this assessment.

This chapter will provide an overview of the pre-existing information which has been included in the assessment. Principally this includes noting the proposed HS2 Phase 2b service patterns as well as the context of the Eastern and Western Leg classic lines.

4.2. HS2 Phase 2b context

The Department specified that the HS2 Phase 2b alternatives should replicate as far as possible the HS2 service pattern used in HS2 Economic Case modelling As a result, the alternative rail-based options are developed from the modelled HS2 Phase 2b service pattern. The service specifications used have evolved since the previous SA report published in 2013.

This section provides the TSS diagrams for HS2 Phase 2b, followed by similar diagrams for the residual services as defined by HS2 and included within their demand model and business case. This provides an overview of all intercity services, followed by a more detailed view of the WCML, MML and ECML.

Figure 4-1 HS2 Phase 2b services

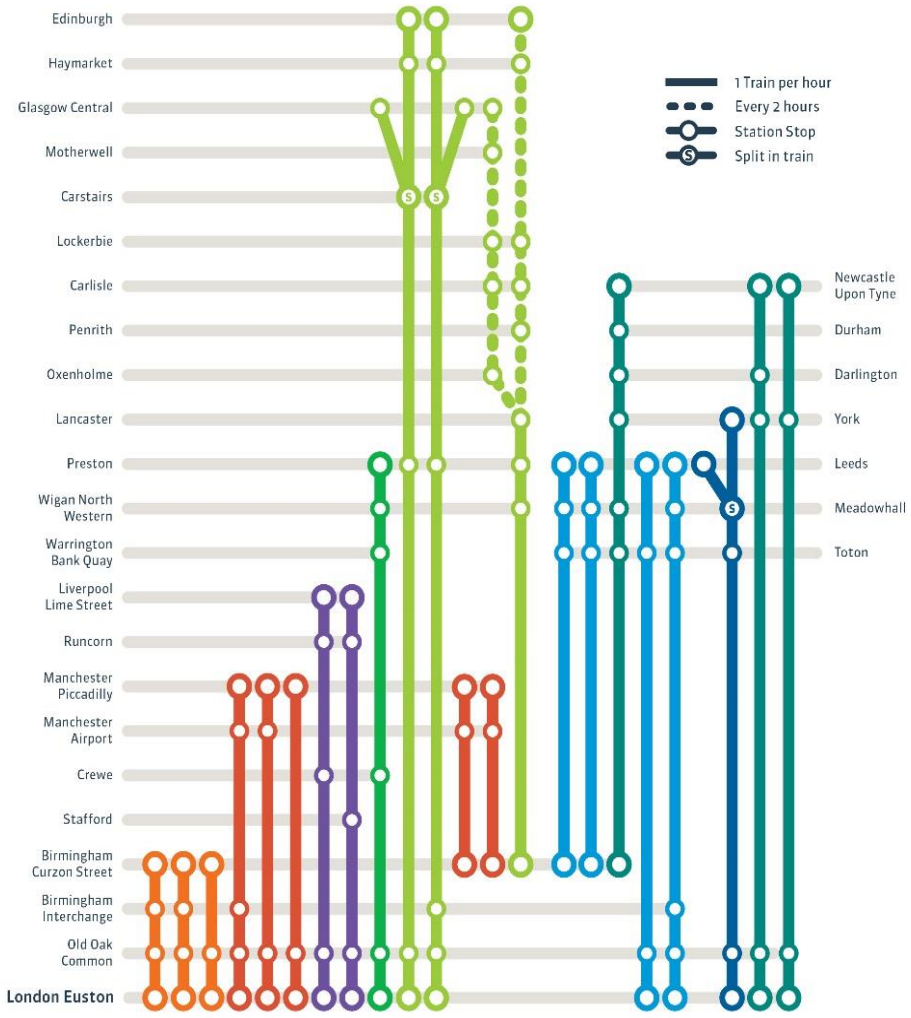
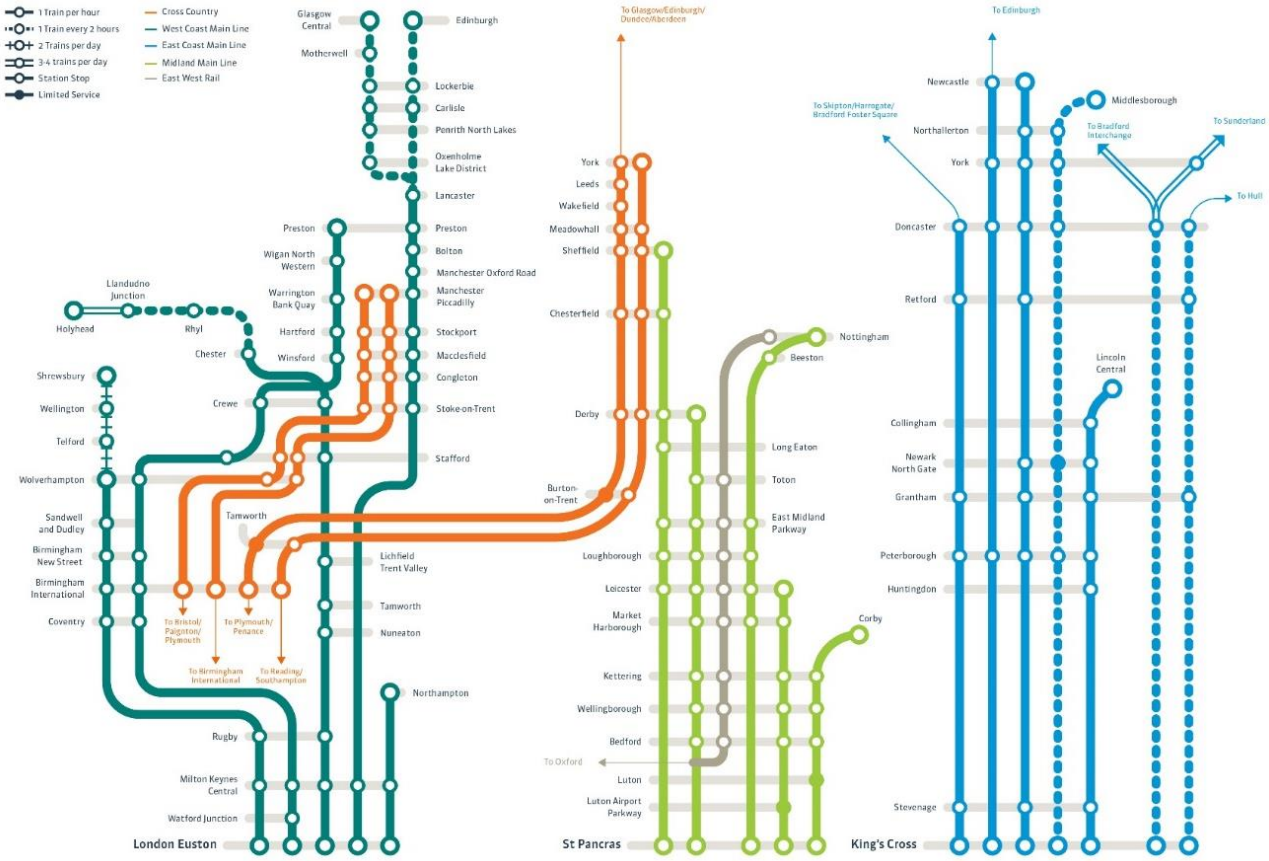


Figure 4-2 Residual Inter City West Coast (ICWC), Cross Country, Inter City East Coast (ICEC) services post Phase 2b (overview*)



*Note: **Figure 4-2** is an overview only and **does not show all stops on residual services**. Please see **Figure 4-3** for a more detailed summary of the WCML, **Figure 4-4** for a more detailed summary of the MML and **Figure 4-5** for a more detailed summary of the ECML.

Figure 4-3 WCML post Phase 2b

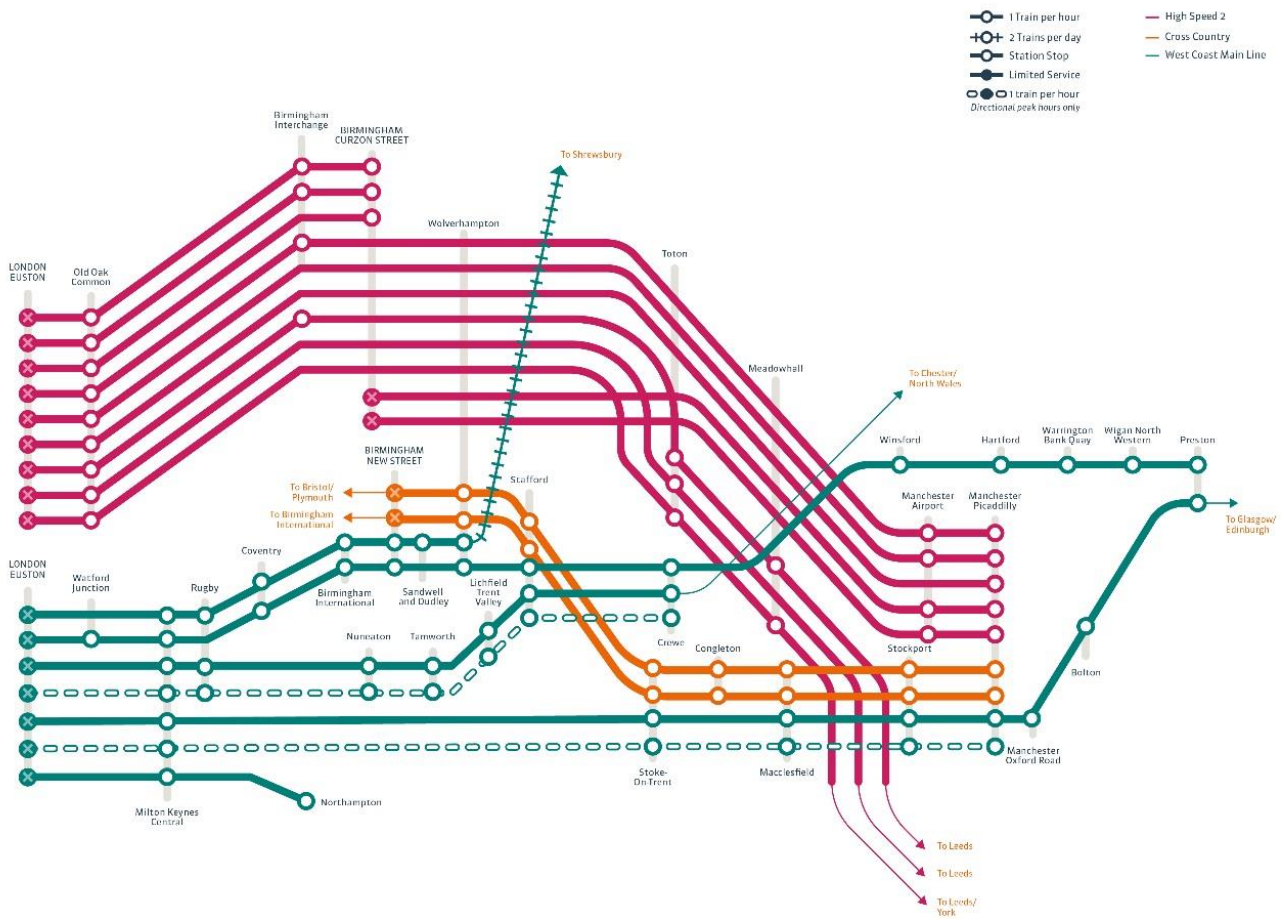


Figure 4-4 MML post Phase 2b

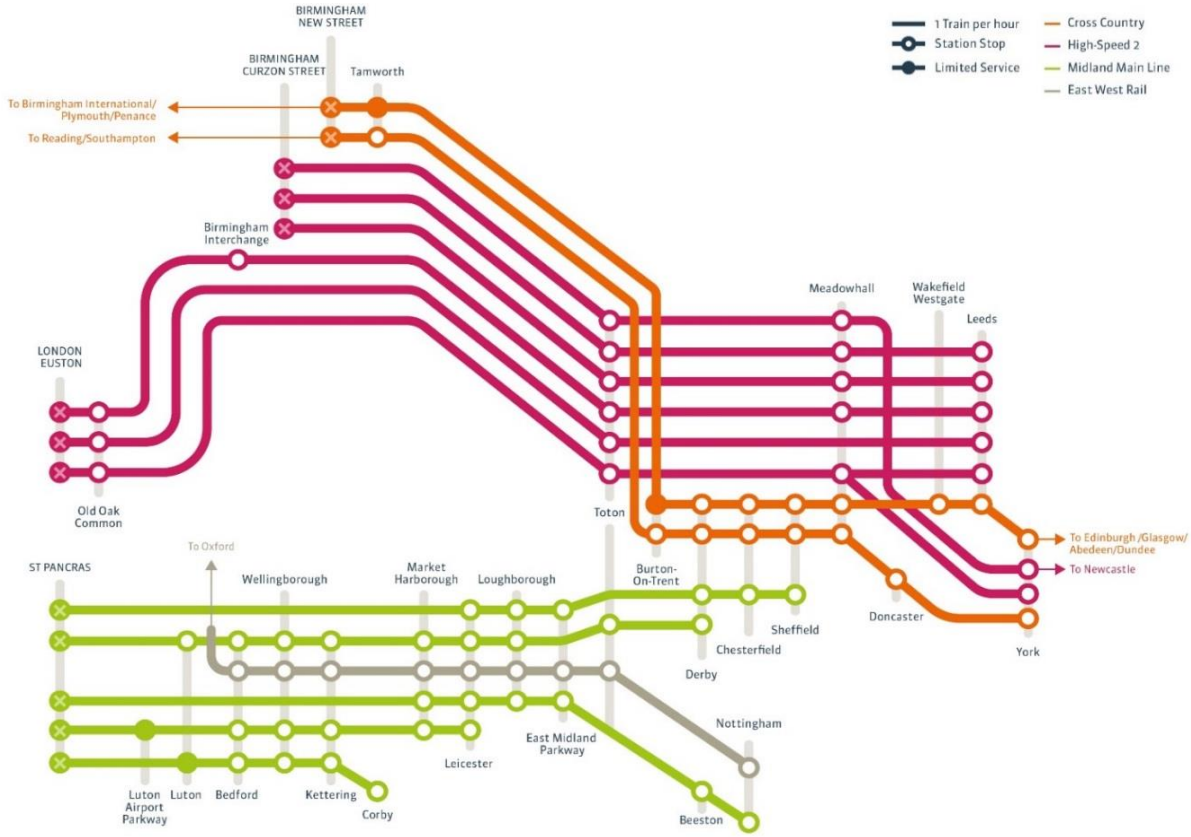
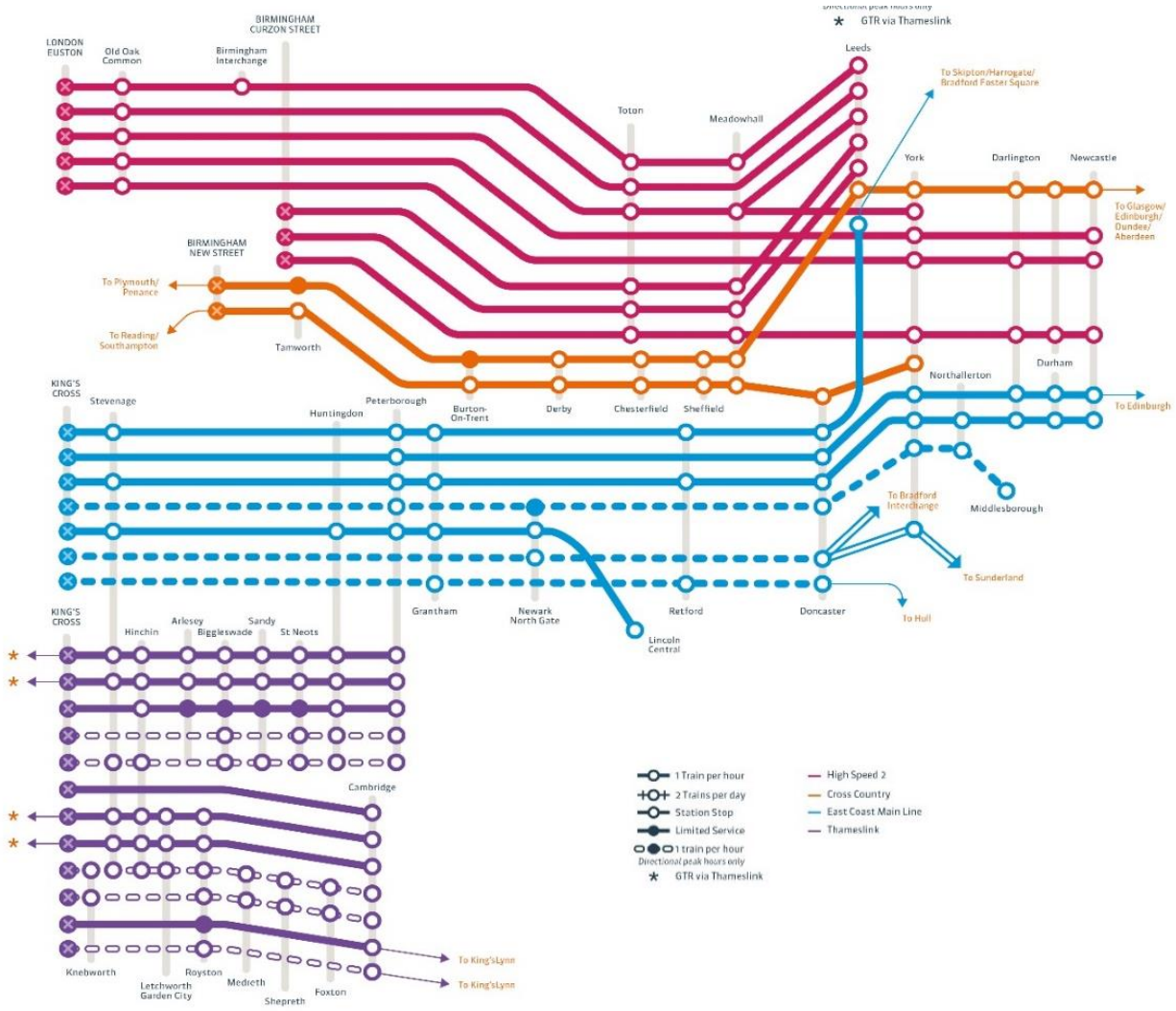


Figure 4-5 ECML post Phase 2b



4.3. Classic lines context

HS2 is being built at a time of rapid change in the railway in terms of infrastructure investment and demand growth. As highlighted in the remit section, there have been a number of alterations to the classic network baseline since the previous HS2 alternatives assessments. It is from this latest baseline that the SA options will be assessed. This section provides an overview of the context for the routes which will most interact with the Eastern Leg and Western Leg of HS2. For consistency, where practical we have assumed the same package of investments in the baseline for the SAs as for Phase 2b.

4.3.1. Eastern Leg

The Eastern Leg of HS2 in this report is used to describe destinations which would otherwise be served by the eastern arm of Phase 2b, with some key centres being Newcastle, York, Leeds, Sheffield, Derby and Nottingham. At present, these destinations are reached by the ECML and / or the MML, both of which have seen substantial recent investment and have a strong portfolio of ongoing schemes.

Recent ECML investments include:

1. Doncaster extra platform (2016)
2. Imminent use of Hitachi IEPs (2018/19)
3. Joan Croft flyover/Doncaster North chord/Shaftholme (2014)
4. GN/GE ("joint line") gauge enhancements
5. Peterborough remodelling + extra platforms (2014)
6. Hitchin grade separation (2013)
7. York 4th track at Holgate junction (2011)
8. Kings Cross platform 0 (2010)
9. Allington Chord

This level of investment has been proposed to continue and so in developing the SA options Atkins has taken account of an agreed list of assumed 'committed' schemes. The 'committed' scheme list was formally shared at a series of project steering group workshops with representatives from DfT, HS2 Ltd, and Network Rail and agreed to be 'committed' by DfT as a working assumption for this project.

The key assumed committed schemes and service enhancements are:

1. Kings Cross throat works including possible reopening of Gasworks tunnel (not Copenhagen tunnel)
2. Power enhancement to Hertford Loop
3. 4 tracking Huntingdon to Woodwalton and reversible signalling over Stilton Fen 2 track
4. Speed improvements at Peterborough,
5. Grade separation at Werrington,
6. Shaftholme junction line speed increase,
7. York station (northern) throat works,
8. Northallerton to Newcastle freight loops
9. ERTMS on the MML and ECML
10. Thameslink schemes (MML and ECML)
11. VTEC proposed timetable; Kings Cross – Edinburgh in 3:59 (1 stop at Newcastle) and 4:02 (2 stops)
12. MML electrification and associated speed increases and associated remodelling works including at Derby station (Hendy Report)

Other potential enhancements under discussion but not assumed to be committed include:

1. Grantshouse freight loop (Source NR Network Planning York)
2. Sheffield station remodelling (Source NR Network Planning York. This scheme is also assumed by HS2 to have been already undertaken by Network Rail in: HS2 Phase 2 Sheffield and South Yorkshire Options Report)
3. Electrification north of Sheffield towards Wakefield (Source NR Network Planning York)
4. Possible CP 6: Stevenage: Extra platform (down) + turn-back (source DfT)

These schemes are included in the baseline for this assessment, which are understood to be consistent with HS2 economic case modelling. Any other schemes developed or highlighted in this report are in addition to these proposals.

In addition to the committed schemes it is recognised that HS2 Ltd and Network Rail are still in discussion as to whether any extra investment is required at certain locations to operate the modelled HS2 Phase 2b TSS and classic train services. At these locations, where no investment has been determined by HS2 Ltd and Network Rail then no cost for a similar TSS to HS2 Phase 2b has been assumed in the SA options.

It is worth adding that a number high number of access applications have been processed for the ECML. At the time of writing (September 2016), access had been granted for the trains shown in **Table 4-1**. The capacity report produced by Network Rail for the ORR access ruling and the ruling itself has helped define more exactly and relatively clearly the existing capacity of the ECML and what enhancements might be required to run more trains and to generate "spare" network capacity; and therefore helped in the assessment within this report.

Table 4-1 ECML recently granted access applications

TOC / operator	Volume	Route
First Group	5 trains per day	King's Cross – Newcastle – Edinburgh including a headline 4 hour service.
Grand Central	c.0.5 trains per hour	King's Cross – Bradford Interchange / Sunderland
Hull Trains	c.0.5 trains per hour	King's Cross – Hull via Doncaster
Virgin Trains East Coast (ICEC franchise)	2 trains per hour	King's Cross – Edinburgh (semi fast and fast)
	2 trains per hour	King's Cross – Leeds via Wakefield
	1 train per hour	King's Cross – Newcastle (calling Northallerton)
	1 train per hour	King's Cross – Newark and other destinations
	c.0.5 trains per hour	King's Cross - Middlesbrough

4.3.2. Western Leg

Destinations on the WCML including Manchester, Liverpool, Preston and Glasgow, will continue to use Phase 2a as far as Crewe. The SA to Phase 2b assumes that Phase 1 and Phase 2a continue as planned. After Crewe, West Coast services would use elements of the classic network, some of which will need to be improved to offer the most competitive journey times as well as necessary capacity. Proposals for a Crewe Hub have not been considered here.

With respect to train access applications, rights have been granted for a new Open Access service from Blackpool to London. However as HS2 Phase 2a will extend as far north as Crewe the open access operations will have less impact on the SA options.

4.4. Summary

This chapter has provided an overview of the proposed changes to high speed and conventional services which have been considered within the baseline for the SA options. The following section will provide further information on the development of the options, including presenting the TSSs for each option, followed by identifying the schemes which are considered to be required to deliver the relevant TSS.

5. Option development

5.1. Overview

This chapter provides information on how the options were developed.

5.2. Methodology

Through the process of creating the TSSs it became clear that Leeds, Edinburgh and Nottingham could be served in different ways, which forms the basis of the variation between options. Changes to the ways in which these destinations were served led to knock on changes and opportunities for the rest of the TSS for each option. Of particular note, different options for serving West Coast destinations are more limited, as all would use Phase 2a as far as Crewe – except that in each of Options 1 and 4 a spare high speed path to Euston follows as a result of the changes on the Eastern Leg which has been used to operate an additional high speed train on the Western Leg.

The TSS for each option is broadly based on the modelled HS2 Phase 2b service pattern, to ensure that each destination retained a similar service provision, particularly in terms of frequency. The rail alternative options cannot precisely replicate HS2 Phase 2b, and judgement has been used to devise suitable service patterns in collaboration with the DfT. For instance, the SA service levels at Derby and Nottingham combined are designed to match the HS2 proposed service levels at East Midlands Interchange (Toton).

Once a comparable TSS was created, a range of different infrastructure improvements were considered to be required over and above schemes which are considered to be committed as part of the baseline.

Residual services and optimisation

In respect of residual services, previous analysis completed as part of the SA commission as well as other work for the DfT has demonstrated that there is likely to be value in operating more residual services on the WCML post HS2 Phase 2a, or at the very least a different TSS to that proposed by HS2.

These services might reduce HS2 income but are expected to increase total rail income. For this commission it was agreed that SA would not further optimise the residual services. This is largely due to ongoing work to assess the potential of optimisation and because any such optimisation could also be incorporated into HS2 Phase 2b's analysis. Furthermore, any use of this capacity would also complicate the requirement for SA to increase total network capacity above that required only to operate the TSS of the options, and make any assessment of spare capacity harder to evaluate.

The options were discussed at a series of workshops chaired by DfT and including representatives of both Network Rail and HS2.

5.3. Route options

As HS2 Phase 2a is being constructed to Crewe, the options for serving destinations on the West Coast are more predefined with limited options to serve via alternative routes. Western Leg options are therefore constrained to alternatives for:

- Crewe to Manchester
- Crewe to Golborne

This equates to approximately 82km.

For the Eastern Leg, previous commissions have identified different but potentially viable ways of reaching Edinburgh, Leeds and Nottingham from Birmingham and London. This means that there is approximately 198km of HS2 route that could see works associated with SA.

As a result, there are fewer viable alternatives to HS2 for destinations on the west compared to the east, and so most options have been developed to provide different tests for Eastern Leg destinations rather than the Western Leg destinations.

All SA options are based on a single, similar option for the Western Leg, with some variations to account for the knock on impact of choices for the ECML, MML and Cross Country services. For the Eastern Leg, the different options reflect the different ways of reaching Edinburgh, Leeds and Nottingham via upgrades to the existing infrastructure. The resulting options are summarised in **Table 5-1**.

Table 5-1 Options and destinations

Key destinations	Route option to Edinburgh	Route option to Leeds	Route option to Nottingham	Route option to WCML destinations	General comments
Option 1	Via ECML	Via ECML	Via new link to HS2 Phase 1	Via upgrades to WCML north of Crewe	Requires greatest volume of upgrades to existing network, mainly ECML
Option 2S	Via ECML	Via new link to HS2 Phase 1 and short new section of HS2 M18 route	Via new link to HS2 Phase 1	Via upgrades to WCML north of Crewe	Requires some upgrades mainly to facilitate extra ECML trains to Edinburgh
Option 2L	Exactly as option 2S (via ECML)	Exactly as 2S except uses a longer new section of HS2 M18 route	Exactly as 2S (via new link to HS2 Phase 1)	Exactly as 2S (via upgrades to WCML north of Crewe)	As per 2S but with longer new line section to Leeds
Option 3	As per HS2, via HS2 and WCML north of Preston	As for 2S	Via new link to HS2 Phase 1	Via upgrades to WCML north of Crewe	Least conventional upgrades
Option 4	Via ECML	As for 2S	Via an upgrade of the Midland Main Line north of Kettering	Via upgrades to WCML north of Crewe	As per 2S but Nottingham via upgraded MML

Based on these route options, a TSS has been produced. The specifications are essentially variations of the HS2 Phase 2b service patterns used in modelling as the SA options are required replicate their functionality as far as possible. All of the SA options assume and utilise a maximum frequency of services into Euston of 16tph, which is in line with Phase 2b.

The resulting TSSs for each option (high speed and conventional) are reproduced below, covering both the Western and Eastern legs. The TSS for Option 2S and Option 2L is identical as the only difference between these options is in the journey time for a small number of services and there is no change to calling patterns or train frequencies.

SA Option 1

The TSS for Option 1 maximises investment in an improved ECML as an alternative to HS2 eastern leg, and as such HS2 the eastern leg destinations Leeds, York and Newcastle are served via the ECML. The ECML line speed is increased to 140 mph (225 kph) to match HS2 journey times. Edinburgh is also served from the ECML because previous studies (mainly 2013) have suggested that having invested in enhancements on the ECML for London services to reach Newcastle the extension to Edinburgh is likely to improve the overall BCR. This also allows high speed services to Edinburgh and Glasgow to be operated separately which avoids the need to split/join high speed services at Carstairs. Instead services split/join at either Crewe or Preston, allowing the other portion of the Glasgow service to call at destinations on the WCML not served by HS2 London or HS2 residual services, such as Carlisle.

HS2 Phase 2b serves Toton (for Derby and Nottingham) and Sheffield Meadowhall via the eastern leg under the 2013 consulted route. In the SA options the city centre stations for each of these destinations are reached via an improved MML route between Trent Junction and Nottingham / Sheffield. It is connected to HS2 via an upgrade of the existing line via Burton (mainly quadrupling) and a new connection to HS2 near Birmingham. This option was first tested in 2013.

Under all the options, the WCML TSS is similar. This is because the Phase 2a extends the HS2 high speed line to Crewe so the opportunity for alternative options on the west is much less than on the east where the Phase 2b high speed spur starts from Birmingham. The main difference between the options in the west is that in option 1 (and option 4) there is one extra London high speed service. Because option 1 operates so many services on the ECML only four London high speed paths are required to serve Nottingham (2 tph) and Sheffield via Derby (2 tph). This frees an extra path which has been used to operate an additional all day service between Manchester and London.

Capacity constraints into Manchester means the 2tph between Birmingham and Manchester travel into Manchester Victoria. The TSS for Option 1 is illustrated in **Figure 5-1** (western leg) and **Figure 5-2** (eastern leg).

Figure 5-1 SA Option 1: Western Leg TSS

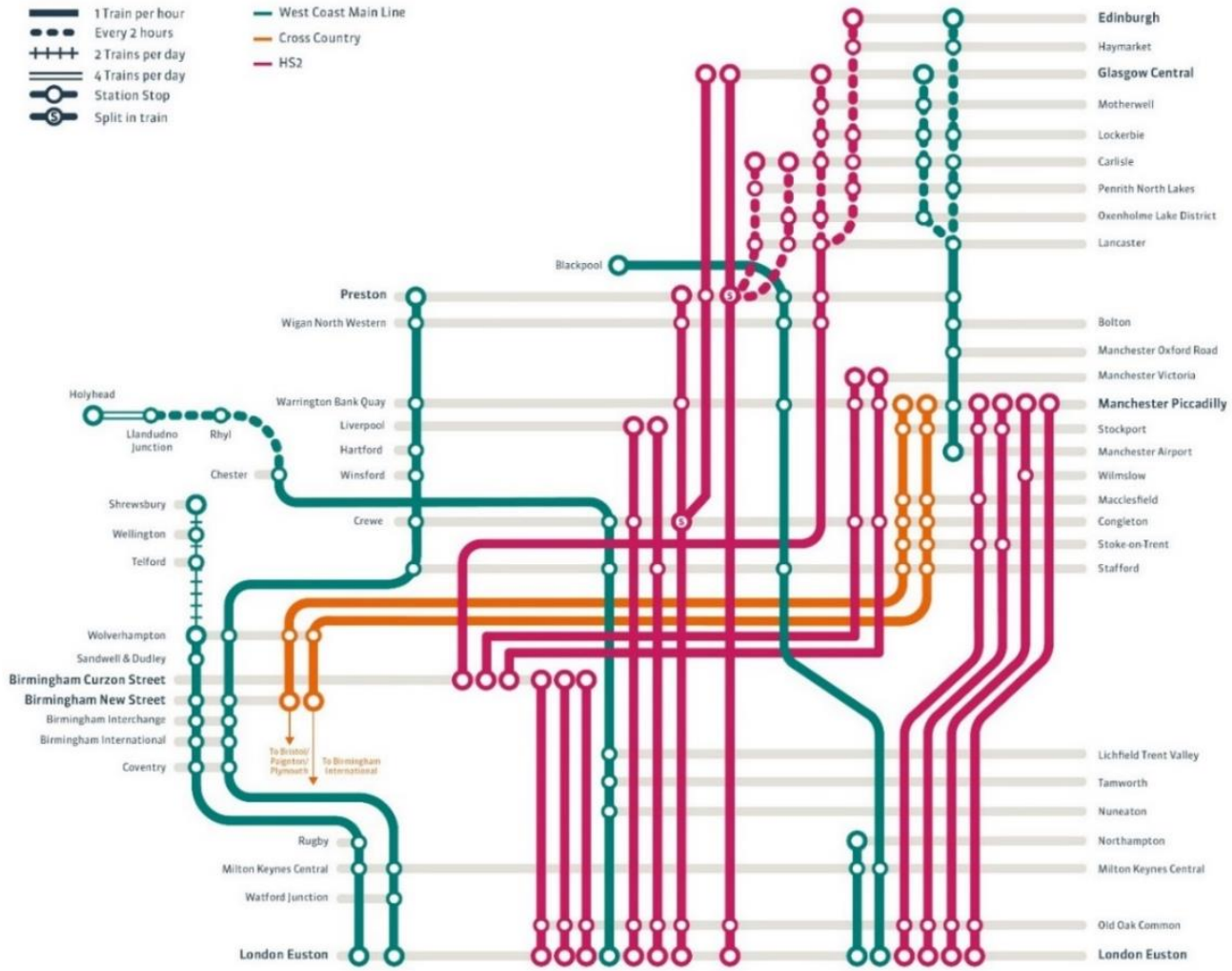
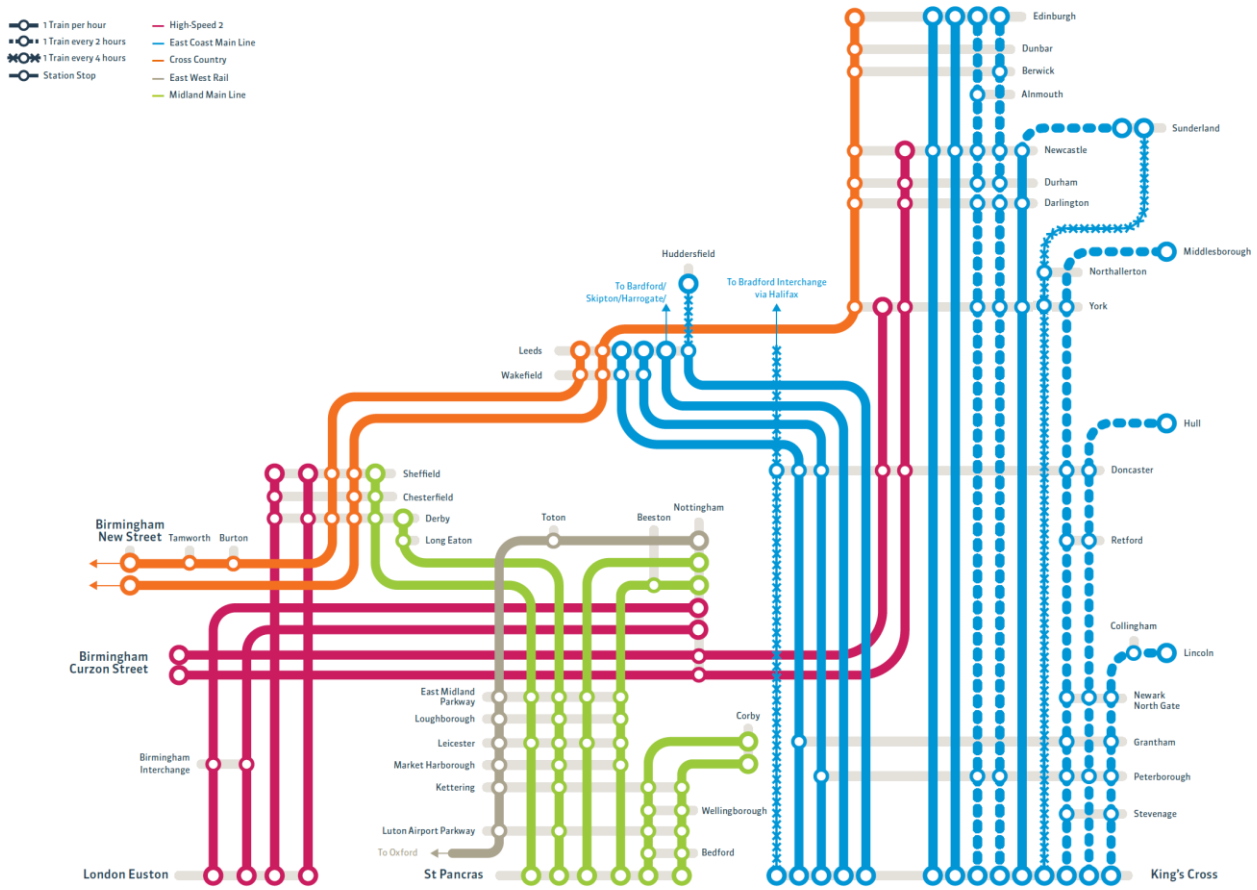


Figure 5-2 SA Option 1: Eastern Leg TSS



SA Option 2

The TSS for SA Option 2 is similar to SA Option 1 except that Leeds is served from a spur to HS2 (with 2 tph direct each hour and 2 tph extended from Sheffield via Derby). Work from the 2013 study tested a "Derwent link", a section of new line running into Leeds. This sub-option was found to perform better than conventional upgrades which proved to be an engineering challenge in an area of historic mining and so close to the Peak District national park. To update the "Derwent link" the SA options use the high speed M18 alignment developed by HS2 Ltd as part of their recent Sheffield and South Yorkshire report[10] (which HS2 Ltd have confirmed is easier and less costly to build). The SA section of new high speed line runs from Leeds to the MML near Sheffield.

Two different lengths of this new line are tested. The first, M18 Short, is 41.8km long whilst the second, M18 Long, is 62.6km long. This test was introduced following discussions at the joint workshops, primarily to compare the value in a shorter or longer section of new line. Both options use the same TSS.

MML destinations continue to use the MML and upgraded route via Burton and so this part of the TSS is unchanged from SA Option 1. In Option 2 York, Newcastle and Edinburgh continue to be served via the ECML as there are sufficient paths after the Leeds services run via HS2. The WCML services broadly match HS2.

The TSS for both Option 2 M18 short (Option 2S) and Option 2 M18 long (Option 2L) is illustrated in **Figure 5-3** (western leg) and **Figure 5-4** (eastern leg).

[10] HS2 Ltd (2016) *Sheffield and South Yorkshire Report 2016*, Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/535307/CS550A_South_Yorkshire_Report_WEB.pdf [Accessed: 21/09/16]

Figure 5-3 SA Option 2: Western Leg TSS

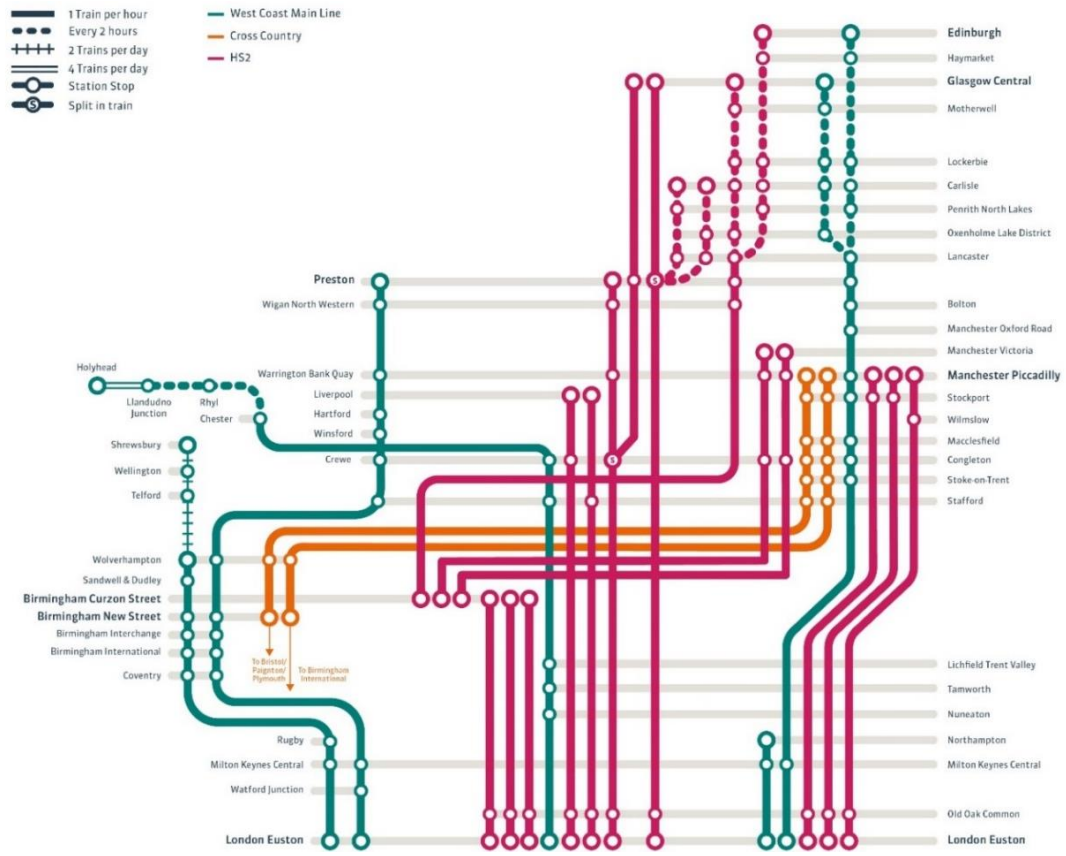
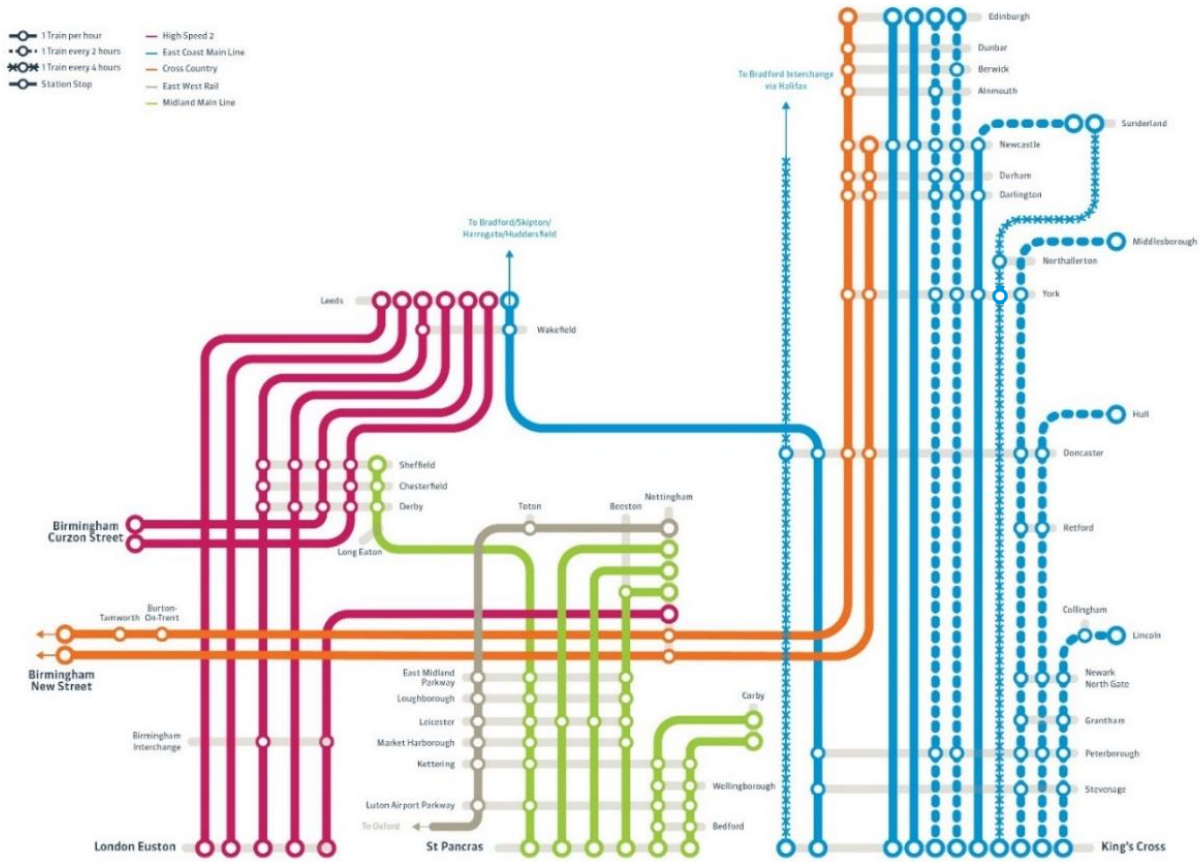


Figure 5-4 SA Option 2: Eastern Leg TSS



SA Option 3

The TSS for Option 3 is the same as Option 2 except that Edinburgh is served via a joint Glasgow service which is similar to the modelled TSS for HS2 Phase 2b. As Edinburgh and Leeds are served via HS2 the scheme to increase line speeds on the ECML to 140 mph ("L2E4") has been removed.

The TSS for Option 3 is illustrated in **Figure 5-5** (western leg) and **Figure 5-6** (eastern leg).

Figure 5-5 SA Option 3: Western Leg TSS

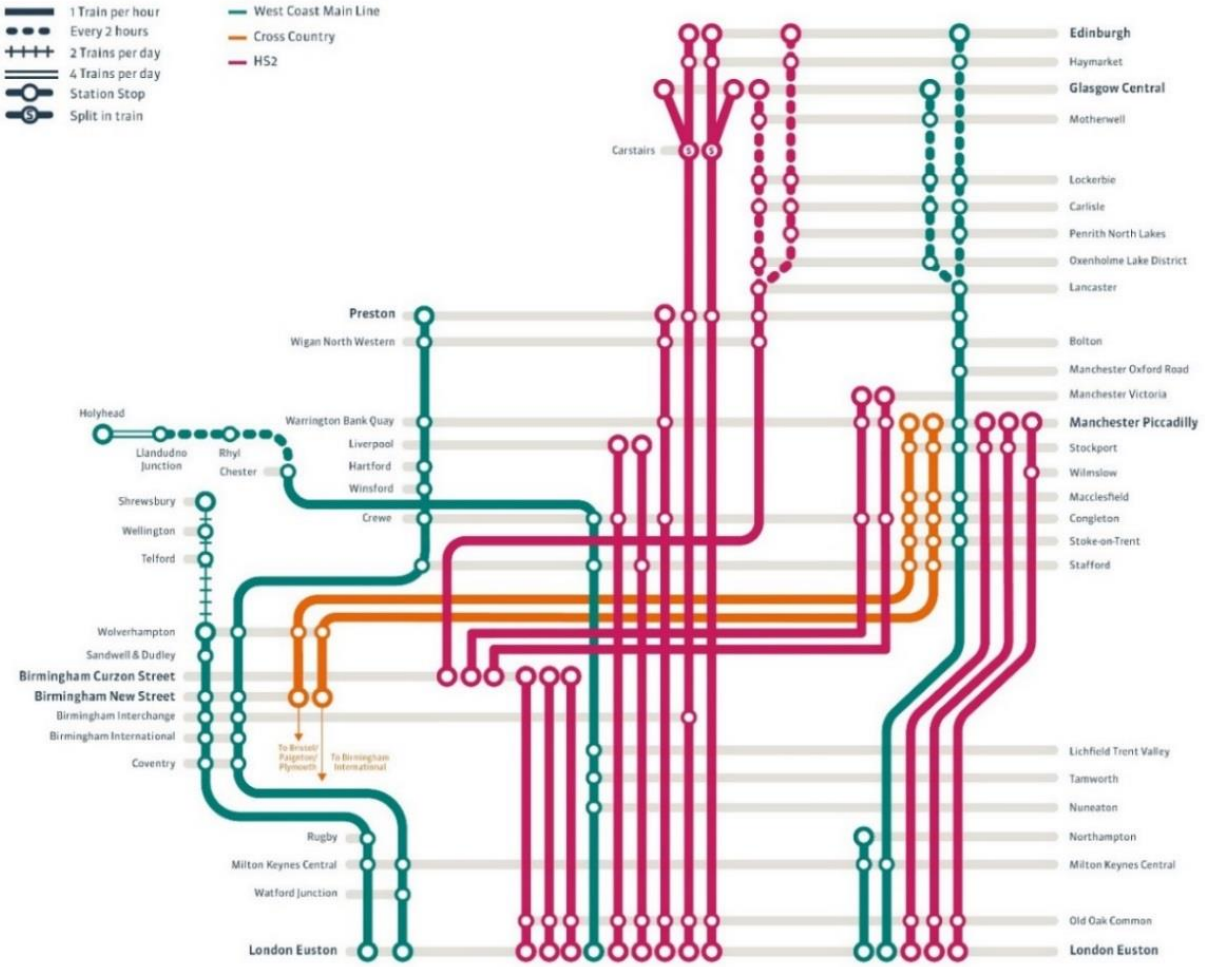
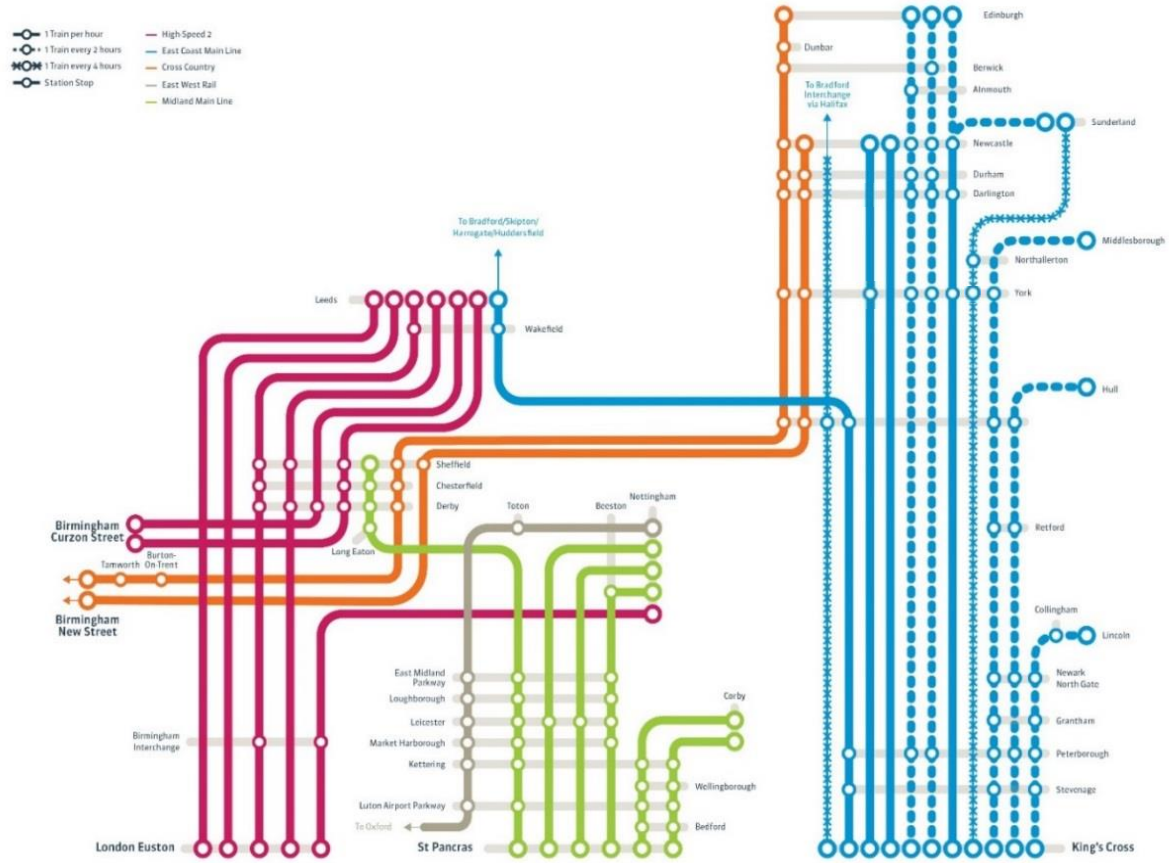


Figure 5-6 SA Option 3: Eastern Leg TSS



SA Option 4

Option 4 is the same as Option 2 in most aspects of the TSS, although Nottingham is served via the MML and not HS2 to maximise the use of an upgraded MML. The extra path is used for a fourth Manchester service which also provides the flexibility to serve Stoke-on-Trent.

The method of serving Nottingham is altered here as it is the third biggest market (after Edinburgh and Leeds) where there is a simple choice in whether services are routed via HS2 Phase 2a and SA routes or the classic network. Previous options tested serving Edinburgh via the WCML and Phase 2a and the ECML and Leeds via the ECML and Phase 2a plus SA improvements.

The TSS for Option 4 is illustrated in **Figure 5-7** (western leg) and **Figure 5-8** (eastern leg).

Figure 5-7 SA Option 4: Western Leg TSS

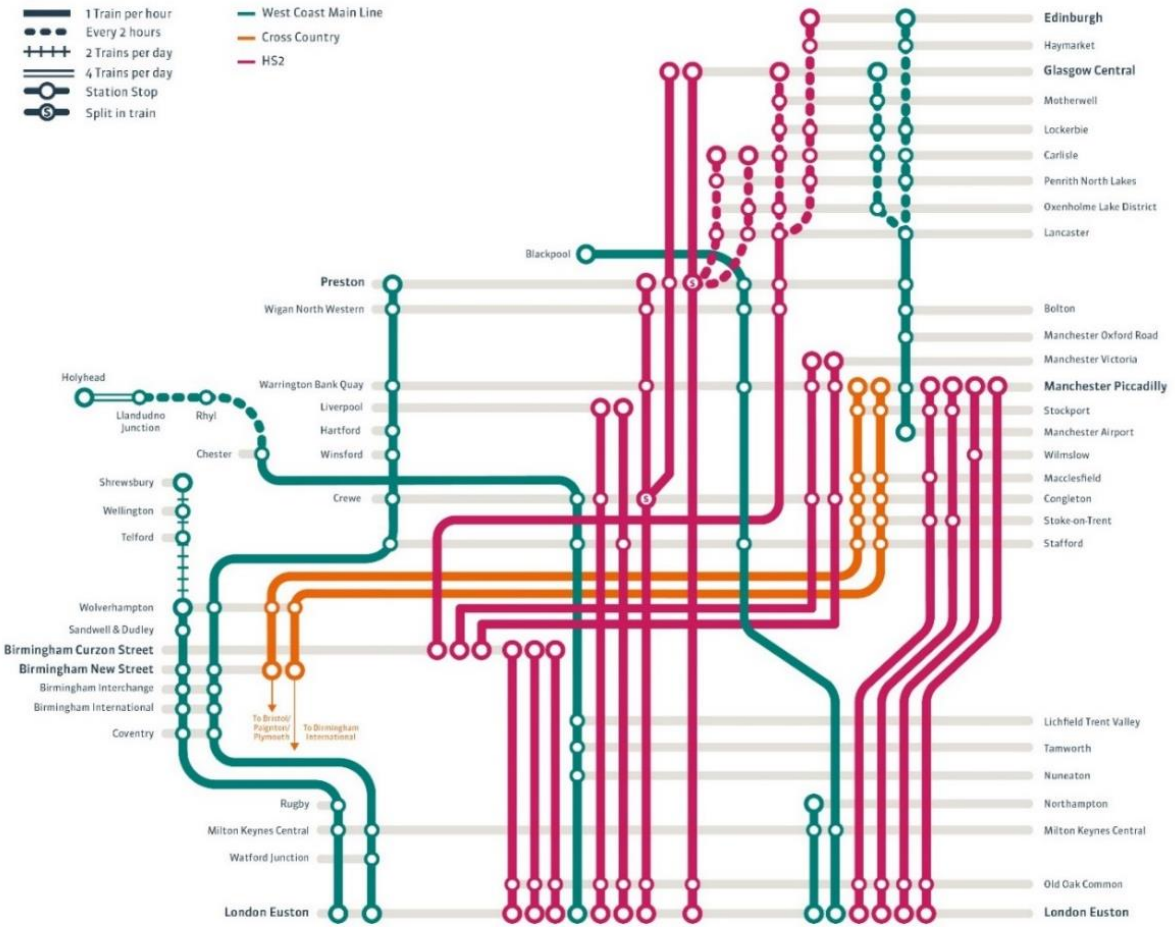
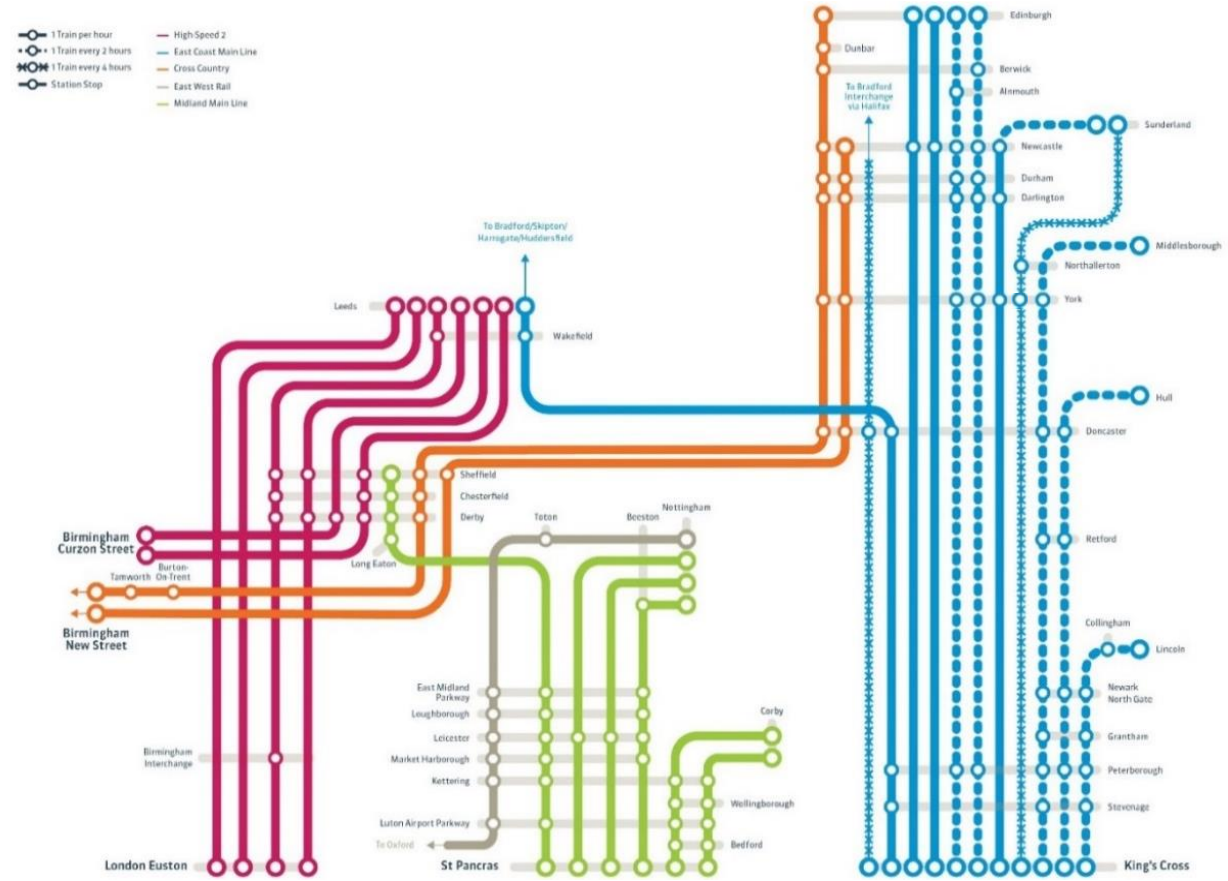


Figure 5-8 SA Option 4: Eastern Leg TSS



5.4. Scheme identification

5.4.1. Overview

The TSSs created for each option require a range of infrastructure improvements. These are largely around supplementing capacity and / or increasing speeds on existing routes to provide a competitive alternative to Phase 2b services and are considered to be enabling schemes.

This section sets out how these schemes were identified and summarises them by SA option.

5.4.2. Process

This commission is essentially a continuation of previous SA work completed by Atkins for DfT. As a result, Atkins has been able to maximise knowledge and schemes developed through previous work.

In this respect, a long-list of schemes was compiled from the previous commissions. In light of the changing context highlighted in Chapter 3, some of the schemes needed to be refreshed or altered, and others were dismissed particularly where they sought to optimise residual services. Atkins then distilled the resulting schemes into four packages that were required to operate the proposed SA TSS (with some spare capacity). These form the core basis of the SA options.

The packages were presented to a series of workshops chaired by DfT including representatives of Network Rail and HS2 Ltd.

The following section provides an overview of schemes which are considered to be necessary to deliver the TSS of the respective option.

5.5. Options and enabling schemes

This section of the report provides an overview of the schemes considered necessary to deliver the TSS for each option.

5.5.1. Option 1

An overview of the proposals is provided in **Figure 5-9**.

In SA option 1 the schemes on the west are similar to those in SA options 2, 3 and 4. The largest item on the west is the partial 4 tracking of Crewe (Wilmslow) – Weaver junction and the doubling of the freight route via Sandbach. In addition the SA options rely on significant grade separation between Crewe and Preston and some platform lengthening. This should provide sufficient to carry the 2+ extra tph that will need to operate north of Crewe which would otherwise have used the Golborne branch of HS2. There may be potential to rationalise the new infrastructure on this section as it may be over-specified for the required service pattern.

There is only minimal investment on the line between Crewe and Manchester Piccadilly as the SA high speed trains run in the same paths between Crewe and Manchester as in HS2 Phase 2a. No simple SA scheme could be found on the route to Manchester that did not trigger significant cost, but no increase in the number of trains is proposed by HS2 Phase 2b above HS2 Phase 2a which will also run on the existing tracks via Wilmslow. In SA Option 1 (and SA Option 4) an extra chord is built from the HS2 trunk route that will allow 2 high speed services per hour to connect with the Stoke branch via Stone to Manchester Piccadilly. This option was also tested in the 2015 study entitled Rail Alternatives to HS2 Phase 2a[11].

In SA Option 1 the ECML is enhanced significantly and the speed increased to 225 kph (140 mph) for most of the route. In Option 1 the two track section through Welwyn North is quadrupled and the local signalling amended so that the two track section over Welwyn viaduct becomes the most congested section, although this should be able to manage the enhanced TSS of option 1 relatively easily. As with all other options, the existing flat crossing at Newark is replaced with a grade separated crossing that also allows grade separated movements to/from Nottingham, the Doncaster area is grade separated for east –west and allows north – south freight, extra capacity is added at Darlington on the east side of the mainline, and additional loops are

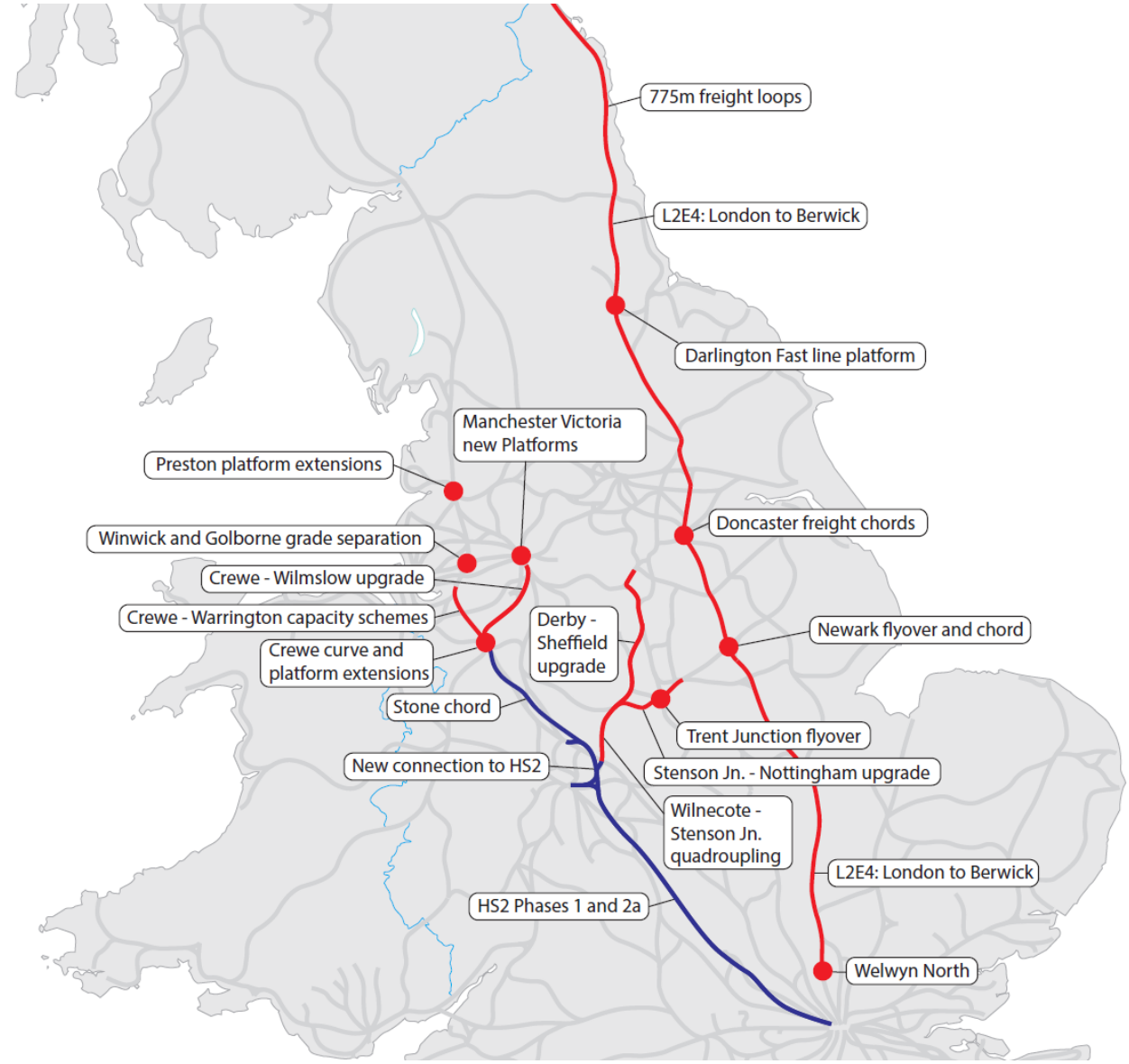
[11] Atkins (2015) *Rail Alternatives to HS2 Phase 2a*, Available online: https://www.gov.uk/government/publications/hs2-rail-alternatives-to-phase-2a [Accessed: 21/09/16]

proposed, as well as other smaller works. This will allow additional and faster intercity east coast trains to operate to Leeds, Newcastle and Edinburgh, as well as to other destinations proposed by HS2.

On the MML, as with most options, Trent and Stenson junctions are wholly or partly grade separated and the line from Derby to Sheffield has a range of small capacity and speed schemes. In addition the line between Tamworth and Derby is connected to HS2 at Wilnecote, is electrified and four tracked through most of its length.

An overview of the proposals is provided in **Figure 5-9**. Please note that not all schemes are shown where they are smallest by volume and least defined.

Figure 5-9 Option 1 schemes



5.5.2. Option 2

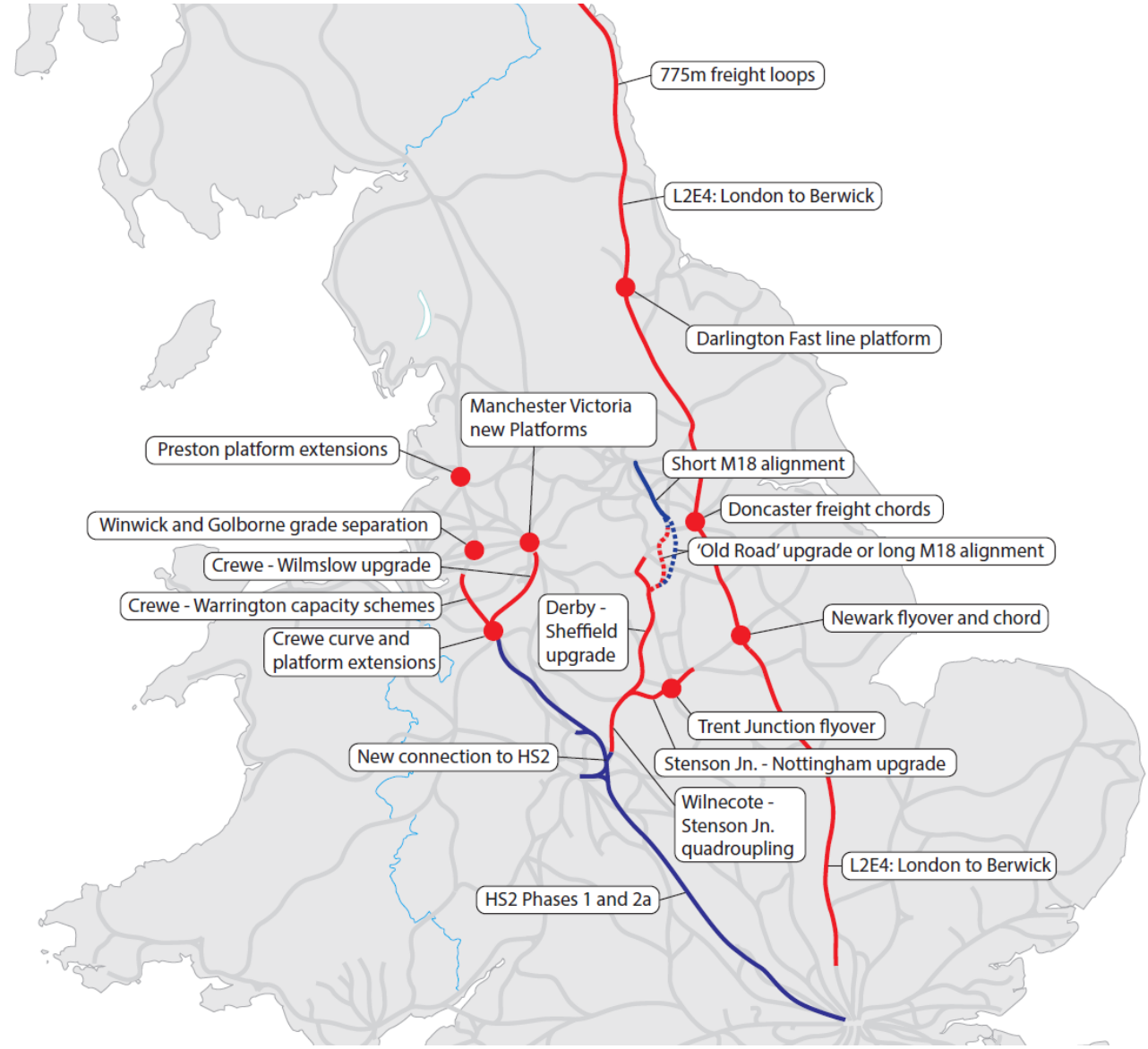
In SA options the proposals on the west are similar to SA Option 1, although the Stoke via Stone chord is not required because in Option 2 only 1 conventional train per hour operates via Stoke between Manchester and Euston.

The major difference in the east is that different lengths of the M18 scheme are built from just north of Sheffield to Leeds. This allows high speed trains to Leeds to operate from Euston. It removes the need for extra capacity schemes on the ECML and in particular at Welwyn. In M18 Short, high speed line is built from Leeds to just south of Mexborough, where the line then diverts away from the proposed M18 alignment to connect to the existing classic line between Sheffield and Leeds (via Moorthorpe) near Rawmarsh. In M18 Long, high speed line is built as far south as Killamarsh before the connection again diverts to meet the same existing line between Sheffield and Leeds further south.

Leeds New Lane station is designed for 260m long trains but has been designed so that extension to 400m is possible as and when demand requires it.

An overview of the proposals is provided in **Figure 5-10**. Please note that not all schemes are shown.

Figure 5-10 Option 2 schemes

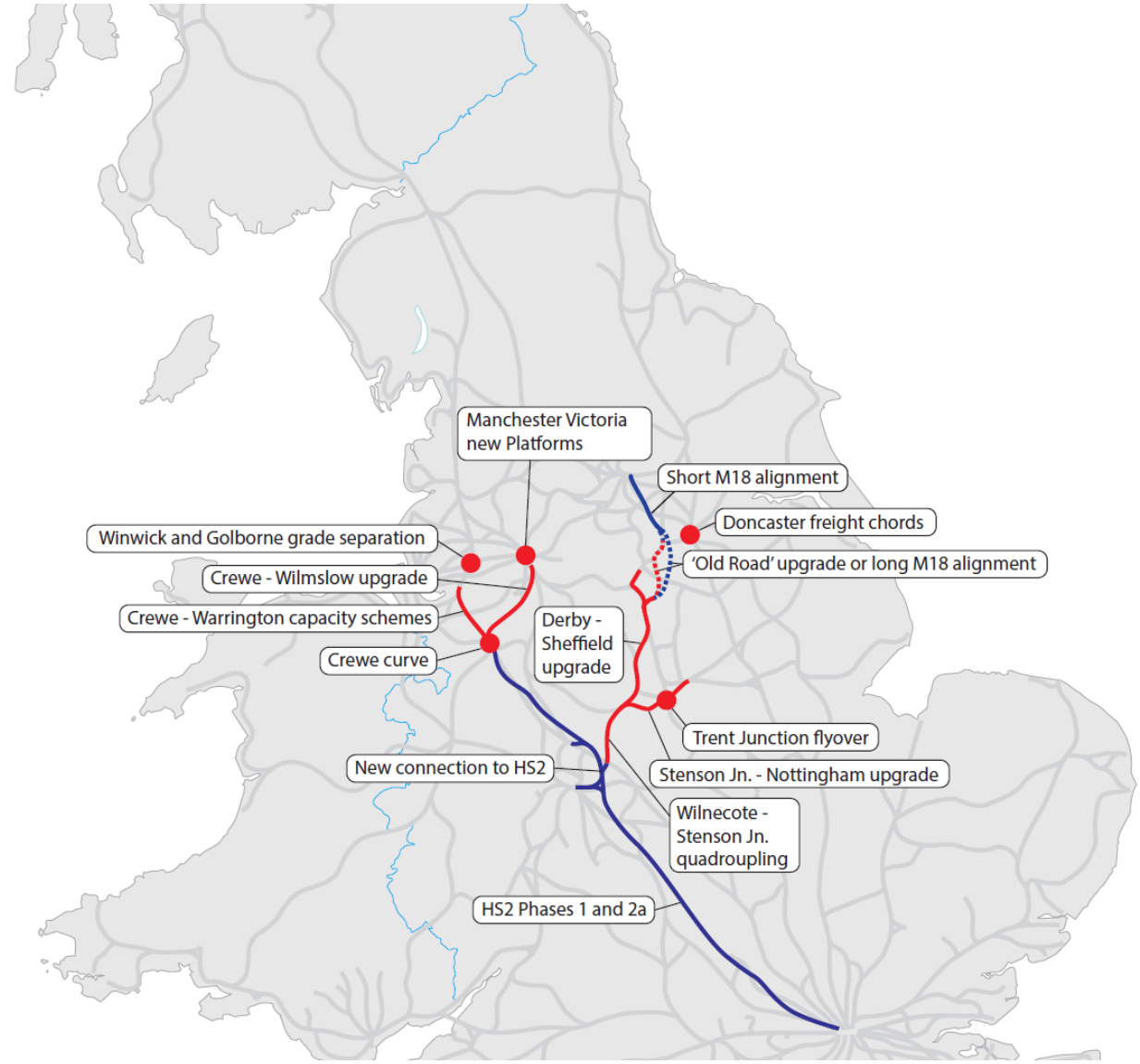


5.5.3. Option 3

Option 3 is the same as Option 2 except that Edinburgh, like Glasgow, is reached via a joint high speed service from Euston as per HS2. Since the ECML no longer is used to serve Leeds or Edinburgh the speed is not increased. One of the largest cost items to allow faster train running on the ECML is the flyover and associated grade separation works at Newark. This is also removed which forces a slightly different pattern of Cross Country train services that revert back to using Doncaster as their main ECML route as currently.

An overview of the proposals is provided in **Figure 5-11**. Please note that not all schemes are shown.

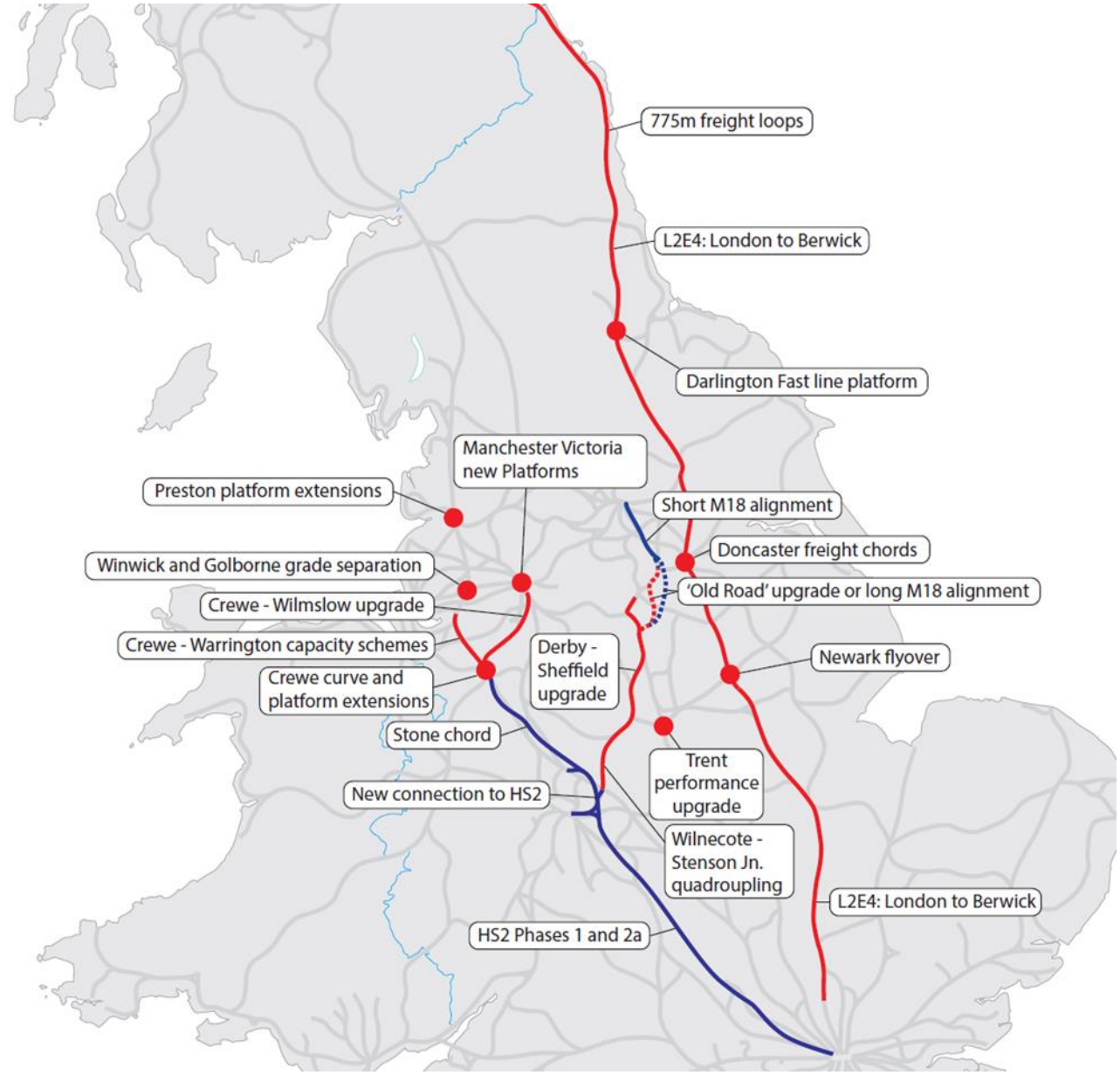
Figure 5-11 Option 3 schemes



5.5.4. Option 4

Option 4 is the same as Option 2 except that some schemes have been removed in the Trent area as Nottingham is now served via the MML. However, a notional scheme with a value of around £500m with a yet to be defined scope has been included to improve capacity from Trent junction northwards. An overview of the proposals is provided in **Figure 5-12**. Please note that not all schemes are shown.

Figure 5-12 Option 4 schemes



5.6. Summary

Generally, Option 1 requires the greatest volume of upgrade work to the existing network, across the ECML, the cross country link between the West Midlands and the East Midlands and elements of the WCML. Option 3 requires the least amount of upgrade work as HS2 infrastructure and an improved Cross Country link is maximised, with less ECML works. Option 2 (with both a longer and shorter M18 section of new line) requires upgrades principally to facilitate extra ECML trains to Edinburgh. Option 4 is similar in works to Option 2, but with an upgraded MML serving Nottingham rather than via HS2.

6. Assessment methodology

6.1. Methodology overview

A long-list of schemes was developed from previous commissions, principally from the 2013 HS2 Strategic Alternatives report produced for the DfT by Atkins. Some of the schemes were refreshed to take account of other changes and some dismissed particularly they sought to optimise residual services. Atkins then distilled those schemes into four packages that were required to operate the proposed SA TSS (with some "spare" capacity). These form the core basis of the SA options.

Over a period of a few months, these options were presented to a series of workshops chaired by DfT but including representatives of Network Rail and HS2. At those workshops Atkins was asked to create SA Option 2L to test if having a longer new line to Leeds might have a significant impact on the BCR and to develop SA Option 4 to test the impact of making better use of the Midland Mainline to serve Nottingham.

The design and selection process of the TSSs and schemes for the SA options was set out in section 5 above. At the project steering group workshops Atkins also set out the proposed assessment methodology for the commission. A number of activities which were previously undertaken by Atkins were to be led by Network Rail and HS2 Ltd.

The table below sets out who led, who checked and who was consulted on the core activities. The key consideration at the workshops in deciding which organisation would undertake the activities was to ensure consistency with HS2 appraisal and to complete the study efficiently.

Table 6-1 Key tasks and responsibilities for the assessment

Category	Atkins	DfT	HS2 Ltd	Network Rail
Journey times	Led		Detailed model results shared. HS2 Ltd's journey time analysis model was used where applicable	Network Rail model used to calculate journey times where necessary. Results shared at workshop
Costs: CAPEX - Infrastructure - Infrastructure Optimism Bias	Led modelling in accordance with NR agreed methodology and Network Rail mandated template.		Provided for M18 scheme	Consulted on unit rates. NR agreed methodology and Network Rail mandated template. Assurance including defined indirect cost and other cost overlays.
- HS2 Rolling stock	Included as per agreement with DfT and HS2. Typically 66% to reflect lower level of scheme development than HS2.	Set optimism bias levels to be applied in line with WebTAG guidance for schemes at a pre-GRIP stage.	Confirmed optimism bias level for M18 scheme	
	Led calculation of number of high speed trains based on hours in traffic as proportion of HS2 Phase 2a/b	Consulted on methodological approach	Set base fleet numbers from which Atkins calculated variances. Consulted over rolling stock.	

Category	Atkins	DfT	HS2 Ltd	Network Rail
			Copied into model calculations.	
Costs: OPEX	Provided inputs to HS2	Consulted by HS2 Ltd over general principles as part of HS2 wider works	Led using outputs from demand model	
- Optimism Bias		Consulted by HS2 Ltd over general principles as part of HS2 wider works	Part of operating cost calculation undertaken by HS2 Ltd	
Network Capacity	Led	Consulted	Consulted at workshops	Consulted at route level and at workshops
On train capacity	Used HS2 capacity figures (or pro-rated them as appropriate)	Consulted on methodology	Calculated passenger capacity per 200m HS2 train	
Punctuality and reliability	Adopted HS2 methodology	Consulted	Provided the methodology	
Disruption	Consulted over scheme designs	Consulted at workshops		Led
Environment	Qualitative assessment only	Consulted	Consulted at workshops	Consulted at workshops
Appraisal - Process	Led	DfT approved methodology	Calculated some elements	
- Demand and benefits calculation	Led using HS2 model	Consulted	HS2 demand model used.	

6.2. Journey times

Category	Atkins	DfT	HS2	NR
Journey times	Led		Detailed model results shared. HS2 Ltd's journey time analysis model was used where applicable	Network Rail model used to calculate journey times where necessary. Results shared at workshop

6.2.1. Overview

Following agreement of the proposed TSSs, each journey time was determined and specified for economic analysis in accordance with a strict hierarchy set out below to determine the most appropriate method to calculate each journey time. Firstly, wherever possible journey times in the existing HS2 demand model were replicated. Where the demand model did not include a suitable time that allowed for the proposed stopping pattern or for the correct train type, existing point to point timings were taken from Network Rail's working timetable where possible. Where timings could not be taken from the demand model or from Network Rail's working timetable they were calculated. On some sections journey time analysis had been undertaken for other project for Network Rail or HS2 (such as L2E4), and typically these were used. For all other timings Route Runner was used which is an NR tool typically used for early scheme development. Consistent with HS2 Route Runner has the design linespeed, design gradient, stopping pattern and train characteristics as inputs. The model then calculates point to point running times. On top of these point to point times Atkins applied the same overlays as HS2 – typically 5% on high speed lines and 7.5% on classic lines.

Hierarchy	Source of journey times
1	HS2 Ltd.'s demand model (to maximise consistency with HS2)
2	Existing point-to-point timings from today's Network Rail working timetable
3	Network Rail's and HS2 Ltd.'s existing journey time analysis for other studies
4	Where no other source existed for the relevant route, Atkins calculated completely new journey times using Route Runner. Atkins used the same methodology as HS2's journey time analysis, described below.

6.2.2. Methodology by route

Below is a breakdown of the sources of journey times and methods of calculation used on a route-by-route basis.

6.2.2.1. ECML

The working timetable in Network Rail's ECML 2020 Capacity – Timetable Assessment Report was used as the basis for all new timings on the ECML. This report assumes new IEP rolling stock will be operating at speeds of up to 125mph on existing infrastructure. It was only necessary to produce new timings for a small number of services as all but the fastest services were already included in the HS2 demand model.

In Options 1, 2 and 4, Atkins have included schemes to permit 140mph running on some stretches of the ECML derived from Network Rail's East Coast Main Line (L2E4) Study (15 May 2014). Atkins used the journey time savings calculated for the relevant schemes in the L2E4 report and subtracted them from the relevant 125mph running times.

6.2.2.2. Midland Main Line and Cross Country

Generally, timings of trains to and from St Pancras on the Midland Mainline were taken from the HS2 demand model. In a small number of instances, it was necessary to generate new timings owing to the

stopping patterns chosen and these were taken from the existing Working Timetable, based on Class 222 rolling stock (which has similar performance to IEP stock).

For services on cross-country routes, Atkins calculated journey times on the following sections using RouteRunner:

- Birmingham New Street – Derby (owing to upgrade schemes on this route)
- Birmingham New Street – Nottingham (owing to upgrade schemes and the route via Castle Donnington being taken)
- Nottingham – Doncaster (owing to the new chord at Newark)
- Derby – Sheffield (non-stop, owing to upgrade schemes)
- Sheffield – Wakefield Westgate (in Options 2L owing to upgrade schemes)

6.2.2.3. West Coast Main Line

Most journey times were obtained directly from the HS2 demand model. However, there were a small number of running times that were not included (Milton Keynes to Stafford and Stafford to Warrington). These were determined from the existing Working Timetable.

6.2.2.4. High Speed 2 services

Where possible, any journey times not in the HS2 demand model were developed using journey times provided by HS2 Ltd. On the following routes, it was necessary to calculate new journey times using Route Runner:

- Old Oak Common – Derby – Sheffield
- Old Oak Common – Derby – Leeds New Lane (via the M18 alignment)
- Old Oak Common – Nottingham
- Old Oak Common – Wilmslow – Manchester Piccadilly
- Old Oak Common – Stoke-on-Trent
- Birmingham Curzon Street – Derby – Sheffield
- Birmingham Curzon Street – Derby – Leeds New Lane (via the M18 alignment)
- Birmingham Curzon Street – Nottingham

6.2.3. Route Runner

Where journey times could not be obtained from existing sources, Atkins used Route Runner, a journey time calculation spreadsheet macro developed by Network Rail (authorised to Atkins for use of calculating journey times). It requires distances (in miles and chains), gradients and line speeds to generate journey time outputs in minutes.

HS2 Plans and Profile maps provide distances in kilometres, and a separate offline spreadsheet was used to convert the kilometres to miles and chains for Route Runner input. Gradients on the classic network were obtained from Network Rail 5 mile diagrams. High speed line gradients were sourced from HS2 Plans and Profile Maps, however these are provided in percentages. An offline spreadsheet was used to convert the percentages to a format recognised by Route Runner.

Line speeds were sourced from HS2 Plans and Profile maps for high speed lines, from HS2 Ltd for the confidential M18 alignment, from Network Rail Sectional Appendix for the classic network and from the Atkins where new schemes affect line speeds.

In order to maintain consistency with HS2 Ltd.'s journey time calculations, an uplift of 5% has been applied to journey times output by Route Runner on high speed lines and 7.5% to times on the classic network.

In addition to this uplift, Network Rail Engineering Allowances were applied. These are minutes which are added to all journey times on Network Rail infrastructure and are set out in the 2017 planning rules. HS2 Ltd have also applied the relevant engineering allowances where classic compatible units run on Network Rail infrastructure.

6.3. Costs: CAPEX

Category	Atkins	DfT	HS2	NR
Costs: CAPEX - Infrastructure - Infrastructure Optimism Bias	Led modelling in accordance with NR agreed methodology and Network Rail mandated template.		Provided for M18 scheme	Consulted on unit rates. NR agreed methodology and Network Rail mandated template Formal sign off including defined indirect cost and other cost overlays – although at the time of publishing this task is incomplete.
- HS2 Rolling stock	Included as per agreement with DfT and HS2. Typically 66% to reflect lower level of scheme development than HS2.	Set optimism bias levels to be applied in line with WebTAG guidance for schemes at a pre-GRIP stage.	Confirmed optimism bias level for M18 scheme	
	Led calculation of number of high speed trains based on hours in traffic as proportion of HS2 Phase 2a/b	Consulted on methodological approach	Set base fleet numbers from which Atkins calculated variances. Consulted over rolling stock. Copied into model calculations.	

CAPEX costs refer to the estimated costs of capital items which are considered to be required to deliver the SA options. This mainly includes the costs of new infrastructure, but also includes high speed rolling stock. This is because HS2 treats high speed rolling stock as a capital item. Conventional rolling stock, on the other hand, was costed on a standard lease-based approach and therefore included within the cost process for operational costs (OPEX).

This section provides an overview of how the capital items (infrastructure and high speed rolling stock) were estimated. The calculation and assessment of capital costs for the SA options has, as much as possible, been estimated using the same assumptions and approach used by HS2 Ltd for their assessment of Phase 2b. However, it should be noted that many of these schemes are at a much earlier stage of design and so not all elements are identical.

This section refers to capital cost estimates only, and there are the following exclusions which were agreed with Network Rail and consistent with the NR mandated template:

- VAT;
- capital allowances and finance charges;
- costs for upgrading existing track (unless specifically included within a scheme); and
- land is also excluded in line with standard practice.

Operational costs are covered separately in Section 6.4.

6.3.1. Infrastructure

Required schemes

The schemes required for each option are outlined in Section 5 of this report. It is these schemes which have been estimated as part of this assessment process.

The range of identified schemes includes the proposed M18 high speed alignment, connections between the existing network and HS2 Phases 1 and 2a, upgrades to existing track, quadrupling, providing loops to increase route capacity and removing conflicts at key locations.

Estimating process for classic network schemes

Most of the schemes which have been identified for the SA options involve changes to the existing classic network. As a result, Network Rail are the key stakeholders in this estimating process. Even though where possible the selected schemes were refreshed from previous studies, the majority of schemes are at a particularly early stage of development and without a real identification of risks as yet, typically pre-GRIP, and this was also considered in the estimating process. An exception to costing in this way is the L2E4 scheme, which was priced previously by Network Rail and so this was not reviewed or altered for this assessment.

The remaining classic network schemes were estimated using a template provided by Network Rail. This involved the following inputs:

- Collating scheme diagrams and drawings to define the scope
- Collecting measurements for each of the items, based on scheme diagrams and drawings and engineering commentary

Once this preparatory work was completed, the relevant information was input into the template. The Network Rail template provides information on direct costs (such as materials), indirect costs (such as preparatory work) and project costs (such as possessions and planning fees).

Direct costs are calculated automatically in line with the template provided by Network Rail. Indirect and project costs are applied on a percentage basis of the direct costs. These percentages are automatically applied and vary for indirect and project costs.

Indirect costs

- Preliminaries: 30%
- Overheads and profit: 10% for both direct costs and preliminaries
- Design fees: Range between 10%-30% subject to the asset type being designed
- Project management costs: 10%

Other Project costs

- Planning fees (TWA): 3%
- Possessions and isolations: 5%
- Schedule 4 costs: 15%

It is important to note that Network Rail senior estimators used their skill and professional judgement in selecting the percentage overlays to be applied by Atkins. They can select from a range. For this study, to reflect the low level of design development, Network Rail elected to use percentage overlays towards to upper end of the range. Atkins considers this as reasonable and appropriate.

A summary is provided by the template, with costs broken down according to group elements sourced from Network Rail's Rail Method of Measurement[12]. These group elements are:

- Railway control systems
- Train power systems
- Electric power and plant
- Permanent way
- Telecommunications systems
- Buildings and property
- Civil engineering
- Enabling works

[12] Network Rail (2014) *Rail Method of Measurement*, Available online: https://www.networkrail.co.uk/rail-method-of-measurement-2-detailed- measurement.pdf [Accessed: 21/09/16]

The result is a scheme by scheme breakdown of estimates by group elements. All estimated costs are provided in 1Q 2015 prices.

Network Rail have been consulted regarding the schemes which involve elements of the classic network and they have undertaken an independent review of the cost estimates. The results from this review are included as a sense-check on the results only.

It is possible that some of the schemes might trigger the need for early renewals of other assets at locations. Where this was known or thought to be likely any early renewals have been included within the direct costs. There remains a risk that unidentified renewals could be triggered but that is true for all rail infrastructure projects and is accounted for within the Network Rail template and approach. It is worth noting that the SA options will replace significant volumes of Network Rail infrastructure. L2E4, for example, includes an upgrade and renewal of much of the overhead line electrification equipment on the East Coast Main Line, and this will push back any requirement for this asset to be renewed by Network Rail.

Costing process for High Speed sections

Parts of the High Speed M18 alignment[13] and Leeds New Lane station were incorporated into all options except Option 1, as was a short section of High Speed track from the current proposed extent of HS2 towards Wilnecote (all options). The costs for the high speed line elements were estimated using rates provided by HS2 Ltd. An estimated sum was produced for Leeds New Lane with 260 metre platforms. Connections to and from the High Speed alignments were costed on the same basis as the classic network schemes except for disruption where the indirect costs for Schedule 4 and Possessions and isolations were reduced to reflect that most of the scheme is new alignment.

Additional capital costs: rolling stock depot

HS2 Ltd provided Atkins with an estimated depot cost including contingencies - £525m in 2016 PV. This figure has not been changed for the SA options as all the SA options still operate 16 high speed trains per hour. This is assumed adequate as whilst some SA options might have more conventional trains on all the key routes it is still less than the number of conventional trains typically run than currently.

6.3.2. Infrastructure optimism bias and sensitivity testing

The SA schemes have typically been worked up to pre-GRIP level - a low level of engineering certainty, which means cost estimates are also inherently more uncertain. The design development of railway schemes progress from GRIP 0 to GRIP 5 in terms of certainty, with single option design being achieved at the end of GRIP 3.

Optimism bias (OB) has been applied to each of the schemes at values recommended by DfT guidance[14]. This is determined by how far the project has been developed. The majority of the schemes related to the existing network are at a 'Project Definition' activity level, pre-GRIP, and so have an OB of 66% of present value capital expenditure added. This level of OB was applied within the Network Rail template. L2E4 also had a 66% OB adjustment added following an appraisal of the design development level in the Arup report.

The sections of high speed alignment which are developed further to an 'Option Selection' level, as advised by HS2 Ltd., have had an OB adjustment of 40% (consistent with HS2 appraisal). For other high speed sections and Leeds New Lane station (with 260 metre long platforms only) and the connections to the conventional network, which fell outside of the M18 alignment, a 66% adjustment was added, reflecting the early development of these alternative routes.

Because of the relatively low level of development and the short programme, it has not been practical to undertake a detailed capacity assessment of whether the schemes proposed as part of SA options are sufficient to deliver the outputs of the TSS. Although Atkins has consulted informally and used appropriate

[13] Department for Transport (July 2016), *M18 / Eastern route section key plan map*, Reference: C321-MMD-RT-DPL-100-580000, 2016 original edition. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/535279/C321-MMD-RT-DPL-100-580000.pdf [Accessed: 07/07/16]

[14] Department for Transport (December 2015), *TAG Unit A5.3: Rail Appraisal*, 2015 original edition. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/487712/TAG_unit_a5.3_rail_appraisal_dec15.pdf [Accessed: 17/08/16]

professional judgement, there is a risk that extra schemes may be required to deliver the TSS operationally. A sensitivity test has been undertaken in which it is assumed that such extra schemes might add 20% to the total capital cost of the proposed infrastructure schemes to deliver each SA option. This sensitivity test is shown in the appraisal results. It should also be noted that some schemes could be overdesigned to deliver the TSS for the SA options.

6.3.3. Rolling stock

All of the SA options require some HS2 classic compatible rolling stock. This is because each of the options involve running on both the high speed and upgraded classic network. Therefore the capital costs of high speed rolling stock costs has been calculated based on a unit price of a classic compatible unit provided by HS2.

Units required for SA Options

In order to identify the rolling stock requirement for incremental HS2 services, the TSS for each option was consulted. This took into account the journey time, routing, stopping pattern, frequency and mileage which underpins the rolling stock calculation.

A total round trip time (RTT) was calculated which included the two way journey time from origin to destination as well as turnaround time for both directions. Atkins has assumed the combined turnaround time for short and medium distance services such as London to Manchester, Liverpool and Birmingham trains to be 40 minutes. Longer distance services such as London to Preston and Glasgow are assumed to have a combined turnaround time of 80 minutes while Birmingham to Newcastle services are assumed to have a combined turnaround time of 60 minutes.

The number of trains required for each service is calculated by dividing the RTT by the frequency. Each of the services within each option were added together to give a total for the number of units required for service, rounded up to the nearest whole number.

The number of spare units for each of the 200m and 260m sets has been assumed to be 5% of the number of train sets required for passenger service, consistent with HS2 Ltd assumptions. Based on this a 'total required for service' was calculated which is the sum of the number required for service and the number of spare units required. The following table provides the incremental HS2 rolling stock requirement for the options

Table 6-2 Incremental HS2 Rolling stock requirement of options

Option	No. of trains by train length		Total
	200m	260m	
1	53	12	65
2S	46	21	67
2L	46	21	67
3	66	21	87
4	42	25	67

Rolling stock costs

Atkins used HS2 Ltd.'s prices of rolling stock (2015 prices). The unit cost of a 260m trainset was prorated from the price of a 200m trainset. The price includes an allowance for contingency (14%), an allowance for future price inflation (15%), and an allowance for project management and procurement (4%). The resulting unit costs of 200m and 260m classic compatible sets are summarised in **Table 6-3**.

Table 6-3 HS2 classic compatible unit cost per trainset

Train length	Cost per set (in 2016 PV)
200m	£20.66m
260m	£26.86m

6.4. Costs: OPEX

Category	Atkins	DfT	HS2	NR
Costs: OPEX	Provided inputs to HS2	Consulted by HS2 Ltd over general principles as part of HS2 wider works	Led using outputs from demand model	
- Optimism Bias		Consulted by HS2 Ltd over general principles as part of HS2 wider works	Part of operating cost calculation undertaken by HS2 Ltd	

The operational costs were calculated by HS2 Ltd, using their model. Atkins therefore received the results of this assessment. The approach is expected to be consistent with HS2 Ltd.'s assessment of operating costs for Phase 2b.

To enable HS2 Ltd to undertake this work, Atkins provided demand modelling outputs describing each option in terms of the **services** (route, frequency, rolling stock type and stopping patterns), **new track mileage** and the **change in mileage** for services on the high speed and classic network.

Services

The service route, frequency and stopping patterns were obtained from the TSS for each of the options.

Service distance utilised information about network length to calculate the number of train services per day based on a 16 hour operating day. This then allowed the total number of unit kilometres to be calculated on both HS2 and the classic network.

The length and location of key points on the network such as the connections onto the classic network were mostly obtained from a combination of Atkins drawings and publicly available HS2 Plans and Profile Maps from both Phase 1 and Phase 2a. A confidential 'M18 alignment' drawing was provided by HS2 Ltd for the purposes of calculating the journey times and distances using the Wilnecote or Mexborough connections.

Track length

In order for HS2 Ltd to incorporate the length of new track required to be built, the total two-way new track length was calculated incrementally. This information is provided in **Table 6-4**.

Table 6-4 New track distance incremental to Phase 2a for each option (km)

Route section	Track Length (Two-Way) Incremental
Option 1	27
Option 2S	114
Option 2L	156
Option 3	114
Option 4	123

Units required for SA Options

Atkins calculated the high speed rolling stock requirement as an increment/decrement to HS2 Phase 2b. To do so Atkins calculated the total hours in traffic for each service taking into account turnaround times, train frequencies, a "spare" requirement (5%). The service frequency (hours), station stops and train length for

each of the routes was developed by Atkins in consultation with the DfT and Network Rail. This is consistent with the model inputs used in the Planet Framework Model.

Changes in total annual train miles by TOC

Atkins also provided HS2 Ltd with the outputs from the demand model which noted the change in total annual train miles by TOC.

The outputs are summarised in **Table 6-5**. It shows the difference in total annual train miles between the each option and HS2 Phase 2b. This table shows the differential in the split between the classic and high speed services for each option.

Table 6-5 Change in total annual train miles by TOC compared to HS2 Phase 2b

	Option 1	Option 2S	Option 2L	Option 3	Option 4
Arriva XC	-723,358	621,873	621,873	33,468	13,197
ICEC	14,504,954	8,224,299	8,224,299	6,135,970	8,224,299
ICWC	596,834	N/A	N/A	N/A	596,834
MML	2,198,278	3,636,777	3,636,777	5,477,875	5,477,875

Optimism bias

The HS2 Ltd operating cost model includes varying rates of optimism bias. SA operating costs have applied the same optimism bias rates.

6.5. Network capacity

Category	Atkins	DfT	HS2	NR
Network Capacity	Led	Consulted	Consulted at workshops	Consulted at route level and at workshops

Atkins has used its professional judgement to assess that the proposed schemes are considered sufficient to operate the proposed TSS for each option. The options were discussed with DfT, HS2 Ltd and Network Rail at the workshops. Atkins has also consulted with the Network Rail route teams informally and included extra interventions wherever a significant capacity issue was raised.

On the WCML, the SA options will operate a broadly similar service to HS2 Phase 2b except on the Manchester branches and between Crewe and Golborne. On the Manchester branches the SA options retain broadly the same levels of high speed train frequency as HS2 Phase 2a, for this reason no extra infrastructure capacity has been added on this route. In HS2 Phase 2b one conventional train will run between Scotland and Euston via Manchester Piccadilly in each hour. It will run through the west side of Manchester Piccadilly station. In SA options 1 and 4 this train is terminated from the north and a separate service operated to reduce the capacity impact between Manchester and Crewe. Between Crewe and Golborne the few extra trains on the conventional network that will need to operate with the SA options bypass the bottleneck between Winsford and Weaver with effective 4 tracking and a new freight route, and operate between Weaver and Golborne with investment in four grade separation schemes and a small section of 4 tracking near Warrington that will allow slower and freight trains to be effectively separated from intercity and high speed services.

On the ECML the SA options 2, 3 and 4 will operate up to 7 tph including “open access paths” between London and Doncaster. HS2 will operate 5.5 paths plus open access which equates to about 1 tph. In addition in all the SA options extra capacity has been added through grade separation at Newark and better use of the GN/GE facilitated by work at Doncaster. Because SA Option 1 operates extra trains it also includes 4 tracking through Welwyn North unlocking the biggest capacity bottleneck on the ECML. Between Doncaster and Colton Junction (south of York and just north of where HS2 Phase 2b is proposed to join the ECML) the SA options operate up to 5 tph from London and up to 2 tph from Birmingham. The existing line capacity should be able to accommodate this particularly after the recent investment in Shalftholme junction and Doncaster station platform; however, to aid performance two freight curves are proposed. These extend

the GN/GE route so that freight trains from the GN/GE (and via Conisborough) do not cross Doncaster on the flat but can run Kirk Sandal to the Humber ports, via Joan Croft to Colton Junction or via Skellow Junction. Between Colton Junction and Newcastle HS2 Phase 2b and the SA options will operate the same number of trains although the SA options have included costs for capacity works at Darlington. North of Newcastle the assumption is that 6 additional loops in addition to new loops at Grantshouse will be sufficient.

On the Midland Main Line, the SA options effectively duplicate the HS2 Phase 2b trains service frequencies south of Trent Junction. From Trent to the north the increments in trains are accommodated by grade separation of Stenson Junction (adjacent to the Midland Main Line) and further grade separation of Trent Junction (the key Midland Main Line junction), works in Derby, smaller scale works between Derby and Chesterfield consistent with a rail industry study into options to serve Sheffield which also includes Network Rail works between Derby and Chesterfield, the rebuilding of the Tapton old road line which bypasses Sheffield and a new high speed line from Sheffield to Leeds.

6.6. On train capacity

Category	Atkins	DfT	HS2	NR
On train capacity	Used HS2 capacity figures (or pro-rated them as appropriate)	Consulted on methodology	Calculated passenger capacity per 200m HS2 train	

Prior to modelling, Atkins used its professional judgement to assess that the proposed schemes are considered sufficient to operate the proposed TSS for each option. The options were then shared with DfT, HS2 and Network Rail at the workshops. However there was no time in the programme to assess the crowding impact and then vary the TSS or schemes to mitigate any crowding that might arise. This is critical because in some places crowding might be reduced with relatively small expenditures or schemes reduced in (operating or capital) cost where expected demand did not materialise.

Atkins has assessed the total number of seats provided by SA and HS2 Phase 2b between selected cities and London.

Some key assumptions have been applied to the assessment, such as:

Conventional

- ECML trains are all 9 car IEPs with 611 seats even though in practice some are 10 car IEPs with 606 seats;
- Open Access trains are 5 car 180s with 264 seats;
- MML trains are 10 car IEPs (2 5-car) with 636 seats; and
- WCML trains are 9 car class 390s with 468 seats.

High Speed

- 200m trains with 550 seats;
- 260m trains with 715 seats; and
- 400m trains with 1,100 seats.

Details are also provided regarding the total seat kilometres operated by HS2 and SA options as modelled. Finally an overview of the crowding levels forecast on each of the SA service groups is provided.

6.7. Punctuality and reliability

Category	Atkins	DfT	HS2	NR
Punctuality and reliability	Adopted HS2 methodology	Consulted	Provided the methodology	

HS2 has accounted for improved reliability and punctuality within their demand model and the same approach has been adopted in the modelling of the SA options. The “spare” network capacity generated by both by HS2 and the SA options on the conventional network is likely to have further reliability and punctuality benefits in addition to this for services on the conventional network but it will be difficult to quantify what this might be or make any differentiation between HS2 and SA, and any such assessment would need to part of a more detailed approach looking at other impacts.

The HS2 process assumes that trains using the high speed line will enjoy a reduction in average minute lateness. This was factored into a rate per km during the development of the business case for HS2 Phase 1. The same approach has been used for HS2 Phase 2a and HS2 Phase 2b. In summary the longer trains are able to operate on the new high speed line the less is their likelihood of being delayed.

This reduction in delays can be expressed as having an impact in demand. Passengers are more likely to travel on more reliable services. The SA options have used the same approach where services use the high speed line.

Please note that no additional benefit for reliability has been claimed by HS2 for the reduced number of conventional services operating over the conventional network following their diversion to HS2. No benefit for reliability has been claimed by the SA options where services levels are reduced against the base case, for the proposed infrastructure investment or the reduction in the splitting and joining of HS2 services.

Please note that the SA options will typically be less punctual and less reliable than HS2 on the HS2 trunk sections as SA options require 10 more trains per hour to operate over the conventional network than HS2. This impact has not been quantified.

6.8. Disruption

Category	Atkins	DfT	HS2	NR
Disruption	Consulted over scheme designs	Consulted at workshops		Led

Network Rail undertook an assessment of the disruption impact of constructing the SA options. As the scheme designs are at an early stage of development, they have changed over time and Atkins have consulted with Network Rail who have provided updated disruption analyses. The DfT were also consulted at the workshops related to the SA project.

The output received from Network Rail was an assessment of the likely possession time required for each scheme in terms of the number of weekday nights (4 hour period across 4 days per week maximum), 28 hour, 54 hour and greater than 54 hour blockades, along with descriptive commentary where applicable. The approach was to maximise weeknight working, with weekend possessions as extra on top of this.

Ideally the disruption would have been quantified as a cost, however in line with other projects at this early stage of design development, Atkins applied a factor to the capital costs of 15% to account for disruption costs and a further 5% for possessions, even where diversionary routes are available. This figure of 15% + 5% was advised by Network Rail based on their recent project experience.

In this report the disruption impact is presented as the number of possessions required for each option, grouped by route. A second table identifies the number of possessions required for each option.

There are some caveats which should be considered whilst reading the disruption results:

1. This analysis is for rail-related disruption only;
2. The calculated disruption does not differentiate between the main line and secondary routes for each scheme. For example at Newark most of the disruption will be to the Nottingham to Lincoln line rather than the ECML. As a result disruption on the heavily-used sections of the WCML, MML and ECML will be less than stated;
3. The estimates are indicative best estimates, reflecting the early stage of scheme development;
4. There are no set timescales for the spread of the disruption, for example longer blockades could be used as an alternative to weeknight /weekend possessions, particularly on overnight freight routes;
5. Variables such as scheme design are subject to change; and

The disruption and subsequent mitigation of each scheme will be a product of discussions between railway customers and Network Rail, which may change the balance between different types of possessions.

Network Rail and Atkins have also identified methods of reducing the impact of the identified periods of disruption. For some schemes, avoiding disruption was included within the design. For example in order to deliver the upgrades on the WCML between Winsford and Weaver Junction it is proposed to complete the proposed works for the Sandbach to Hartford Junction line in advance, providing a diversionary route. Despite this a disruption overlay was included for both schemes. For other schemes alternative diversionary routes have been identified where available although this report has not assessed the capacity of these diversionary routes which requires further detailed analysis.

It should also be noted that some schemes were amended with additional or reduced elements prior to report completion. Disruption information has therefore not been generated for the following:

- **Connection to M18 alignment:**
  - Disruption for the north of Sheffield to HS2 M18 alignment - although it is possible this disruption would be included within the assumed electrification north of Sheffield.
  - Disruption for the upgrade of the 'Old Road' will only lead to minimal freight diversion with limited capacity issues elsewhere, would be phased to ensure the route is open if the route via Dore into Sheffield is closed.
  - High speed crossings between Tapton and Clay Cross were a late addition.
  - The Clayton Junction connection from the Sheffield to Leeds line to the M18 alignment has not been assessed. This is an HS2 scheme.
- **Stenson Junction and Castle Donnington:**
  Disruption for the upgrade of the Castle Donnington route will only lead to minimal freight diversion with limited capacity issues elsewhere.

6.9. Environment

Category	Atkins	DfT	HS2	NR
Environment	Qualitative assessment only	Consulted	Consulted at workshops	Consulted at workshops

A high level environmental assessment was undertaken for each SA scheme to minimise known locations of environmental sensitivity. No location has been proposed with environmental issues that are known to be unmanageable, however, it is possible at the low level of current design that environmental issues may emerge with some schemes.

6.10. Appraisal

Category	Atkins	DfT	HS2	NR
Appraisal - Process	Led	DfT approved methodology	Calculated some elements	
- Demand and benefits calculation	Led using HS2 model	Consulted	HS2 demand model used.	

6.10.1. Process

The appraisal methodology is consistent with DfT WebTAG guidance. A 60 year appraisal, with the opening year of 2033, has been assumed for all the SA options. Costs and benefit streams were developed to be consistent with the HS2 Phase 2b appraisal. The demand and operating costs models utilised for SA options are the same models that underpins the HS2 Phase 2b assessment.

An allowance for infrastructure renewals is also included based on the assumptions that asset value equivalent to 20% of the capital costs associated with Tunnels, Civil Engineering, and Stations will be required to be renewed at 50,40, and 40 years respectively. For Rail Systems, 15% asset value has been assumed to require renewals at 20 year intervals. The renewal estimates also includes a 20% contingency.

The benefits and costs stream were discounted to 2016, converted to market prices, and BCRs for each option were determined.

All appraisal has been undertaken using a 2016/17 discount year.

Chapter 7 provides details of the appraisal results.

6.10.2. Demand and benefits analysis

The demand and benefits of each alternative option have been assessed using version 6.1c of the PLANET Framework Model. The same version of this model has been used to assess the case for HS2 Phase 2b, and the mechanism by which the benefits of HS2 and the alternatives have been determined is therefore broadly comparable. This ensures consistency of key assumptions such as: how the demand cap is implemented; the values of travel time savings; the definition of the do minimum scenario; the approach to calculating benefits; and, the calibration of the model. Within the appraisal all costs and benefits are presented as a 2016 present value.

It is important to note that the demand model used, in line with standard appraisal guidance, has a cap on growth from 2036. The impact of this cap on HS2 Phase 2b is likely to be greater than for the SA options because HS2 is likely to be missing out on more benefits from more missing passengers.

Wider Economic Benefits have been calculated by linking PFMv6.1 with DfT's WITA model. Again this follows the approach used by HS2 Ltd for the appraisal of HS2. However due to a known issue with the integration of PFM with WITA, the agglomeration benefits for the alternative options have not been fully calculated for short distance trips that are modelled within the PLANET Midlands element of the PLANET Framework Model.

7. Results

7.1. Summary

This section summarises the results from each assessment element in the following order:

- Journey time results and comparison
- CAPEX: capital costs
- OPEX: operating costs
- Network capacity assessment
- On-train capacity assessment
- Punctuality and reliability
- Disruption
- Environment
- Appraisal

7.2. Journey time results and comparison

The journey times for Phase 2b, do minimum and the five assessed options are provided in **Table 7-1** for London and **Table 7-2** for Birmingham. Where more than one time is shown, it reflects the range that results from different stopping patterns and different rolling stock used.

Table 7-1 London journey times[15]

Destination	HS2 Phase 2b (2013 consulted route)[16]	Do minimum: HS2 Phase 2a[17] or conventional	Option 1	2S	2L	3	4
Nottingham	0:52 (Toton)	1:30	1:12 2tph	1:12 1tph		1:12 1tph	1:23 2tph
Derby	0:52 (Toton)	1:26	0:57 2tph	0:57 1tph 1:02 1tph		0:57 1tph 1:02 1tph	1:02 2tph
Sheffield	1:09 (Meadowhall)	1:55	1:23 2tph	1:23 1tph 1:31 1tph		1:23 1tph 1:31 1tph	1:27 1tph 1:31 1tph
Leeds	1:15[18] 1:22 with stops	2:06	1:48 2tph 1:59 1tph	1:35 2tph 1:48 1tph	1:30 2tph 1:48 1tph	1:35 2tph 1:48 1tph	1:35 2tph 1:52 1tph
Newcastle	2:19	2:35	2:26 2tph	2:26 2tph		2:35 1tph 2:39 1tph	2:26 2tph
Edinburgh	3:40	4:05	3:49 2tph	3:49 2tph		3:50 1tph 3:54 1tph	3:49 2tph
Manchester	1:08 non stop 1:11 1 stop	1:27	1:17 non stop 1:20 1 stop	1:20 3tph		1:20 3tph	1:17 1tph 1:20 1tph
Glasgow	3:40	3:42	3:45 1tph 3:48 1tph	3:45 1tph 3:48 1tph		3:49 1tph 3:53 1tph	3:45 1tph 3:48 1tph

[15] Journey times on HS2 (in both Phase 2b and SAs) include a stop at Old Oak Common.
[16] HS2 journey times have been calculated using the Train Service Specification in the current Economic Case modelling for Phase 2b for the 2013 consulted route via Meadowhall.
[17] HS2 Ltd (2016) *HS2 Phase Two West Midlands to Crewe: Economic Case*
[18] HS2 Ltd advise that a London-Leeds service would take 1:15 if the Toton stop assumed in the business case was removed. This would require a change to the modelled train service specification.

Table 7-2 Birmingham journey times

Destination	HS2 Phase 2b (2013 consulted route)	Do minimum: HS2 Phase 2a or conventional	Option 1	2S	2L	3	4
Nottingham	0:20 (Toton)	1:14	0:37 2tph	0:42 2tph		0:42 2tph	1:14 2tph
Derby	0:20 (Toton)	0:35	0:29 1tph 0:35 1tph	0:26 2tph		0:26 2tph	0:26 2tph
Sheffield	0:37 (Meadowhall)	0:65	0:58 1tph 1:00 1tph	0:52 1tph 0:56 1tph		0:56 2tph	0:56 2tph
Leeds	0:54	2:00	1:40 1tph 1:43 1tph	1:17 1tph 1:21 1tph	1:18 1tph 1:22 1tph	1:07 1tph 1:21 1tph	1:07 1tph 1:21 1tph
Newcastle	2:03	3:10	2:29 1tph	2:40 2tph		2:54 1tph	2:54 1tph
Edinburgh	3:11	4:01	3:26 0.5tph	3:26 0.5tph		3:26 0.5tph	3:26 0.5tph
Manchester	0:41	1:28	1:10 2tph	1:10 2tph		1:10 2tph	1:10 2tph
Glasgow	3:20	3:56	3:29 0.5tph	3:29 0.5tph		3:29 0.5tph	3:29 0.5tph

The alternatives deliver significantly faster journey times than the “do minimum” (with HS2 Phase 2a) to many of the key HS2 destinations. However, HS2 creates faster journey times between London and Leeds, Manchester, Newcastle, Toton (for Nottingham and Derby) and Sheffield that are typically about 10 minutes faster than the SA options. There are fewer differences to the other HS2 destinations although to compensate for slower running speeds the SA options rely on changes to the stopping pattern and/or the removal of splitting and joining of HS2 services. HS2 delivers transformative faster journey times between cities in the North and the Midlands in line with the economic priorities of Transport for the North and Midlands Connect which seek to support growth in knowledge-based sectors, increasingly located in major cities. The SAs cannot match this connectivity, with journey times between Birmingham and the major cities in the North and Midlands that are typically between 15 and 30 minutes slower than HS2 Phase 2b (2013 consulted route) for services with equivalent stopping patterns.

7.3. Capex cost results

7.3.1. Infrastructure

An overview of the estimated costs for each option is provided in **Table 7-3**. A more detailed scheme by scheme breakdown is provided in **Appendix A**.

Table 7-3 SA option costs (£m) (1Q 2015 prices)

Option	Option 1	Option 2S	Option 2L	Option 3	Option 4
Total	£10372m	£12934m	£14270m	£9936m	£11938m

Atkins’ option estimates were validated by Network Rail and these were used in the appraisal. At the same time, Network Rail continued to develop the schemes. As a result the latest estimates are not directly comparable to Atkins’ estimates which were used in the appraisal, as:

1. The scope of each scheme may have changed since the original design.
2. A different approach to the costs of disruption has been used in the latest costings.

3. For any schemes which have increased in cost, SA options would have looked to remove or re-scope the scheme. Conversely, for schemes which have decreased in cost, this shows the strength of SA schemes in the opportunity to reduce costs.

The latest cost estimates were not received in time to be used in the appraisal but have been included to provide context. There are no BCRs produced using Network Rail's most recent costings as the costs are not directly comparable. **Table 7-4** summarises the total cost estimate per option using the latest Network Rail estimates (lower and upper values) where these are available. Where updated costs were not provided, Atkins' original costs have been used. Both sets of costs are in the same price base, 1Q 2015.

Table 7-4 Indicative SA option cost estimates with latest NR figures (£m) (1Q 2015 prices)

Option	Option 1	Option 2S	Option 2L	Option 3	Option 4
Total (low range)	£9998m	£12459m	£13795m	£9629m	£11824m
Total (high range)	£12491m	£14701m	£16037m	£11522m	£13677m

7.3.2. HS2 rolling stock

A summary of the high speed rolling stock costs is provided in **Table 7-5**.

Table 7-5 PV of incremental rolling stock

OPTIONS	Classic Compatible		PV of HS2 Rolling Stock Capex (£bn) including maintenance and renewals (2016 PV)
	200m units	260m units	
Option 1	53	12	**£2.2**
Option 2S	46	21	**£2.4**
Option 2L	46	21	**£2.4**
Option 3	66	21	**£3.1**
Option 4	42	25	**£2.5**

Option 1 requires the fewest number of incremental HS2 trainsets followed closely by Options 2 and 4. Option 3 requires an additional 20 trains. This is principally since options 1, 2 and 4 involve upgrading the ECML, which would be delivered by standard (non HS2 trains). The costs for this conventional rolling stock is captured within the OPEX assessment.

7.4. Costs: OPEX

The incremental operating costs from Phase 2a for each of the options are summarised in **Table 7-6**. 'HS2 services' refer to services which operate at least partially on the high speed network, with 'classic line' not operating on any high speed infrastructure. The final row is the net total of the operating costs for each SA option.

Table 7-6 OPEX costs

Opex costs (£bn PV 2016)	Opt 1	Opt 2S	Opt 2L	Opt 3	Opt 4
HS2 services	£13.3	£13.5	£13.4	£16.0	£13.8
Classic line	-£0.6	-£3.9	-£3.9	-£4.2	-£3.3
Total Opex	£12.7	£9.6	£9.5	£11.8	£10.6

Option 1 has the most classic line running as a result of Edinburgh and Leeds being served via the ECML and therefore sees the lowest level of savings in classic line operating costs. Similarly, Option 3 which serves Edinburgh via HS2 has the largest saving in classic line operating costs. This difference is enhanced as classic line rolling stock costs are incorporated into OPEX, whereas the rolling stock cost for HS2 services are included as a separate CAPEX item.

7.5. Network capacity assessment

Atkins used its professional judgement to assess whether the proposed infrastructure investments were considered sufficient to robustly operate each SA option. Care was taken to future proof the SAs by avoiding using last paths over capacity constrained bottlenecks in particular. This was reviewed and refined though discussions with DfT, HS2 Ltd and Network Rail. No timetabling was undertaken. In recognition of this and the risk that additional schemes may be required a sensitivity test has been undertaken showing the potential impact if extra schemes were required.

In most cases where the SA options have had to invest in infrastructure schemes at key bottlenecks to facilitate the extra trains or speeds required by the SA TSS, the schemes typically also generate some additional "spare" capacity. In addition the SA options build an extended freight route on the ECML (and a much shorter freight route on the WCML) which frees further capacity. In comparison HS2 generates "spare" capacity both on its own network and on the conventional network because the number of conventional trains on the existing intercity routes are fewer than currently, as services switch to using the high speed line.

In summary, therefore, both HS2 and the SA options create extra ("spare") capacity on the national network for other services. However, only HS2 creates extra capacity for potential additional high speed services on the high speed line on the eastern and western legs north of Birmingham. In effect they extend Phase 2a into a new national network. It is this network that is being considered for additional train services by stakeholders such as Transport for the North and Midlands Connect.

The main difference between the SA options is set out below, summarising passenger capacity in **Table 7-7** and freight capacity in **Table 7-8**.

Table 7-7 Passenger capacity

Route	Option 1	Option 3	Options 2S + 2L + 4
ECML	RA generates excess capacity to today on core ECML through investments e.g. Newark, Darlington and Welwyn etc. Slightly less capacity on some branches than today (e.g. Lincoln) because of some enhanced local services.	RA generates significant uplift in extra and excess capacity released through 7 tph TSS and investment in Newark, Darlington and in freight chords. Slightly less capacity on some branches than today where there are additional London services (for example this means an extra train every two hours between Lincoln and Newark).	RA generates significant uplift in extra and excess capacity released through 7 tph TSS and investment in Newark, Darlington and in freight chords. Extra capacity Edinburgh – Newcastle also through loops. Slightly less capacity on some branches than today (e.g. Lincoln) because of some enhanced local services.
MML	Releases capacity through use of Burton link but no capacity released between Trent junction (HS2 propose to run 1 tph less) to / from St Pancras because the HS2 do minimum level of service is retained.	As per option 1	As per option 1

Route	Option 1	Option 3	Options 2S + 2L + 4
WCML	Generates extra (and some excess capacity) on Crewe – Warrington/Preston section of WCML. On some branches no uplift in capacity but quantum of trains largely as today. Sandbach branch capacity enhanced.	As per option 1	As per option 1

Table 7-8 Freight services network capacity

Route	Option 1	Option 3	Options 2S + 2L + 4
ECML	Uplift due to investment on GN/GE extension to Colton Junction, Newark flyover, freight loops north of Newcastle and at Darlington. Extra capacity on Edinburgh – Newcastle through loops but extra trains also. Enhanced passenger service to Hull + Middlesbrough + Lincoln reduces capacity for freight on these routes but impact less than 1 tph.	As per Option 1 (including capacity from freight chords near Doncaster) but: Extra capacity released through M18 route on Wakefield branch. No extra capacity Newcastle – Edinburgh but no of ICEC trains reduced.	As per Option 3 but: Extra capacity on Edinburgh – Newcastle through loops but extra trains also
MML	Increase in capacity from Burton 4 tracking and Trent flyover + electrification, but loss of capacity on Castle Donnington freight route due to use by passenger services.	As per option 1 but: Extra capacity released through M18 route on MML between South Yorkshire and Leeds.	As per option 1 but: Extra capacity released through M18 route on MML between South Yorkshire and Leeds.
WCML	Increase in capacity through "4" tracking Winsford – Weaver and 2 tracking Sandbach and through Warrington area schemes. Some extra IC trains but less than extra capacity.	As per option 1	As per option 1.

Table 7-9 below compares the network capacity impact of HS2 Phase 2b and SA options over key sections of route.

Table 7-9 Network capacity comparison

Section	HS2 Phase 2b	SA options	Comparison
Crewe - Preston	New route diverts 3 tph off high speed trains from this section of the WCML between Wigan and Crewe with 2 tph remaining on the WCML via Warrington (1 HS2, 1 residual).	Through virtual doubling of route (including grade separation and building freight diversionary route) total train capacity increased by between 50 and 100% - or approximately by 8/16 tph each way. Some benefits to existing users through improved performance of junctions e.g. freight to/from/via Sandbach	SA releases more capacity on the existing network than HS2 Phase 2b, but less than the total "spare" classic and high speed capacity generated by HS2
Preston - Carstairs	Service patterns on this section subject to ongoing work by HS2 and NR	Similar to HS2 but options 1 and 4 have +1 tph compared with HS2 on southern section but no split/join at Carstairs.	Similar to HS2 but options 1 and 4 have +1 tph compared with HS2 on southern section but no split/joining at Carstairs
Crewe - Manchester via Stockport	New route diverts 3 tph from existing lines but reinstates 1 tph – net impact 2 tph	No capacity change. SA uses the same number of paths as HS2 Phase 2a.	HS2 Phase 2b releases 2+ tph more than SA and provides "spare" capacity on the new high speed branch to Manchester
Birmingham – East Midlands	New route but all services are additional to today so no material impact	SA 4 tracks Tamworth – Stenson and grade separation on Stenson junction so generates around 50% "extra capacity" on key Cross-Country and freight route	Similar levels of "spare" capacity on the classic network are released, but HS2 generates additional high speed "spare" capacity.
Midland Mainline (Trent area)	Despite diverting some MML services, HS2 business case also includes some enhancements to local services which are probably equal in terms of impact	All SA options – except SA option 3 - include further grade separation of Trent but SA options also operate more trains so benefit is marginal	Similar on southern end because of additional local services broadly match between SA and HS2 although composed differently.
Sheffield	2013 consulted route (Meadowhall) option diverts up to 1+/2 tph away from Sheffield	Additional trains only marginally off-set by additional capacity schemes. Varies between options. Broad approach consistent with	2013 consulted HS2 options releases more capacity

Section	HS2 Phase 2b	SA options	Comparison
		HS2 Ltd.'s proposed Sheffield (M18) option	
ECML Welwyn - Doncaster	HS2 reduces ICEC and Open Access to 5.5 tph. Currently there are track access rights for up to 8 tph.	Options 2, 3 and 4 reduce ICEC to 7 tph and increases capacity at Doncaster and Newark. Option 1 increases ICEC to 10 tph but 4 tracks line through Welwyn North station which adds 4 tph at this key bottleneck.	Options vary but similar.
Doncaster – Colton Junction	Reduces number of ICEC and Open Access to 4.5 tph through Doncaster and 3.5 tph to Joan Croft Junction	Options 2, 3 and 4 reduce through existing services levels to around 6.5 tph but also includes grade separation allowing all north-south freight to avoid this section. Option 1 requires 9.5 IC-EC trains to run through Doncaster but has fewer Cross Country trains and also includes grade separation at Doncaster for freight.	Other than for option 1 SA provide similar or higher levels of capacity than HS2 Phase 2b. SA option 1 provides less capacity than HS2 Phase 2b.
Northallerton – Newcastle	HS2 will operate 6 tph long distance after Phase 2b (including Cross Country) with no infrastructure improvements	All SA options also operate 6 tph in total but with some infrastructure investment in addition – mainly at Darlington to remove up London and Middlesbrough crossing movements (c.4 tph)	SA generate extra capacity but HS2 could do the same with additional investment
Newcastle - Edinburgh	Intercity services reduced to 2 tph – although in Edinburgh station 4 tph each way will operate.	Intercity services operate up to 4 tph each way with additional infrastructure to loop freight trains	Marginal benefits although HS2 simpler to operate south of Edinburgh.

7.6. On train capacity results

The Strategic Alternative options roughly match or slightly better the train frequencies of HS2 Phase 2b. However HS2 is currently modelled as operating significantly longer trains (400 metres in length) than the SA options to the key destinations of Manchester, Leeds, Sheffield Meadowhall and Toton. Although the SA options vary, typically they operate longer trains (260 metres) all day than assumed in the HS2 demand model (200 metres) to other destinations including York, Newcastle, Liverpool, Glasgow and Edinburgh, and more trains to Derby and Nottingham (rather than Toton). DfT have advised Atkins that no final decision has yet been taken about HS2 train lengths.

Table 7-10 highlights the different rolling stock proposed for each option (high speed, non-conventional services only).

Table 7-10 Rolling stock for high speed services for each option, compared to today's conventional services

	Current	Phase 2a (do min')	Phase 2b	SA 1	SA 2, 3 + 4
Euston HS2 - Manchester	11 car Pendolino	200 m HS2	400 m HS2	260 m HS2	260 m HS2
Euston HS2 - Birmingham	11 car Pendolino	200 m HS2	400 m HS2	400 m HS2	400 m HS2
Euston HS2 - Scotland	11 car Pendolino	200 m HS2	400 m HS2	400 m HS2	400 m HS2
Euston HS2 - Liverpool	11 car Pendolino	200 m HS2	200 m HS2	260 m HS2	260 m HS2
Birmingham + Manchester HS XC services	n/a	200 m HS2	200 m HS2	200 m HS2	200 m HS2
Euston – Leeds	n/a	n/a	400 m HS2	n/a	260 m HS2
Euston via Derby/Sheffield	n/a	n/a	400 m HS2	260 m HS2	260 m HS2
Nottingham	n/a	n/a	200 m HS2	200 m HS2	200 m HS2

The following table shows the number of seats per hour (taken from HS2 Ltd.'s demand model) on direct trains from London to key HS2 destinations (high speed and intercity). **Table 7-11** shows the total seat capacity on conventional and high speed services in HS2 Phase 2b and SA Options 1 and 3.

For both the SA options and HS2 Phase 2b we have shown the maximum number of seats in an hour where train lengths vary across the day. Generally the tables show that SA options operate more seats than the "do minimum" and will operate fewer seats than HS2 to some key HS2 destination cities. Some of the SA services could be lengthened further in principle with further infrastructure investment.

Table 7-11 Number of seats provided into key cities from London per hour, for all High Speed and residual services

Destination city	HS2 Phase 2b (consulted route)	SA option 1	SA option 3
Toton/Derby + Nottingham[19]	5,208[20]	5,074[21]	4,524[22]
Leeds	3,361[23] (3,911[24])	2,444[25]	3,471[26]
York	3,177[27] (2,627[23])	1,598[28]	2,209[29]
Newcastle	2,322[30]	2,444[31]	2,444[32]
Edinburgh	1,711[33]	1,833[34]	2,016[35]
Manchester	3,768[36]	2,860[37]	2,613[38]
Liverpool	1,100[39]	1,430[40]	1,430[41]

[19] Total for SA options are for both Nottingham and Derby.
[20] Toton seat capacity consists of 3 x 400m HS2 (3300 seats) + 2 x IEP (EM IEP assumed to be 10-car and have 636 seats) to Derby (1272 seats) + 1x IEP to Nottingham (636 seats) – 5,208 seats. Toton seat capacity is a range subject to whether 200m or 400m HS2 trains are used to Leeds. Either 3 x 400m HS2 OR 2 x 200 HS2 + 1 x 400 HS2 (before split at Meadowhall), (incudes 2 x IEP EM to Derby with 4 and 8 intermediate stops + 1 x IEP to Nottingham with 5 intermediate stops) – 4,108 seats. Note maximum is shown in table.
[21] To Derby + Nottingham city centres: 2 x 260m HS2 (Derby) + 2 x 200m HS2 (Nottingham) + 4 x IEP (2xDerby and 2xNottingham)
[22] To Derby + Nottingham city centres: 2 x 260m HS2 (Derby) + 1 x 200m HS2 (Nottingham) + 4 x IEP EM (1xDerby and 3xNottingham)
[23] Leeds seat capacity is a range subject to whether 200m or 400m HS2 trains are used. Either HS2 2 x 400m + 1 x 200m HS2 (after split at Meadowhall) + 1 x IEP (EC IEP assumed to be 9-car and have 611 seats) to West Yorkshire = 3,361 seats OR HS2 3 x 200m + 1 x IEP to West Yorkshire which equals 2,261. Maximum number of seats shown in table.
[24] There are choices to be made about the exact split of capacity between York and Leeds. The alternative figures show the capacity provided with 3 400m trains per hour to Leeds. Atkins agree that this configuration would be possible.
[25] 4 x IEP
[26] 4 x 260m HS2 + 1 x IEP
[27] 3 x 200m HS2 and 2.5 x IEP To Leeds and Middlesbrough
[28] 2.5 x IEP. Trains that run through but do not stop are not counted. Also 0.25 x Class 180 (284 seats).
[29] 3.5 x IEP. Also 0.25 x Class 180 (284 seats).
[30] 2 x 200m HS2 and 2 x IEP
[31] 4 x IEP
[32] 4 x IEP
[33] 2 x 200m HS2 + 1 x IEP
[34] 3 x IEP
[35] 2 x 200m HS2 + 1.5 x IEP (1 390 via Manchester excluded)
[36] 3 x 400m HS2 and 1 x 390
[37] 4 x 260m HS2
[38] 3 x 260m HS2 and 1 x 390
[39] 2 x 200m HS2
[40] 2 x 260m HS2
[41] 2 x 260m HS2

Atkins has examined the seat numbers excluding those services that are overtaken. This gives similar headline results but with variations across key cities.

Atkins have also completed a comparison of seat kilometres operated for high speed services and intercity services on the WCML, ECML and MML. The results show that SA options operate between 94-98% of the seat kilometres operated by HS2.

Table 7-12 Seat kms by TOC for each option per day (millions)

TOC	HS2	Option 1	Option 2S	Option 2L	Option 3	Option 4
HS2	201m	148m	155m	154m	169m	157m
ICEC	36m	76m	59m	59m	53m	59m
ICWC	27m	28m	27m	27m	27m	28m
MML	19m	23m	25m	25m	28m	28m
Total	283m	276m	265m	265m	277m	272m

Crowding analysis using the demand model suggests that there is little total difference across the SA options if all flows are taken into account. The load factors below are the range in average loading figures for each service at its busiest point.

Table 7-13 Service load factor ranges by route and option

Route	Option 1	Option 2S	Option 2L	Option 3	Option 4
London to Manchester	45 – 63 %	66 – 67 %	66 %	64 – 68 %	42 – 60 %
Manchester to London	38 – 70 %	65 – 66 %	65 – 66 %	64 – 68 %	37 – 69 %
Liverpool to London	51 – 73 %	56 – 75 %	56 – 75 %	57 – 80 %	51 – 74 %
London to Liverpool	54 – 72 %	59 – 73 %	59 – 73 %	61 – 78 %	54 – 72 %
London to Preston	65 %	63 %	63 %	72 %	59 %
Preston to London	67 %	65 %	65 %	75 %	63 %
London to Scotland	54 – 75 %	65 – 74 %	65 – 74 %	62 - 69 %	65 – 73 %
Scotland to London	30 – 77 %	63 – 75 %	63 – 75 %	65 – 72 %	59 – 63 %
London to Leeds	39 – 53 %	56 – 81 %	61 – 81 %	57 – 69 %	61 – 82 %
Leeds to London	41 – 51 %	55 – 85 %	61 – 84 %	56 – 73 %	62 – 86 %
London to Newcastle	62 %	54 %	53 %	23 – 38 %	55%
Newcastle to London	55 %	60 %	59 %	22 – 38 %	60 %
London to Carlisle	46 – 48 %	55 – 63 %	55 – 63 %	N/A	56 – 59 %
Carlisle to London	51 – 56 %	57 – 62 %	57 – 62 %	N/A	57 – 62 %

7.7. Reliability results

The appraisal of the SA options captures the reliability benefits of new infrastructure in the same way as the appraisal of HS2, and this has been taken into the demand model. However, in total, the additional network resilience that will derive from having a new line built to modern standards of resilience will be less for the SA options than HS2 because there will be less new line.

No benefit has been claimed by HS2 or by the SA options for the punctuality and reliability benefit on the existing network from infrastructure investment proposed by the SA options and from released capacity from HS2, and no benefit has been claimed for any increase or reduction in the splitting/joining of services. The SA options will typically be less punctual and less reliable than HS2 on the HS2 trunk sections as SA options require 10 more trains per hour from London and Birmingham in each direction to run off HS2 and on to the conventional network.

7.8. Disruption results

Network Rail has undertaken an assessment of the disruption impact of constructing the SA options.

Table 7-14 provides a breakdown of the possessions for each route and then each option. A key point to note is that whilst the disruption has been grouped into WCML, ECML and MML categories it does not necessarily translate into an impact on the main line in either option, for example the WCML impact includes 154 28-hour possessions on the Sandbach route, which will mostly not be disruptive to the WCML as this is a lightly used freight route at present. Similarly for Newark on the ECML, most of the disruption will be to the Lincoln to Nottingham route with much less disruption on the ECML itself. Further detail can be found in **Appendix B**.

Table 7-14 Possessions for each option per route

Route	Option	Possession length			
		Week nights	28 hours	54 hours	54 hours +
ECML	1	360	19	16	3
	2	90	15	14	0
	3	20	9	6	0
	4	90	15	14	0
MML	1	250	2	6	0
	2 – M18 Long	265	8	9	0
	2 – M18 Short	280	4	13	0
	3	280	4	13	0
	4	30	2	7	0
WCML	1	725	298	54	5
	2	710	291	52	4
	3	710	291	52	4
	4	725	298	54	5
Other (Cross Country)	1	637	57	19	12
	2	637	57	19	12
	3	637	57	19	12
	4	627	53	14	10

Table 7-15 Possessions per option

Option	Possession length			
	Week nights	28 hours	54 hours	54 hours +
1	1972	376	95	20
2 – M18 Long	1702	371	94	16
2 – M18 Short	1717	367	98	16
3	1647	361	90	16
4	1472	368	89	15

Therefore in summary, across the whole network, the SA options would each take:

- Between 1,500 and 2,000 weeknight closures;
- Approximately 360 “equivalent Sunday” closures; and
- Around 100 full weekend or extended weekend closures.

Some disruptive schemes in terms of quantum of possessions (such as the route via Sandbach) affect only a limited number of services.

For the disruptions on the ECML, WCML and MML there are diversionary routes albeit with constraints – both existing and proposed as part of SA – which could reduce the disruption impact on services. The most disruptive closures are likely to be to passenger services on the Cross Country route between Wichnor Junction and Derby, as after Wichnor Junction trains can avoid disruption by diversion into and out of Birmingham via Lichfield City. There are alternative routes for most freight traffic.

So, whilst SA options initially appear to be disruptive the only route with severe disruption with no diversionary route is likely to be the Cross Country route between Wichnor Junction and Derby. On all other main lines the impact of the disruption is mitigated with diversionary routes available for at least some train services.

Schemes are in an early stage of development and will be designed with disruption in mind. Schemes with very high levels of disruption will be discarded and different schemes developed where practical. In addition, the schemes would also be subject to consultation with Network Rail’s customers to develop a suitable implementation programme. Naturally where possible NR would try to combine physical works, including with planned renewals, so that the total number of possessions can be minimised where possible by carrying out several works within one possession.

HS2 Ltd have not published an assessment of the disruption impact for the existing network so no direct comparison can be made. In addition the HS2 schemes are still evolving with support from Network Rail to minimise the impact on passengers and freight.

Standard overlays for the cost of disruption, possessions and compensation have been included within the capex estimates for the SA options – typically around 20% of direct costs before the application of optimism bias. For some schemes where there are significant “on network” works this may be too little but for other schemes, particularly larger schemes where the amount of “on network” work is relatively small, the overlay may be too great.

In summary the total disruptive impact of the SA options do not make them undeliverable and the approximate impact been included within the overall costs.

7.9. Environmental impact results

Most of the SA schemes are either within or adjacent to railway estate and so do not necessarily require further land take, avoiding environmental disruption as much as possible. For example, the extension of four tracking around Welwyn North and quadrupling of the cross country route (Wilnecote to Stenson Junction) is expected to be deliverable close to the existing railway alignment. The environmental impact of schemes such as this is lower than some other SA schemes which require new land away from railway estate. The most notable schemes in this regard are:

- Newark chords (connections from flyover to ECML only),
- Doncaster + Barnby Dun freight chords,
- Trent junction flyover,
- Stone HS2 chord and
- M18 alignment.

These will have a particularly notable local impact, particularly as:

- One of the proposed Doncaster chords is near a Site of Scientific Interest,
- Stone HS2 chord (options 1 and 4) avoids the Pasturefield site, but within an area of a complicated water table and
- Trent junction flyover (options 1-3) in complicated environment (although also passed through by HS2 Phase 2b) and costed as a viaduct throughout.

That said, it is unlikely that the SA schemes when added together will be seen to be more environmentally damaging than HS2 given that HS2 Phase 2b is effectively greenfield throughout. The environmental impact of the M18 alignment is also applicable to HS2.

7.10. Appraisal

The core appraisal results are set out in **Table 7-16**.

Table 7-16 Appraisal results

2016 Present Value (£bn)	Option 1 (Max ECML)	Option 2S (ECML-HS2 mix, short M18)	Option 2L (ECML-HS2 mix, long M18)	Option 3 (Max HS2, short M18)	Option 4 (Nottingham MML, short M18
Benefits	27.1	29.4	29.8	29.6	28.2
Revenues	15.2	16.6	16.8	16.9	15.9
Operating costs	12.7	9.6	9.5	11.8	10.6
Capital costs	13.0	15.6	16.9	11.8	14.4
HS2 rolling stock capital costs	2.2	2.4	2.4	3.1	2.5
Wider Economic Impacts	7.9	7.8	8.0	7.9	7.9
NPV (excluding WEI)	14.2	18.4	17.8	19.9	16.7
NPV (including WEI)	22.1	26.2	25.8	27.8	24.6
BCR (excluding WEI)	**2.1**	**2.7**	**2.5**	**3.0**	**2.4**
BCR (including WEI)	**2.7**	**3.4**	**3.1**	**3.9**	**3.1**

WebTAG guidance suggest that schemes with a BCR of greater than 2.0 are considered high value for money. However, please note that the results and the ranking of the options from this necessarily high level and complex analysis are very sensitive to key input assumptions.

The appraisal results for a sensitivity test assuming an increase of 20% in the total present value cost of the infrastructure are set out in **Table 7-17**. This test is to understand how the appraisal results are affected if there any additional schemes that could be found to be required to operate the SA TSSs.

Table 7-17 Sensitivity results

2016 Present Value (£bn)	Option 1 (Max ECML)	Option 2S (ECML-HS2 mix, short M18)	Option 2L (ECML-HS2 mix, long M18)	Option 3 (Max HS2-WCML, short M18)	Option 4 (Nottingham MML, short M18
Benefits	27.1	29.4	29.8	29.6	28.2
Revenues	15.2	16.6	16.8	16.9	15.9
Operating costs	12.7	9.6	9.5	11.8	10.6
Capital costs	15.6	18.7	20.3	14.1	17.2
HS2 rolling stock capital costs	2.2	2.4	2.4	3.1	2.5
Wider Economic Impacts	7.9	7.8	8.0	7.9	7.9
NPV (excluding WEI)	11.6	15.2	14.4	17.5	13.8
NPV (including WEI)	19.5	23.1	22.4	25.5	21.7
BCR (excluding WEI)	**1.8**	**2.1**	**1.9**	**2.5**	**2.0**
BCR (including WEI)	**2.3**	**2.6**	**2.5**	**3.1**	**2.5**

Even with a 20% increase in costs, 2 of the 5 options provide high value for money BCRs (greater than 2.0). Once WEI are taken into account, all options are still considered high value for money.

8. Conclusions

According to WebTAG guidance, the strategic alternative options can be considered to be high value for money. The infrastructure schemes provide significant improvements in journey times and capacity against the base case.

The total benefits provided by the alternatives are less than for HS2 Phase 2b. Phase 2b generates more rail demand and benefits more passengers. In accordance with standard appraisal guidance, the demand for HS2 Phase 2b and the alternatives is capped in the modelling in 2036, only 3 years after Phase 2b is due to open. The impact of this cap on the benefits of Phase 2b is likely to be greater than on the alternatives.

The alternatives provide sufficient capacity for the TSS modelled but do not match the ultimate capacity of Phase 2b. If, in the very long term, rail demand continues to grow in line with the trend of the last 20 years, then, even if the full HS2 scheme is built, there may be elements of the SA schemes that are still worth considering in their own right to increase the overall capacity of the UK rail network even further, for example, on the ECML and on the northern end of the WCML.

The effectiveness of the SA options varied across the network. On some route sections in particular the alternatives struggled to match HS2 Phase 2b:

- **Manchester route**: No conventional alternative option was identified that could connect Manchester to HS2 that was not unreasonably disruptive. It proved even more difficult to increase train speeds significantly, and in the alternatives services from Birmingham can only be accommodated at Victoria, not Piccadilly. The alternatives effectively relied on using the existing routes into Manchester which are acknowledged to be highly capacity-constrained and do not offer the levels of reliability that high speed passengers might reasonably expect.

- **Leeds route**: Similarly no conventional alternative could be found to serve Leeds that was not unnecessarily expensive or disruptive, or that could deliver sufficient benefits in terms of speed. Options 2-4 – which rely on building the HS2 M18 route – perform significantly better than option 1 (which is based on upgrading the existing East Coast Main Line). This strongly suggests that high speed offers the most appropriate solution to Leeds.

Midlands Connect and Transport for the North are examining options that could use capacity created on HS2 Phase 2b as a first step to transforming the economies of the Midlands and the North. This would rely in particular on some sections of route that would not be built under the alternatives. It follows, therefore, that the aspirations of Midlands Connect and Transport for the North may be more expensive or difficult to achieve with the alternatives.

In total the alternatives provide fewer seats and fewer “seat-kilometres” than HS2 Phase 2b.

The alternatives do not deliver the transformative journey times of HS2 Phase 2b particularly for connections between Birmingham, Manchester and Leeds. The alternatives are typically 10 minutes slower to/from London and approximately 15 to 30 minutes slower to/from Birmingham. The alternatives also struggle to provide the same journey times between cities on the Eastern leg of HS2 Phase 2b (East Midlands, Sheffield, Leeds and Newcastle).

The design development of the alternatives is lower than for HS2 Phase 2b. Whilst an industry-appropriate factor has been included for this within the cost modelling, including in the application of a higher optimism bias and in indirect costs, there remains a significant cost estimate risk because of the lower level of design development. The cost increases seen on some recent rail programmes suggests than this risk is not insignificant.

The alternatives generate similar levels of improvements in performance on the national network as HS2 Phase 2b. However, Phase 2b sees 10 fewer high speed trains per hour operating over both the conventional and the high speed network in each direction as they can stay entirely on high speed infrastructure, and as a result the high speed network is likely to be less reliable and punctual with the SA options than with HS2 Phase 2b as more delay is expected to be imported from the classic network onto Phase One of HS2.

Both HS2 and the strategic alternatives will require work on the national network that will inevitably cause some disruption to existing train services. The calculations setting out the disruption impact of the SA options are set out in the main report but the total impact is not thought to be so great as to prevent the SA options from being constructed.

Finally, it is worth noting that the appraisal technology and techniques used in this assessment and in calculating the BCRs are in line with standard industry practice, and were developed originally to test enhancements to the existing rail network. These work well with the alternatives. However, in Atkins' opinion, they do not capture the beneficial impact of more transformative schemes such as HS2 Phase 2b as well. In comparing HS2 and the SAs, the overall strategic case is as important as the value for money assessment.

Appendices

Appendix A. Scheme costs

Scheme name	Option 1	Option 2S	Option 2L	Option 3	Option 4
Welwyn North (ELR ECM1)	£567m				
Newark (ELR ECM1, NOB1, NSE)	£1146m	£1146m	£1146m		£554m
Doncaster chords	£175m	£175m	£175m	£175m	£175m
Darlington (ELR ECM5 44m10c)	£30m	£30m	£30m		£30m
North of Newcastle: 775m freight loops	£85m	£85m	£85m		£85m
Wilnecote (ELR DBP)	£648m	£648m	£648m	£648m	£648m
Wilnecote – Tamworth – Burton – Stenson Junction quadrupling (ERL DBP)	£1237m	£1237m	£1237m	£1237m	£1237m
Stenson Junction grade separation (ELR DBP1 / SSJ2 4m56c)	£568m	£568m	£568m	£568m	
Trent Junction Flyover (ELR SSJ1 / TSN1)	£728m	£728m	£728m	£728m	
Nottingham capacity	£3m	£3m	£3m	£3m	
Connections to HS2 M18 alignment and high speed line to Leeds					
Short Link Option		£3438m		£3438m	£3438m
Long Link Option			£4774m		
Crewe Curve	£491m	£491m	£491m	£491m	£491m
Sandbach - Hartford Junction (ELR SNJ / CDM2)	£559m	£559m	£559m	£559m	£559m
Winsford – Hartford – Weaver Junction (ELR CGI)	£541m	£541m	£541m	£541m	£541m
Winwick Junction – Newton le Willows – Golborrne Junction (ELRCGJ / WEE / NGJ / CGJ)	£782m	£782m	£782m	£782m	£782m
Weaver Junction – Acton Grange Junction – Warrington (ELR CG12 / CHW1)	£465m	£465m	£465m	£465m	£465m
Manchester Victoria (ELR DSE)	£37m	£37m	£37m	£37m	£37m
Stone: Connection to HS2	£309m				£309m
Crewe Platforms	£10m	£10m	£10m		£10m
Preston Platforms	£14m	£14m	£14m		£14m
Derby to Sheffield Upgrade	£53m	£53m	£53m	£53m	£53m
Crewe to Cheadle Hulme	£39m	£39m	£39m	£39m	£39m
Performance Works at Trent					£587m
Power upgrades Crewe to Preston	£172m	£172m	£172m	£172m	£172m
L2E4 - London to Spittal	£1713m	£1713m	£1713m		£1713m
Total	**£10372m**	**£12934m**	**£14270m**	**£9936m**	**£11938m**

Appendix B. Disruption

Scheme	Route	Options required	Disruption (possessions)			
			Week nights	28H	54 hr	54 hr +
ECML L2E4: London to Berwick (Spittal)	ECML	1, 2, 4	*Disruption applied as 15% of the scheme capital cost based upon Arup's L2E4 report.*			
Welwyn North (ELR ECM1)	ECML	1	270	4	2	3
Newark (ELR ECM1, NOB1, NSE)	ECML	1, 2, 4	5	4	3	0
Doncaster chords (Bessacarr Junction and Barnby Dun - both)	ECML	1, 2, 3, 4	20	9	6	0
North of Newcastle: 775m freight loops	ECML	1, 2, 4	50	2	3	0
Darlington (ELR ECM5 44m10c)	ECML	1, 2, 4	15	0	2	0
Wilnecote (ELR DBP)	Other	1, 2, 3, 4	20	6	6	6
Wilnecote – Tamworth – Burton – Stenson Junction quadrupling (ERL DBP)	Other	1, 2, 3, 4	607	47	8	4
Stenson Junction grade separation (ELR DBP1 / SSJ2 4m56c)	Other	1, 2, 3	10	4	5	2
Trent Junction Flyover (ELR SSJ1 / TSN1)	MML	1, 2, 3	250	2	6	0
Nottingham capacity	MML	1, 2, 3	Minor scheme			
Connections to HS2 M18 alignment and high speed line to Leeds Killamarsh Mexborough	MML	2, 3, 4	 15 30	 6 2	 3 7	 0 0
Crewe Curve	WCML	1, 2, 3, 4	600	83	16	1 plus 9 months closure of depot area, 6 month close of Crewe North
Sandbach - Hartford Junction (ELR SNJ / CDM2)	WCML	1, 2, 3, 4	0	154	0	0
Winsford – Hartford – Weaver Junction (ELR CGI)	WCML	1, 2, 3, 4	20	7	15	0
Winwick Junction – Newton le Willows –	WCML	1, 2, 3, 4	50	17	17	3

Scheme	Route	Options required	Disruption (possessions)			
			Week nights	28H	54 hr	54 hr +
Golbourne Junction (ELRCGJ / WEE / NGJ / CGJ)						
Weaver Junction – Acton Grange Junction – Warrington (ELR CG12 / CHW1)	WCML	1, 2, 3, 4	15	17	3	0
Manchester Victoria (ELR DSE)	WCML	1, 2, 3, 4	25	13	1	0
Stone: Connection to HS2	WCML	1, 4	15	7	2	1
Crewe platforms	WCML	1, 2, 4	Minor scheme			
Preston platforms	WCML	1, 2, 4	Minor scheme			
Derby to Sheffield upgrade	MML	1, 2, 3, 4	Included within MML electrification delivery			
Crewe to Cheadle Hulme	WCML	1, 2, 3, 4	Minor scheme			
Power upgrades Crewe to Preston	WCML	1, 2, 3, 4	Minor scheme			
Performance upgrade works at Trent	MML	4	Scope undefined			

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