MOTT MACDONALD

Strategic Alternatives to High Speed 2 Phase 2b

MML, ECML and Eastern Leg Combined Options

13th October 2021

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Introduction

In February 2020 the Department for Transport (DfT) published the Terms of Reference for an Integrated Rail Plan (IRP) for the Midlands and the North. The IRP is intended to ensure that Phase 2b of HS2 and other planned rail investments in the Midlands and the North are scoped and delivered in an integrated way, including with the wider rail network, whilst driving down unnecessary costs and over-specification. The IRP will seek to deliver several key Governmental strategic objectives by: i) improving transport for users by enhancing capacity and connectivity; ii) growing and levelling up the economy by creating opportunities for skills, employment, agglomeration and regeneration; iii) reducing environmental impact by supporting decarbonisation of the rail network; iv) and ensuring value for the taxpayer through efficient delivery of rail infrastructure.

Mott MacDonald has been commissioned to support DfT in the development of the IRP, specifically by examining Strategic Alternatives to the HS2 Phase 2b Eastern Leg. This is an independent report produced by Mott MacDonald, and whilst we have briefed Network Rail and HS2 Ltd. during our work, engineering and cost assurance has only been provided by Mott MacDonald, except where otherwise specified.

Strategic Alternatives Considered

We have considered four overall alternative concepts, ranging from upgrades to the conventional lines only to a combination of new line and upgrades. These concepts are summarised below, and are shown as illustrations at the end of this Executive Summary.

Upgrades Only

Replacing the whole of the Eastern Leg with an upgrade of the conventional network, specifically:

- The East Coast Main Line (ECML).
- The Midland Main Line (MML) and Burton and Tamworth Line.

First Phase to Sheffield

Replacing the Eastern Leg as planned with a new HS2 alignment from Birmingham to the Midland Main Line near East Midlands Parkway (EMP). This would allow HS2 services to EMP, Nottingham, Derby, Chesterfield and Sheffield. Leeds, York and Newcastle would be served via upgrades to the ECML (with Edinburgh served by the Western Leg of Phase 2b).

Optional further infrastructure has been identified for this package which would enable further improvements in connectivity, for example Lincoln, but which are not core to the alternative in question.

First Phase to Leeds

Replacing the Eastern Leg as planned with a new HS2 alignment from Birmingham to the Midland Mainline near EMP. The Leeds HS2 station would also be constructed as planned, but connected to the Woodlesford Line near Hunslet. The existing line between Hunslet and Hare

Park is upgraded and combined with Northern Powerhouse Rail (NPR) proposals between Sheffield and South Kirby.

This package would enable initial HS2 services to Leeds via Sheffield and could represent a sensible phasing choice if the government's preferred HS2 end state network was via Newark (see below), or potentially Erewash if the scope of the initial intervention was reduced. As a standalone package York and Newcastle would be served via upgrades to the ECML (with Edinburgh served by the Western Leg of Phase 2b).

Alternatives forms of end-state Eastern Leg

Building on the investments described above. Replacing the Eastern Leg as planned with a new HS2 alignment from Birmingham to the Midland Main Line near East Midlands Parkway, plus upgraded conventional and new infrastructure further north, along a choice of two alignments:

- Eastern Leg: Erewash Alignment. Upgrades to the Erewash Valley Line, the Chesterfield – Masborough Junction route (known as the Old Road) and then a new high speed line between broadly Rotherham and Leeds, known as the M18 Short Alignment. The majority of the M18 Short Alignment is as per the planned Eastern Leg, including the proposed HS2 station in Leeds. The route to York and Newcastle would be via an upgraded ECML, similar to the other Strategic Alternatives.
- Eastern Leg: Newark Alignment. This would route trains from Nottingham to Newark and up the East Coast Main Line corridor. There are choices as to how much new line would be provided; for the purposes of assessing costs and benefits we have assumed the largest scale of intervention, comprising a new line east of Nottingham, crossing the ECML outside Newark and bypassing the ECML to the east and north of Doncaster. This would be combined with junctions on/off the ECML at Newark, Bawtry and north of Doncaster as well as an upgraded conventional route to Leeds via Normanton and Woodlesford. The final approach into the centre of Leeds as well as the HS2 station in Leeds would be the same as under the planned Eastern Leg.

Optional further infrastructure has been identified for the alternatives which would enable further improvements in connectivity, but which are not core to the alternative in question.

Scope of work and approach taken

The purpose of our work is to inform strategic decisions on the future of HS2 Phase 2b Eastern Leg and our analysis is therefore at the first stage of the normal rail industry planning process. Our results and conclusions should be viewed as indicative as many of our assessments will be at a far earlier stage than for the currently planned Eastern Leg, and some caution should be exercised when comparing between the Eastern Leg and the Strategic Alternatives.

To develop each Strategic Alternative we produced initial Train Service Specifications (TSSs) and Infrastructure Specifications, which we refined iteratively to identify sensible and logical combinations.

For each Strategic Alternative we have reported two main sets of outputs, and added commentary on some other key issues. The main outputs are:

- Connectivity. This comprises journey time, train service frequency and train capacity (seats) for key origin-destination pairs. Our TSS development and capacity assessments were early-stage using mainly spreadsheet-based modelling supported by best practice assumptions typically used for this type of work.

- Infrastructure Costs. We have reported early stage, indicative cost estimates for the infrastructure interventions which comprise each Strategic Alternative. The cost estimates presented are from one of three sources:
    - Estimates supplied by HS2 Ltd.
    - Estimates produced by third party consultants.
    - Estimates produced by Mott MacDonald. These estimates have been produced using the best available desktop information, using the normal processes adopted in UK rail cost forecasting. Given the early stage nature of the work, we have listed some notable exclusions (such as the cost of land purchase required, although we have made an allowance per square metre for indicative purposes only) and have included risk/optimism bias at 66%.

Other key issues considered were:

- Rail network punctuality (performance). We have used a combination of analysis and professional judgement at this stage of development around which schemes are certainly and potentially required from a performance standpoint. In general performance was assessed and reported on at a high-level, which is typical for early-stage development work. In places we have suggested some performance mitigations which are not strictly required but may yield downstream benefits.
- How easily or otherwise the proposed infrastructure can be constructed.
- The potential for the Strategic Alternatives to compliment other network improvements being planned in other or parallel processes. We have not attempted to address problems which other planning workstreams (e.g. the Northern Powerhouse Rail programme) are investigating, but have noted where synergies or conflicts may occur.

Stakeholder involvement

We have worked closely with officials from the Department for Transport to agree planning assumptions and confirm that the options developed provide a good coverage of the potential alternatives to the Eastern Leg. We have also briefed Network Rail and HS2 Ltd at various points as the study has progressed. We are grateful for the input of these organisations, but stress that this study is an independent report produced exclusively by Mott MacDonald.

Assumptions

We have stated our assumptions and caveats, highlighted any gaps in our analysis and recommended areas for further development.

The baseline (Do-Minimum scenario) for our work assumes that the committed[1] infrastructure enhancements are complete, and that HS2 Phase 2a is operational. At the request of the Department, we have also assumed that the Midland Main Line (MML) is electrified in full. The individual enhancements and our assumed impact on baseline train services are described in the relevant chapters of this report.

Key conclusions

Upgrades Only

The ECML only investment has a comparatively low infrastructure cost, avoiding almost all of the cost of the Eastern Leg. However, this near cancellation of the Eastern Leg would see many

[1] Defined as enhancement projects which the Department or other key government or organisations have committed, notwithstanding ongoing funding and procurement discussions. The schemes included in this definition have been discussed and agreed with the Department.

sizeable locations such as Nottingham, Sheffield, Leeds and Derby lose the bulk of journey time and frequency benefits. Some locations such as York and Newcastle would retain significant improvements albeit at a lower level than previously proposed under HS2 Phase 2b. This Strategic Alternative does not therefore appear to meet Government's objectives.

Similarly, replacement of the Eastern Leg with a package of upgrades only on the MML would save most of the cost and retain some important benefits to locations in the East Midlands and South Yorkshire. However, it would forgo all improvements for places on the ECML and the adjoining network. Again, it seems that this alternative does not meet Government's objectives.

Combing both sets of upgrades would see most locations on the proposed Eastern Leg receive generally modest benefits over the Do-Minimum scenario albeit at a cost likely to be several times lower than that of the Eastern Leg. However, given the lack of largescale or transformational connectivity improvements it is difficult to see how this scheme would meet Government's objectives.

First phase to Sheffield

Constructing a new high speed route between Birmingham and the MML near East Midlands Parkway (EMP) would deliver some transformational improvements to Derby, Nottingham and East Midlands Parkway, and could also benefit locations east of Nottingham, such as Newark and Lincoln, with further optional infrastructure investment. The connectivity benefits to the East Midlands, on balance, look to outperform Phase 2b as it is currently planned to Birmingham and London, but it would not provide better connectivity from the West and East Midlands towards Leeds and the North East. This option otherwise would deliver a similar level of connectivity to Chesterfield and Sheffield as per the Eastern Leg in full.

On the ECML, some locations, such as York and Newcastle, would retain significant improvements to London (but not Birmingham), whereas Leeds would likely receive only modest improvements from London.

In summary this infrastructure package would potentially be less than a third of the cost of the Eastern Leg, however it would not deliver many of the benefits for locations further north that would occur if the Eastern Leg went ahead as planned, and so would seem unlikely to meet Government's strategic priorities. However, as an interim state this alternative may offer a good compromise of rail improvements and costs savings as well as lay the foundation for future implementation of the Erewash or Newark versions of the Eastern Leg as set out below (or indeed, for a continuation of the original HS2 scheme north thereof).

First phase to Leeds

This infrastructure package would deliver all of the benefits of First Phase to Sheffield infrastructure package but bring additional benefits to Leeds. HS2 services would reach Leeds via Sheffield, enabling connectivity improvements to Leeds from Sheffield, Derby, East Midlands Parkway, Birmingham, and London (especially for connections at Old Oak Common). This package would also represent a sensible phasing choice if the government's preferred HS2 end state network was via Newark (or via Erewash, if the scope of the initial intervention was reduced, though this would require further analysis which we have not undertaken for purposes of this report).

This Strategic Alternative would be potentially less than half of the cost of the Eastern Leg, not including the cost estimate for the NPR infrastructure which has not been provided to us. This alternative would still not deliver a number of benefits for locations further north, especially between West Midlands and North East, that would occur if the Eastern Leg goes ahead as

planned, however it may offer a good compromise of rail improvements and costs savings. Despite this, if adopted as the end state Eastern Leg it may still fail to deliver all of Government's strategic priorities.

Eastern Leg Erewash or Eastern Leg Newark

These two Eastern Leg alternatives would deliver all of the benefits of the first phase infrastructure packages and substantial connectivity improvements to/from locations further north. This means that the places which benefit through Phase 2b would also see significant improvements under the Strategic Alternatives. On balance, the planned HS2 Eastern Leg offers the perhaps largest improvement in journey times to the locations in the north of England which are set to benefit from Phase 2b, however these two alternatives are not far behind, could be more beneficial to places not currently served by HS2, and be delivered for a cost saving potentially in excess of £10bn.

Considering all of the above, the two Alternatives would - subject to further development work - provide a transformational improvement in connectivity, and offer a significant potential cost saving over the current proposal.

Comparing the Erewash and Newark Eastern Leg alignments:

- The Newark Alignment is forecast to cost roughly 18% less than the Erewash Alignment.
- The Erewash Alignment perhaps offers better overall longer distance journey time saving to Leeds from London and Birmingham, but would not enable HS2 to serve the North East. HS2 services could also call at a new Toton station.
- The Newark Alignment offers better connectivity between the East and West Midlands and places on the ECML, such as Leeds, Doncaster, York, Durham, Darlington and Newcastle, although the gap could be narrowed through inclusion of optional additional infrastructure in the Erewash alignment specification.
- Both alignments could have a phased programme of construction, thereby allowing advanced delivery of some of the HS2 Phase 2b benefits. The Newark alignment could be delivered in three distinct phases, versus two for the Erewash alignment, with the former offering an earlier overall delivery of more of the end-state benefits.
    - (via Erewash) Phase 1 - The via Erewash alignment could see the ECML upgrades and the route between Birmingham and East Midlands Parkway built first, along with enabling infrastructure in the Trent Junctions area and at Nottingham. At this point something akin to the 'first phase to Sheffield' TSS could operate.
    - (via Erewash) Phase 2 - Thereafter, the remaining infrastructure to the north could be built.
    - (via Newark) Phase 1 - The first stage of the via Newark alignment could be the ECML upgrades, the route to EMP, and the enabling work in the Trent area and at Nottingham. At this stage a variant of the 'first phase to Sheffield' TSS could run.
    - (via Newark) Phase 2 - A second stage could see construction of the HS2 station in Leeds as well as the upgrade of the Woodlesford corridor. This would deliver a next step of benefits to Leeds, and if NPR was approved and constructed via a separate process, would enable operation of the 'first phase to Leeds' TSS.
    - (via Newark) Phase 3 - The ECML bypass could then be constructed as a third phase, delivering the end-state benefits of this option.

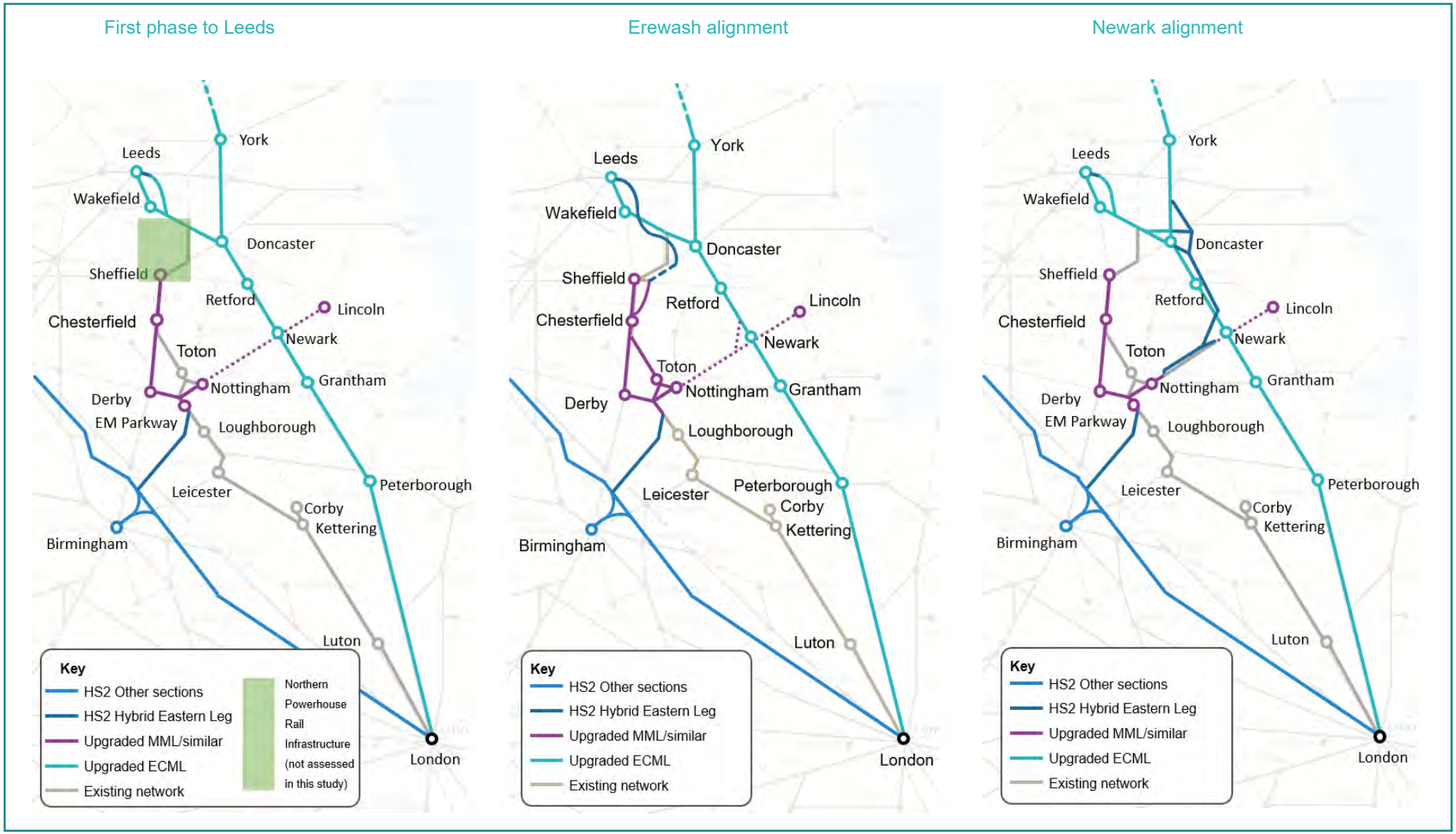
Route Overview 1. HS2 Phase 2b Eastern Leg, Upgrades Only, First phase to Sheffield

HS2 Phase 2b Eastern Leg

Upgrades Only

First phase to Sheffield

Route Overview 2. First Phase to Leeds, Eastern Leg alternatives Erewash and Newark alignments



1 Introduction

In February 2020 the Department for Transport (DfT) published the Terms of Reference for an Integrated Rail Plan (IRP) for the Midlands and the North[2]. The IRP is intended to ensure that Phase 2b of HS2 and other planned rail investments in the Midlands and the North are scoped and delivered in an integrated way, including with the wider rail network, whilst driving down unnecessary costs and over-specification.

Mott MacDonald has been commissioned to support DfT in the development of the IRP, specifically by examining strategic alternatives to the HS2 Phase 2b Eastern Leg, building on work undertaken by consultants Atkins in 2016[3].

This report provides a summary of our investigation of alternatives to the Eastern Leg of Phase 2b, shown below in Figure 1. As previously planned, the Eastern Leg would consist of a new high-speed line between Birmingham and Leeds, with connections to the MML and ECML enabling HS2 services to reach Sheffield and the North East. The new line would include construction of two new stations at Toton (in the East Midlands) and Leeds.

The DfT has requested that Mott MacDonald undertake an assessment of strategic alternatives to the current HS2 Eastern Leg against the following the objectives:

- Addressing major capacity, frequency and speed shortfalls on the existing network
- Tackling key performance and reliability constraints
- Delivering benefits to those places currently served by the HS2 Eastern Leg, as well as destinations further afield.
- Minimise detrimental impacts on communities
- Avoid disadvantaging existing passengers and other users.

The most recent estimate of the cost of the Eastern leg is £32bn[4] in 4Q2019 prices at maximum contingency, which may be unaffordable alongside other major investments. Our assessment has therefore considered alternatives which could deliver a range of transformational benefits but at a lower cost than current plans.

We have set out five alternative proposals to the Eastern Leg. All of these alternatives outlined can be delivered as standalone packages, however we have considered the potential to phase the delivery of an end state Eastern Leg, which could enable benefits to be delivered more quickly than under current plans. Some of the alternatives could therefore form an interim phase of the end state options identified.

The five alternatives we have set out are intended to provide Government with an understanding of the key choices and trade-offs if the Eastern Leg is not taken forward as planned currently. Other variants of these alternatives are likely to exist (e.g. through changes to the scope of enabling infrastructure and/or to the train service patterns), and we expect that some changes would be made as part future development work if any of the alternatives were taken forward.

Our review of the Eastern Leg is presented in two main parts.

[2] Terms of reference for an integrated rail plan for the north and midlands - GOV.UK (www.gov.uk)

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/568309/strategic-alternatives-to-hs2-phase-2b-atkins-report.pdf

[4] Figure provided by DfT

Part One. An assessment of upgrades to conventional railway. Primarily this focussed on:

- Assessment of whether and how well locations on the East Coast Main Line (ECML) and its branches served by previous HS2 plans could instead be served by an upgraded ECML. Our work considered several interventions previously suggested by Atkins 2016, as well as some new proposals.
- Assessment of whether and how well locations in, principally, the East Midlands and Sheffield could be served by an upgrade of the Midland Main Line (MML) and adjoining routes. Our work considered a previous proposal put forward by Atkins 2016 for a HS2 connection to the Burton and Tamworth line in the West Midlands.

Part Two. An assessment of HS2 new line combined with upgrades to the conventional network. We considered four infrastructure packages :

- First phase to Sheffield. Constructing the HS2 Phase 2b alignment as planned as far as the M1 (East Midlands) but then rerouted to connect to the MML just south of East Midlands Parkway. The MML is then upgraded and electrified enabling HS2 services to reach Nottingham, Derby and Sheffield. HS2 services do not reach Leeds, York, or Newcastle, which are instead served via an upgraded ECML.
- First phase to Leeds. Building on the intervention outlined above, the planned high-speed station at Leeds is connected to the existing Woodlesford Line near Hunslet. The railway between Hunslet and South Kirby is upgraded, and proposed NPR interventions between Sheffield and South Kirby are also delivered. This package enables HS2 services to reach Leeds via Sheffield
- Alternative forms of end-state Eastern Leg. We considered two variants to the full Eastern Leg that enabled high speed services to reach a range of locations north of Sheffield. Both packages build on the infrastructure outlined in the ‘first phase to Sheffield’ infrastructure package
    - Eastern Leg Erewash alignment: HS2 services reach Leeds via a retained section of the planned Eastern Leg between the Rotherham area and Leeds city centre, combined with an upgrade of the Erewash Valley and Old Road line.
    - Eastern Leg Newark alignment: We have assumed the most ambitious package of a new high-speed bypass along the Nottingham – Newark Castle line, and connected to a series of bypasses on the ECML between Newark Northgate, Doncaster and North thereof. Under this proposal the main HS2 route to Leeds, York and the North East would be via the new bypass. This option could be phased after the ‘first phase to Leeds’ infrastructure package. There are likely sub-choices to not build all of the different by-pass sections.

This paper presents a summary of our assessment, intended to provide DfT with a clear picture of the feasibility of the alternative proposals, and the trade off that each proposal is likely to entail. Throughout this report we have used simplified drawings and maps, to avoid any perceived or potential planning blight. This is appropriate as scheme designs are indicative, with precise alignments yet to be identified.

Our assessments are at the first stage of the normal rail industry planning process, and should therefore be viewed as indicative. We have therefore stated our assumptions and caveats, and highlighted any gaps in our analysis and recommended areas for further development.

The baseline (Do-Minimum scenario) for our work assumes that the committed[5] infrastructure enhancements are complete, and that HS2 Phase 2a and the 2b Western Leg is operational. The individual enhancements and our assumed impact on baseline train services are described in the relevant chapters of this report.

The remainder of this report is set out as follows:

- Chapter two lists our key assumptions and caveats.
- Chapter three presents the upgrade only options.
- Chapter four presents our assessment of the First Phase to Sheffield package.
- Chapter five presents our assessment of the First Phase to Leeds package.
- Chapter six presents our assessment of alternative forms of end-state Eastern Leg.
- Chapter seven presents our conclusions.

[5] Defined as enhancement projects which the Department or other key government or organisations have committed, notwithstanding ongoing funding and procurement discussions. This schemes included in this definition have been discussed and agreed with the Department.

Figure 1. HS2 Eastern Leg as planned (not to scale/simplified)

2 Key Assumptions and Caveats

2.1 Introduction

The work presented in this report has been conducted at the earliest phase of the typical rail industry planning process intended to develop a strategic-level understanding of potential alternatives to the HS2 Phase 2b Eastern Leg. Throughout our assessments we have used industry-standard techniques and assumptions, however given the early-stage nature of the work it is important to set out our key assumptions, exclusions and caveats. This is particularly the case as the development work underpinning the Eastern Leg as is currently planned will be at a more advanced stage and therefore comparison between our analysis and work supporting the current Eastern leg requires an informed level of caution.

2.2 Scope of our assessment

Our remit was to focus predominantly on the direct impact of the changes required to deliver the Strategic Alternatives to HS2 Phase 2b, and where relevant to note potential synergies or interdependencies with other rail industry planning work.

There are several separate ongoing rail industry work streams concerned with addressing other key issues ranging from short term/ongoing punctuality problems, through to the development of the transformational Northern Powerhouse Rail and Midlands Engine Rail programmes. We have attempted to be cognisant of these other work packages, without directly attempting to address the issues they have been set up to resolve.

This report is the culmination of work which commenced in the latter part of 2019, and has been produced largely in the order presented. It has been necessary to fix some planning assumptions as the work has progressed, to avoid significant repetition. We have flagged where subsequent rail industry planning work may have changed any of our assumptions, indicating the potential risk to our assessment and conclusions.

2.3 Engineering feasibility and design

Current infrastructure capabilities were sourced from the Network Rail Sectional Appendices. Proposed new infrastructure has been designed to meet standards generally accepted by Network Rail or by HS2 Ltd, depending on the location of the infrastructure.

For new and amended infrastructure we have developed early stage feasibility assessments, illustrations and quantities for the infrastructure interventions we believe would be necessary to deliver the Train Service Specification (TSS) relevant to each Strategic Alternative.

Our drawings use the mapping available to us (Ordnance Survey, Google Earth/Google Maps, Network Rail Sectional Appendices) and were intended to enable us to assess:

- Feasibility.
- Infrastructure capability e.g. line speed for various train types.
- Whether interventions could reasonably be constructed, and general levels of disruption during construction.
- Quantities of infrastructure components for estimating purposes.

We have not produced detailed engineering designs at this stage.

Quality Assurance was undertaken through a review by competent engineers and by the Project Director.

2.4 Capacity planning and punctuality

A key part of this study has been analysis to inform the indicative TSS, e.g. train routeing, frequency, and journey times operable under current and proposed future rail infrastructure specifications.

Baseline (Do-Minimum) TSSs were agreed with the Department, as were the types of rolling stock (trains) in operation. Where a stock type currently exists, we have used known sectional running times and/or acceleration and braking characteristics. Where a new stock type is assumed, e.g. HS2 Classic Compatible services, we used information from the nearest existing train set we have data for.

Journey times on the current planned HS2 network were taken from data produced by HS2 Ltd. Where relevant, enhanced line speeds on the ECML were taken directly from the ARUP L2E4 report published in 2014 (discussed below).

Given the strategic nature of our work our analysis was typically concept level mainly using spreadsheets. We have not typically used specialist operational planning software packages, as the potential additional precision is not warranted given the often indicative nature of our infrastructure and rolling stock assumptions.

Some of the times we have reported are for journeys where it would be necessary to change trains to travel between the locations in question. In these instances we have compared the total journey start station – end station time inclusive of a time penalty equivalent to the inconvenience passengers face when changing trains. Inclusion of this penalty is consistent with the demand forecasting approach adopted by HS2 Ltd, as well as with the guidance set out in DfT's TAG publication[6].

Where specific infrastructure interventions are clearly likely to influence train punctuality (referred to hereafter as performance) we have flagged this likely impact, and where relevant set out choices whether additional infrastructure work, hence expenditure, will result in improved performance beyond the minimum infrastructure specification required to deliver the TSS in question. We have not undertaken detailed performance analysis, as work of that nature normally occurs during later planning stages.

Noting the above caveats and assumptions, all of the service routeings, calling patterns, frequencies and journey times presented in this report are indicative, intended to inform strategic-level decisions.

Quality Assurance on the capacity conclusions and journey time assessments, by a qualified expert who had not undertaken the original work, as well as by the Project Director.

2.5 Infrastructure Cost Estimates

We have produced indicative infrastructure cost estimates for the interventions considered in this study. Our approach has varied depending on the level of work undertaken previously. Our estimates fall into four broad categories:

- **Bespoke estimates.** A number of the required infrastructure interventions have not been considered previously or in sufficient detail to support this work. We have therefore

[6] Transport analysis guidance - GOV.UK (www.gov.uk)

undertaken a high-level estimate. Here, specialists in track design, civil engineering and railway signalling have produced early stage sketches of the infrastructure, which our cost estimating specialists have used to produce cost estimates applying an industry standard price per item or m^2. All of our work was desk based, and no site visits were made.

- **ECML line speed upgrade (L2E4).** Key to all options is an increase in permitted ECML line speeds up to a maximum of 140mph (versus a current maximum of 125mph). 140mph operation was the subject of a 2014 study for Network Rail, undertaken by consultants ARUP[7] in 2014, and was used by Atkins' in their 2016 work, which our assessment updates.

  The cost estimates in our current work are taken directly from ARUP, with some adjustments made:

  - To avoid double counting the cost of interventions we have priced separately.
  - To reflect the likely scope of work, in particular structures heights, based on several years of lessons learnt from actual electrification schemes (e.g. Great Western Main Line Electrification).
  - To remove any obviously poor Value for Money items.
  - To update to the price base and risk/Optimism Bias levels used in this report.

  Undertaking a new assessment of an ECML line speed upgrade was beyond the scope of our remit.
- **Route Electrification.** The Strategic Alternatives Considered include some route electrification. We have produced indicative costs for these sections on a unit price per single track km basis[8], with bespoke adjustments included the structures on the route section in question. Generally we assumed that 2-track electrification would be required, unless it is a specific requirement of the intervention to electrify additional tracks. All alternatives assume the completion of MML electrification.
- **HS2 Costs.** HS2 Ltd has developed cost estimates for the route sections which would join the conventional infrastructure we have considered. Here we have removed and/or replaced items which are inappropriate for our options. Otherwise, the estimates are exactly as produced by HS2 Ltd, with only the price base updated.

Other general estimating assumptions and exclusions are as follows:

- The price base for all figures show in 4Q2019 unless stated otherwise.
- Overheads were typically included as follows:
  - Preliminaries: 30%
  - Overheads and profit: 10%
  - Design fees: Range between 10% - 25%
  - Project management team fees: 10%
  - Other Project Costs: Vary dependant on nature of intervention e.g. brownfield, greenfield sites etc.
- Risk/Optimism Bias has been included at 66% intended to be consistent with HMT Green Book requirements .
- No allowance has been included for inflation.
- We have <u>not</u> estimated the cost of any land purchase required. Where interventions would require land we have made an allowance per square metre seen elsewhere, however this is an allowance only and cannot be relied upon. Where HS2 Ltd has already assessed the cost of land purchase, we have requested this information and used it where possible in our work.

[7] *East Coast Main Line L2E4 Study Phase 2 - Developing the Options.* Issue 2 | 14 October 2014

[8] Overhead Line Electrification rate used is £1.2m per STK (Single Track Kilometre). This rate was instructed by NR for use on the Strategic Alternative Project and was based on benchmark data from North West Electrification Programme (NWEP) Phases 3, 4 and 5.

- We have generally assumed that Utility diversions will not be required, unless we have specific information or mapping to suggest that this is not the case. Where we are aware that Utility diversions would be required we have made an allowance for this work. Generally our designs have attempted to avoid major Utilities such as gas mains.

Finally, some of the interventions would require Transport and Works Act Orders (TWAO) or Development Consent Orders (DCOs). Significant sections of new line would require a hybrid Bill. These processes can be complicated, and time consuming, and significant problems could lead to additional cost being incurred.

For cost estimating our Quality Assurance process was as follows:

- Suitably qualified and experienced people (SQEP) have been allocated to the project on a role by role basis
- Information briefed to the estimators by the engineering leads
- Detailed review of information undertaken by the estimating team with queries being raised where gaps and/or ambiguities have been identified. The engineering teams in these instances have provided clarity and/or confirmed what assumptions the estimates should be based upon. These have been clearly documented in the Cost Plans so the basis is fully understood
- Quantities prepared in accordance with the Rail Method of Measurement and included in the NR template agreed for use on the project
- The Cost Plans have been priced using predominantly benchmarked cost data, or in some limited instances using percentages which had been agreed with Network Rail. Where specialist or volatile items were required market testing has taken place
- Benchmarking against similar schemes performed where necessary
- Cost Plans reviewed with engineering teams to make sure the scope has been captured correctly
- Technical check has been undertaken by senior estimator
- Arithmetical check has been undertaken by assistant estimator
- All Cost Plans have all been approved by our Estimating Manager, and were also subject to challenge by our Project Director.

2.6 Stakeholder Involvement

We have collaborated with the Department for Transport, Network Rail, and HS2 Ltd to develop the assessments presented in this report, enabling us to consider other planning activity and to access a broad set of information. However, this is an independent report, produced exclusively by the Mott MacDonald study team.

2.7 Quality Assurance

As set out above, Quality Assurance has been undertaken using our normal process for DfT and HS2 work. We have consulted with Network Rail and HS2 Ltd at key points in the study, but they have not assured our work.

3 Upgrade only options

3.1 Introduction

In this chapter we present options to replace the whole Eastern Leg with upgrades to the conventional network. We have considered improvements to the ECML and to the MML.

In principle the upgrades of the two lines could be undertaken in isolation, however both would need to be combined to improve services to the main spread of locations served by the HS2 Eastern Leg. We have therefore presented the MML and ECML upgrades separately, and then brought both together into a package of improvements. Our conclusions are presented at the end of this chapter, considering both sets of upgrades.

3.2 East Coast Main Line Upgrade

3.2.1 Introduction

In this option a package of upgrades to the ECML would be implemented, specifically to increase the Long Distance High-Speed (LDHS) capacity on the route as well as the maximum permitted line speed. The intention would be for northern ECML locations, including Leeds, York and Newcastle to receive journey time and capacity benefits through this upgrade package, instead of through the HS2 Eastern Leg. Locations further south on the ECML would also be likely to benefit from improved capacity and journey times delivered by this upgrade package, instead of through the capacity released by the HS2 Eastern Leg.

We have assumed that the HS2 Western Leg would form the main LDHS route between Edinburgh. We have therefore shown potential ECML service improvements to/from Edinburgh as optional.

Our starting point for this assessment is the Atkins study as well as the L2E4 assessment undertaken by ARUP. We have taken evidence from these publications, and in several areas have updated this work with our own analysis.

3.2.2 Assumptions

The baseline (Do-Minimum scenario) for our assessment assumes that the ECML Enhancements Programme is complete, European Train Control System (ETCS) Level 2 signalling is operational throughout the ECML, and HS2 Phase 2A is operational.

We also assume that the broad Train Service Specification (TSS) which underpinned the ECML Enhancements Programme is operational. This TSS has been subject to significant revision during the rail industry planning process to develop an end state timetable for implementation once the programme is complete. Where relevant, we have added commentary to explain the impact of these changes, though we wish to make clear that at the time of publication of this report the do-minimum journey times might have been superseded by more recent timetabling planning.

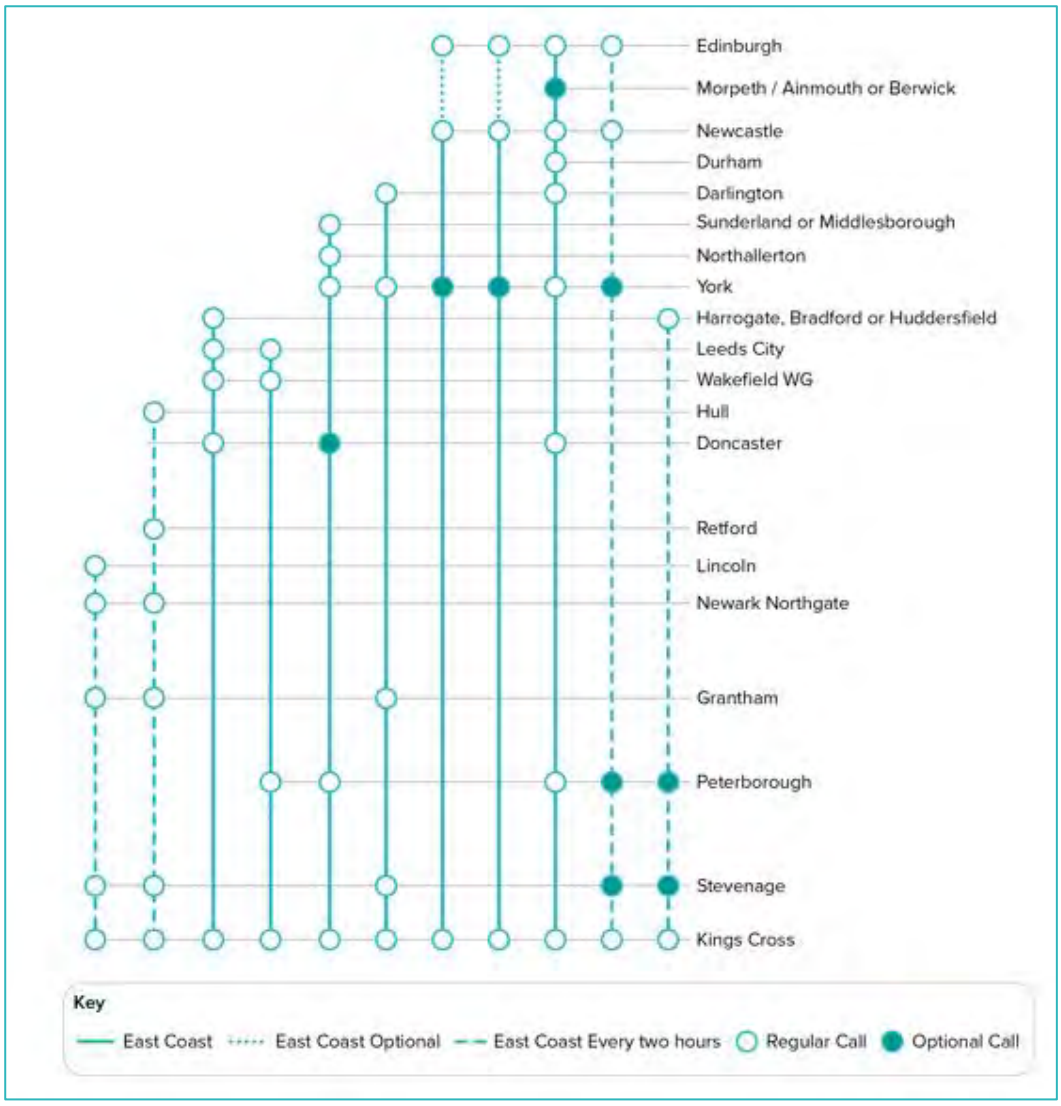
The ECML is served by both train companies operating under a contract with Government and Open Access operators. For the purposes of this assessment we have not distinguished between the different types of operator, focussing only on the overall service offer.

3.2.3 Train Service Specification

Working with DfT, we developed an indicative TSS.

The process to develop the end state TSS beyond the completion of the ECML Enhancements Programme (assumed in the Do-Minimum) has identified platform constraints at London King's Cross which may make the operation of 10 LDHS trains per hour challenging. However, it should be noted that the work undertaken here has assumed a uniform rolling stock fleet and has not distinguished between Government contracted and Open Access operators, which would increase the efficiency of the station. The ECML Enhancements workstream produced outputs after the work undertaken here was completed; additional investigation should be considered if this alternative is developed further.

Figure 2. Indicative standard hour LDHS stopping pattern (services to/from London shown only)



Note. Harrogate, Bradford and Huddersfield are shown as a single location to keep the illustration legible. The third train from the left would terminate at Bradford Forster Square one hour and Harrogate the next. The closest train to the right of the graphic would terminate at Bradford Interchange or Huddersfield depending on the time of day.

London – Newcastle would receive a minimum of three trains per hour, with four services operating in some hours (reflecting the end state ECML Enhancements Programme timetable). Two of these services would have either one or zero stops between London and Newcastle, offering fast journey times described below. The other service would call at several intermediate locations, providing good connectivity along the route.

London - Edinburgh would receive between one and three trains per hour depending on the business case for ECML services north of Newcastle after the HS2 Western Leg is complete. The ECML Enhancements Programme work suggests that three trains per hour is around the maximum that can be achieved north of Newcastle.

Darlington would be served by two trains per hour. One would be the Newcastle stopping service and the other would be a stopping service which terminates at Darlington. These stopping services allow the removal of calls from the two limited-stop London – Newcastle trains described above.

London – York would receive three or four trains per hour. This assumes on average one fast (limited stop) Newcastle service per hour would call at York, therefore offering fast journey time to/from London.

London – Leeds would receive 2 services per hour with a limited number of stops and could achieve fast end to end journey times. One output from the ECML Enhancements Programme work was the introduction of a third (stopping) train to Leeds every second hour (alternating with the Lincoln service). Rail industry work to develop an end state timetable for this investment programme has not been able to find a capacity for this additional Leeds service. We expect that work will continue to accommodate this service in the timetable, and if successful it could be added to the TSS for this Strategic Alternative.

Middlesbrough would receive a two-hourly service, with faster journey times than could currently be achieved.

Other services would operate broadly as today, such as to Hull, Sunderland, Bradford Interchange and intermediate locations. Again, journey times are likely to be faster than today.

3.2.4 Infrastructure Interventions

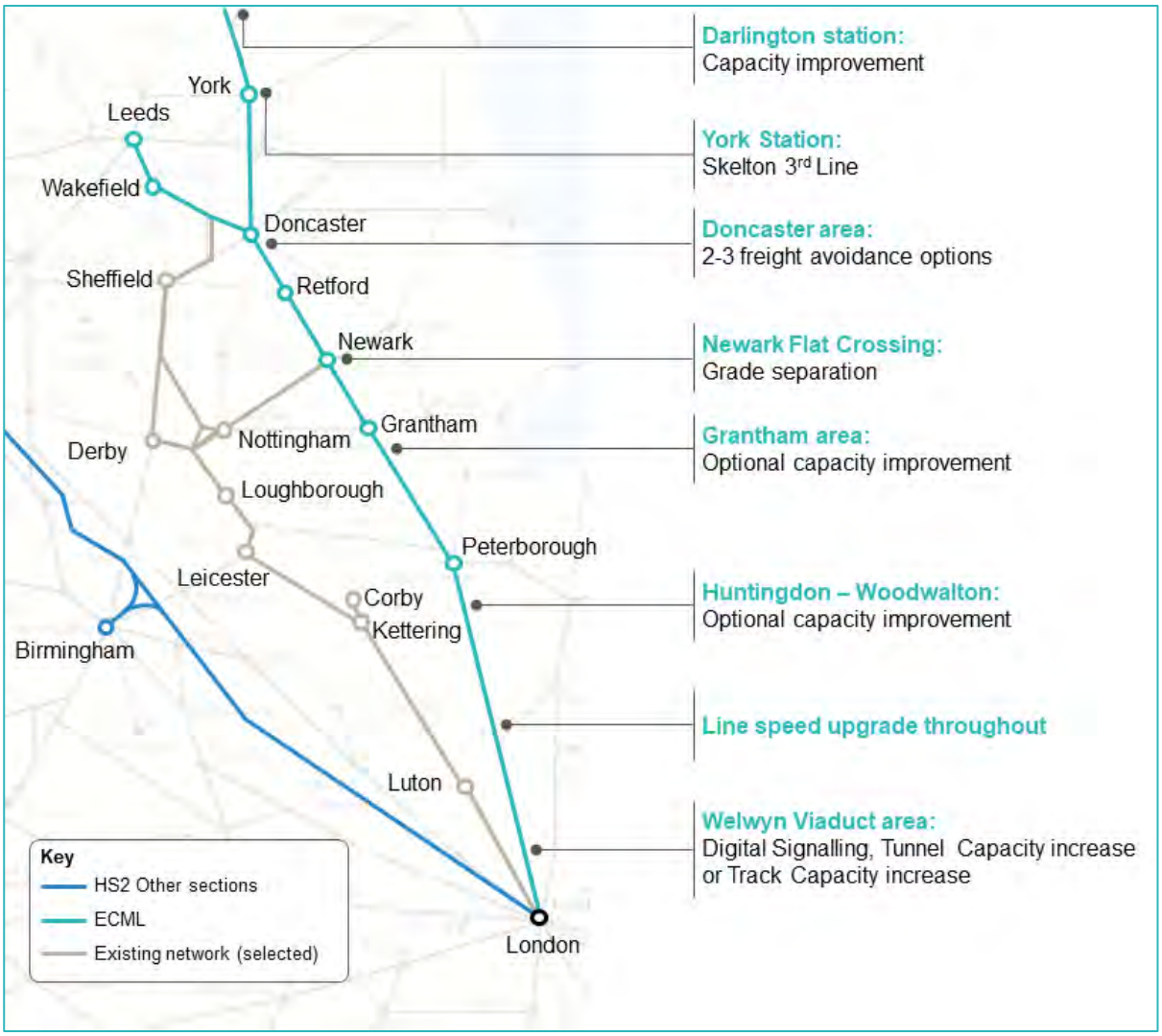
In this section we provide a summary of the infrastructure interventions to deliver the proposed TSS including construction disruption level and risk. Figure 3 shows the proposed interventions, with the subsequent text describing each intervention.

Given the early stage nature of our work we have not undertaken quantitative modelling of the impact of this strategic alternative on operational punctuality (referred to as performance). Instead we have identified a package of improvements which would lead to a TSS which in principle is operable based on typical planning assumptions. We have then added some further interventions which would build in additional performance resilience, enabling us to estimate the likely additional cost of this resilience. In our view, presenting a range of interventions is required given the scale of the potential changes on the ECML and historical performance challenges on this route.

We have presented infrastructure interventions in the following packages:

- **Core** – to deliver the proposed Train Service Specification (TSS) and maintaining performance approximately per the outcome of the ECML Enhancements Programme.
- **Performance** – adding further performance resilience that we recommend as meeting wider industry objectives.
- **Performance Plus** – our performance package of interventions plus the Welwyn *Light* alternative scheme and a larger additional intervention between Huntingdon and Woodwalton. The Welwyn area, in particular, is an important capacity pinch point on the route and our core and performance packages assume a solution enabled by signalling technology which has yet to be implemented on the route. We have therefore developed a conventional solution, to identify the potential impact on cost if the technology-enabled solution proves not to be deliverable.

Figure 3. ECML Infrastructure Interventions and the Revised HS2 Phase 2b Eastern Leg



3.2.4.1 Line Speed Upgrade (often referred to as L2E4)

- Core Option. This intervention is an increase in permitted line speeds up to a maximum of 140mph (versus a current maximum of 125mph). 140mph operation was the subject of a 2014 study for Network Rail, undertaken by consultants ARUP. Our assessment

used the line speeds and infrastructure cost estimates from this report, with the amendments described in Chapter 2 of this report.

- Performance Package. As per the Core Option.
- Performance Plus Package. As per the Core Option.

3.2.4.2 Welwyn Viaduct Area

The Welwyn Viaduct Area is a key capacity constraint on the ECML and an intervention would be required to enable train services over and above the Do-Minimum.

- Core Option. Reduced ETCS-enabled signal headways. We assume a change in capability of planned ETCS Level 2 signalling to enable a reduction in the post implementation signal headway from 2.5 minutes to 2 minutes.
- Performance Package. We have also developed a smaller scale, albeit still significant, intervention to build in additional performance resilience. This is an extension of the four track section back towards the north of the tunnel portal at Woolmer Green. We have flagged this as a lower cost alternative to the Welwyn Light scheme, should that intervention prove unaffordable or too challenging to deliver.
- Performance Plus Package. A significant intervention which would build in additional performance resilience is the Welwyn Light scheme as set out in the Atkins study. This involves four-tracking the currently two track Woolmer Green Tunnel, thereby extending the four-track section almost as far as Welwyn Viaduct. Welwyn North station would then be relocated with platforms placed on the new slow lines. The tunnelling scheme is tunnel option 2 from the associated Atkins technical note. This scenario offers considerable performance benefits if deliverable, however due to the order of magnitude difference in cost implications compared with our other Performance package recommendations, Welwyn Light is presented as an incremental intervention constituting a Performance Plus package.

3.2.4.3 Huntingdon – Woodwalton

- Core Option. Our assessment suggests that the current infrastructure is adequate for the TSS considered. Therefore, no infrastructure is proposed under the Core Option.
- Performance Package. An extension of the four-track section where the alignment narrows between Huntingdon and Woodwalton would have some performance benefits and/or enable journey time savings for some lightly used Thameslink services, as well as providing capacity for ‘Outer Suburban’ peak services. Network Rail has developed five options with various length of four track sections. (We have updated the price base of the Network Rail estimates to 4Q2019 prices). For the Performance Package we have assumed the smallest and least expensive scheme developed by Network Rail.
- Performance Plus Package. For this package we have assumed the largest and most expensive scheme developed by Network Rail.

3.2.4.4 Grantham Area

- Core Option. Our assessment suggests that the current infrastructure is adequate for the TSS considered, therefore no infrastructure is included.
- Performance Package. Provision of track and signalling work enabling an additional line through the station would be likely to have performance benefits, particularly in TSSs where the frequency of services increases. This scheme has therefore been included in the Performance package.
- Performance Plus Package. This is as per the Performance Package.

3.2.4.5 Newark Flat Crossing

Newark flat junction is a constraint on the maximum number of LDHS services and on maximum permitted line speed. Grade separation of this junction is likely to be required to enable these improvements, and we have developed, considered and sifted several schemes. The two best schemes are:

- Core Option. Grade separation of the flat junction, and an at grade chord from the Lincoln line to the ECML up line.
- Performance Package. This is the same scheme as above, except that track layout in and around Newark North gate is reconfigured to allow to separate down direction stopping and through services. In particular, this provides more flexibility in the way that ECML – Lincoln services can be timetabled.
- Performance Plus Package. As per the Performance Package.

3.2.4.6 Doncaster Area

Conflicts between freight and mainline services are a significant constraint in the Doncaster station area. Three options are suggested:

- Core Package. South Kirby and Ferrybridge freight diversion, and limited Doncaster remodelling. Freight services would be routed through the west (Down) side of the station, along the Doncaster – Wakefield line and then via a new chord near South Kirkby Junction onto the Moorthorpe – Ferrybridge line (and then on to Milford Junction and York). This enables freight traffic running from Doncaster (and south thereof) to York (and other destinations in Yorkshire) to avoid impacting on the ECML. Some remodelling of Doncaster station is also required, to enable some freight services to bypass to the east of the station, and a small amount of additional flexibility in the centre of the station layout.
- Performance package. South Kirby and Ferrybridge freight diversion, and extensive Doncaster remodelling. As above, but with a more comprehensive remodelling at Doncaster Station, including the provision of two new platform faces and footbridge access. *A potential alternative to this intervention is a GNGE Joint line Doncaster bypass. Under this scheme a number of freight services would bypass Doncaster to the east, via new chords near Loversall Carr Junction and Kirk Sandall, and gauge clearance work at Brotherton Tunnel. We have some concerns about the ultimate potential operability of this scheme and have therefore flagged it is an alternative option only.*
- Performance Plus Package. As per the Performance Package.

3.2.4.7 York-Skelton 3rd line

- Core Option. While there is only a small increase (~1 tph) in the number of services using York station in future scenarios compared to today, it is a known current performance and timetable constraint. One of the key constraints identified is the layout at the north end of the station which restricts the number of available parallel moves to/from the higher numbered platforms (and therefore to/from Leeds via Skelton Junction).
  It is proposed, therefore, that the north station throat layout is reconfigured to provide additional parallel moves by provision of an additional line. Extension of this into a third line north of York would further enhance this, and also helps to enable the operation of two trains per hour from York to the Harrogate line. As agreed with the Department, the

Strategic Alternative scheme proposed allows for some other changes in the station layout funded by the Northern Powerhouse Rail (NPR) project.

- Performance Package. As per the Core Option.
- Performance Plus Package. As per the Core Option.

3.2.4.8 Darlington Station

- Core Option. A scheme to reduce the number of crossing moves at Darlington is required. The scheme developed is similar to that being worked up as a possible planned intervention for the current Control Period, eliminating the need for crossing moves and providing the opportunity to turn-back a longer distance service from the south.
- Performance Package. As per the Core Option.
- Performance Plus Package. As per the Core Option.

3.2.5 Performance

The interventions in the Core Option are designed to offset the additional train services introduced through the ITSS when compared to the outputs of the ECML Enhancements Programme (i.e. the increase from the ECML Enhancements Programme to this ITSS should be 'performance neutral' at worst); this will need to be tested through further modelling at a later date if this option is progressed. This therefore provides interventions at the key performance 'hotspots' on the ECML, i.e. Welwyn Viaduct, Newark Flat Crossing, Doncaster, York and Darlington. It is also likely that some of these schemes could provide additional benefits to non-ECML services and freight services, for example by enabling additional trains to operate on the Newark – Lincoln route. However, the impact of using this capacity to operate additional trains has not been considered as part of this assessment.

The ECML route is already known as an area of performance concern, and therefore the opportunity could be realised to provide a step-change in performance through the infrastructure delivered. The Performance Package builds upon the Core Option through providing more significant schemes at the locations already identified, or tackling additional constrained locations (i.e. Huntingdon – Woodwalton and Grantham). It is therefore anticipated that these schemes will deliver notable better network performance than the Core Option.

After delivery of the Performance Package, the largest constraint remaining on the southern end of the ECML will be Welwyn Viaduct. This would remain a barrier to further growth and could constrain the timetable structure, as well as still potentially impacting performance. The purpose of the Performance Plus package would be to significantly reduce this constraint, although not completely resolve it due to the cost and scale of the schemes required.

3.2.6 Costs

The estimated infrastructure costs for the three packages of interventions are as follows:

- Core Option. £2.5bn.
- Performance Package. £3.1bn.
- Performance Plus Package. £3.9bn.

A breakdown by intervention is set out in Table 1 with the highest cost interventions discussed in some more detail.

The largest single intervention at circa £1.8bn is an upgrade of the maximum line speed on large sections of the ECML, which is required to deliver the bulk of the journey time

improvements over the do-minimum scenario. This intervention is included in all three packages.

As agreed with DfT, the interventions required to increase line speeds and the resultant estimate of costs and journey time savings are based on the 2014 L2E4 study[9], undertaken by consultants ARUP. We have reviewed this work and, based on the information presented believe that it is likely that a proportion of the recommended infrastructure work could be descoped or avoided entirely, for only a marginal loss of journey time at most equating to a minute increase[10] on the times shown in this report.

Our review considered three specific areas where cost could be saved:

- Whether there is potential to reduce the total structures cost through a reduced scope of bridge works.
- Whether any of the route section costs could be reduced or removed entirely if the resultant journey time improvement looks to offer poor value.
- Whether there are any obvious double counts with work already included in our recommended interventions for the ECML.

As noted above, the Welwyn area is a particular capacity constraint which would require an intervention in all of the scenarios considered.

In both our Core Option and Performance Package the ETCS signalling would be designed with a reduced signal headway than the Do-Minimum specification, to increase the capacity of this bottleneck on the route. We estimate that this would be relatively inexpensive at around £24m. In the Performance Plus Package the Welwyn 'Light' scheme is assumed, involving tunnelling to enable an extension of the four track section north of the Viaduct. This is a high cost item, which we estimate at around £970m. We also advise that this is an intervention with the potential for high construction and disruption risks, and have developed a lower scope extension of the four track section towards the north portal of Woolmer Green Tunnel as a potential alternative.

All three scenarios include grade separation of the flat crossing at Newark. The specification varies depending on the design of the new junction and its feeder routes. In our Core Option our cost estimate is £270m, rising to £331m in the Performance and Performance Plus Packages.

Similarly, all scenarios require a Doncaster freight avoidance element, with the Core Option estimated at £177m the Performance and Performance Plus Packages, at £308m. Both options include alterations to the layout at Doncaster to create additional parallel moves. (An alternative option based on bypassing the Doncaster area entirely is estimated at £244m).

[9] *East Coast Main Line L2E4 Study Phase 2 - Developing the Options.* 14th October 2014

[10] The descoping we have identified would result in a circa 23-27 second loss of journey time improvements

Table 1. Estimated Infrastructure Costs. £m Q4,2019

Infrastructure scheme	Scenario	Cost
Maximum line speed increase from 125mph to 140mph (L2E4 work)	All Scenarios	1,797
Welwyn capacity upgrade	Core	24
	Performance	168
	Performance Plus	966
Huntingdon – Woodwalton 4-tracking	Core	-
	Performance	94
	Performance Plus	187
Grantham Performance Improvement	Core	-
	Performance/Performance Plus	128
Newark Flat Junction Grade Separation	Core	270
	Performance/Performance Plus	331
Doncaster freight avoidance	Core	171
	Performance/Performance Plus	308
	Performance/Performance Plus Alternative (not included in totals)	*244*
York – Skelton 3rd line	All Scenarios	152
Darlington additional platforms	All Scenarios	73
Total ECML Interventions	**Core**	**2,487**
	Performance Package	**3,051**
	Performance Plus Welwyn North	**3,942**

3.2.7 Outputs

In this section we present estimated journey times for the ECML Strategic Alternative, focussing on key destinations which would see service improvements over the Do-Minimum scenario. A longer list of locations is provided in the conclusion to this report.

Table 2 and Table 3, respectively, show the indicative fastest journey times and typical hourly train service frequencies.

London – Newcastle and London – Edinburgh would receive a broadly comparable level of service (both journey times and train service frequency) under either the HS2 Eastern Leg or an upgraded ECML.

London – Leeds would receive a significantly worse journey time and direct service frequency under the ECML upgrade than the HS2 Eastern Leg.

London – York would receive a better service under the HS2 Eastern Leg than under the ECML upgrade, however the difference in journey time is only around 14 minutes.

In the ECML upgrade, connectivity from Leeds, York and Newcastle to Birmingham is similar to today, and so is significantly worse than the HS2 Eastern Leg.

Table 2. Fastest direct journey times, indicative standard hour, off peak, northbound

	London – Leeds	London - York	London – Newcastle
Dec 19	2 hrs 13 mins	1 hr 46 mins	2 hrs 49 mins
Do-Minimum	2 hrs 00 mins	1 hr 46 mins	2 hrs 34 mins
HS2 Phase 2b*	1 hr 21 mins	1 hr 24 mins	2 hrs 17 mins
ECML Alternative	1 hr 53 mins	1 hr 38 mins	2 hrs 25 mins

**HS2 Phase 2b target journey times*

Table 3. Direct trains per hour, indicative standard hour, off peak, northbound^

	London – Leeds	London - York	London – Newcastle	London – Edinburgh
Today and Do-Minimum	2-3 ECML	4 ECML	3 to 4 ECML	2 to 3 ECML 0 to 1 WCML
HS2 Phase 2b	3 HS2 1 ECML	3 HS2 3 to 4 ECML	2 HS2 1 to 2 ECML	2 HS2 1 to 2 ECML
ECML Alternative	2 to 3 ECML	4 ECML	3 to 4 ECML	3 to 4 ECML

^ Source: PLANET Framework Model version 9 (PFMv9). This is the forecasting software currently supporting the business case for HS2.

The following table gives an indication of seats per hour for key flows based on currently-supported maximum train lengths on the ECML (10-car Class 80xs at 699 seats). The 'ECML Alternative (theoretical maximum)' row expands the comparison to assume train lengths for ECML services can be increased to 11-car trains at 787 seats (except the 2 fast Scotland services, assuming 12-car at 875 seats). This is intended to set out the maximum feasible capacity without reconfiguring the interior of the trains.

Table 4. Indicative seats per hour - key flows, indicative standard hour, off peak, northbound (total standard and first class seats)

		London – Leeds	London - York	London – Newcastle	London – Edinburgh
Dec 2019 and Do-Minimum	ECML	1,398 to 2,097	2,796	2,097 to 2,399	1,398 to 1,700
	WCML				0 to 591
	Total	1,398 to 2,097	2,796	2,097 to 2,399	1,398 to 2,291
HS2 Phase 2b	HS2	**2,744 (Peak) / 1,636 (Off-peak)**	**1,584**	**1,056**	**1,056**
	ECML	699	2,097 to 2,796	699 to 1,001	699 to 1,001
	Total	**3,443 (Peak) / 2,335 (Off-peak)**	**3,681 to 4,380**	**1,755 to 2,057**	**1,755 to 2,057**
ECML Alternative (10-car IEPs)	-				
	ECML	1,398 to 2,097	2,796	2,097 to 2,399	2,097 to 2,399
	Total	**1,398 to 2,097**	**2,796**	**2,097 to 2,399**	**2,097 to 2,399**
ECML Alternative (theoretical maximum)	-				
	ECML	1,574 to 2,361	3,324	2,537 to 2,839	2,537 to 2,839
	Total	**1,574 to 2,361**	**3,324**	**2,537 to 2,839**	**2,537 to 2,839**

Notes:

- *HS2 services based on 554 (captive) and 528 (conventional-compatible) seats per 200m unit*
- *Dec 2019 and Do Minimum: ECML services based on 10-car IEPs (currently supported maximum train lengths) at 699 seats or 5-car IEPs at 302 seats per unit.*
- *HS2 Phase 2b assumptions*
  - *Leeds: Peak - 4 Captive and 1 CC unit per hour, Off-peak - 2 Captive and 1 CC unit.*
  - *York: 3 CC units per hour all day. ECML King's Cross London - York current assumption adopted from NPR Full EL scenario 2tph (1 Scotland, and 1 Middlesbrough/Sunderland, both assumed to be 10-car IEP).*
  - *Newcastle: 2 CC units per hour all day. 10-car IEP assumed on residual LNER, and 5-car on the Open Access.*
- *Strategic alternative: 10-car IEPs assumed as core scenario. Illustrative additional 'theoretical maximum' scenario shows capacities assuming 11-car IEPs on all services (except the 2 fast Scotland services, assuming 12-car). This is intended to set out the maximum feasible capacity without reconfiguring the interior of the trains.*
- *London – York may receive a moderate further capacity uplift under the Strategic Alternatives, depending on the eventual stopping pattern selected.*

3.3 Midland Main Line Upgrades

3.3.1 Introduction

Under this Strategic Alternative the HS2 Eastern Leg would not go ahead, and would be replaced by an upgrade of the MML and Burton and Tamworth Line. Under this proposal (northbound) HS2 services would use the current planned HS2 Phase One infrastructure and shortly after calling at Birmingham Interchange, would join the conventional network via a new junction at Wilnecote near Tamworth. Trains would continue either via an upgraded conventional network to Sheffield or Nottingham. The route to Sheffield would be via Derby and Chesterfield, with the route to Nottingham via the Castle Donington line. Southbound HS2 services would follow the same alignment in reverse.

Locations beyond Sheffield and Nottingham would not receive HS2 services.

This Strategic Alternative is very similar to one of the proposals developed by Atkins 2016.

3.3.2 Assumptions

Full electrification of the MML is assumed in the Do-Minimum (baseline) scenario. *We have also produced an indicative cost assessment for the sections of electrification required specifically for the MML Strategic Alternative. These indicative cost estimates are shown for completeness.*

Common with the other Strategic Alternatives, the Do-Minimum scenario also includes the assumption that HS2 Phase 2A is operational, with the quantum of other passenger services and freight services agreed with the Department.

Unlike the ECML, it is assumed that the MML will continue to be controlled using conventional signalling.

3.3.3 Train Service Specification

The infrastructure specification set out above would result in four HS2 services per hour comprising:

- Two London Euston – Sheffield; and
- Two London Euston – Nottingham.

In principle there would be some spare capacity between Birmingham Curzon Street and locations to the north, however journey times to and from Birmingham would not see a material improvement. We have therefore assumed that there would be no HS2 services between Birmingham Curzon Street and locations further north.

On this basis two LDHS Cross Country services per hour would continue to serve Birmingham New Street as per the Do-Minimum Scenario.

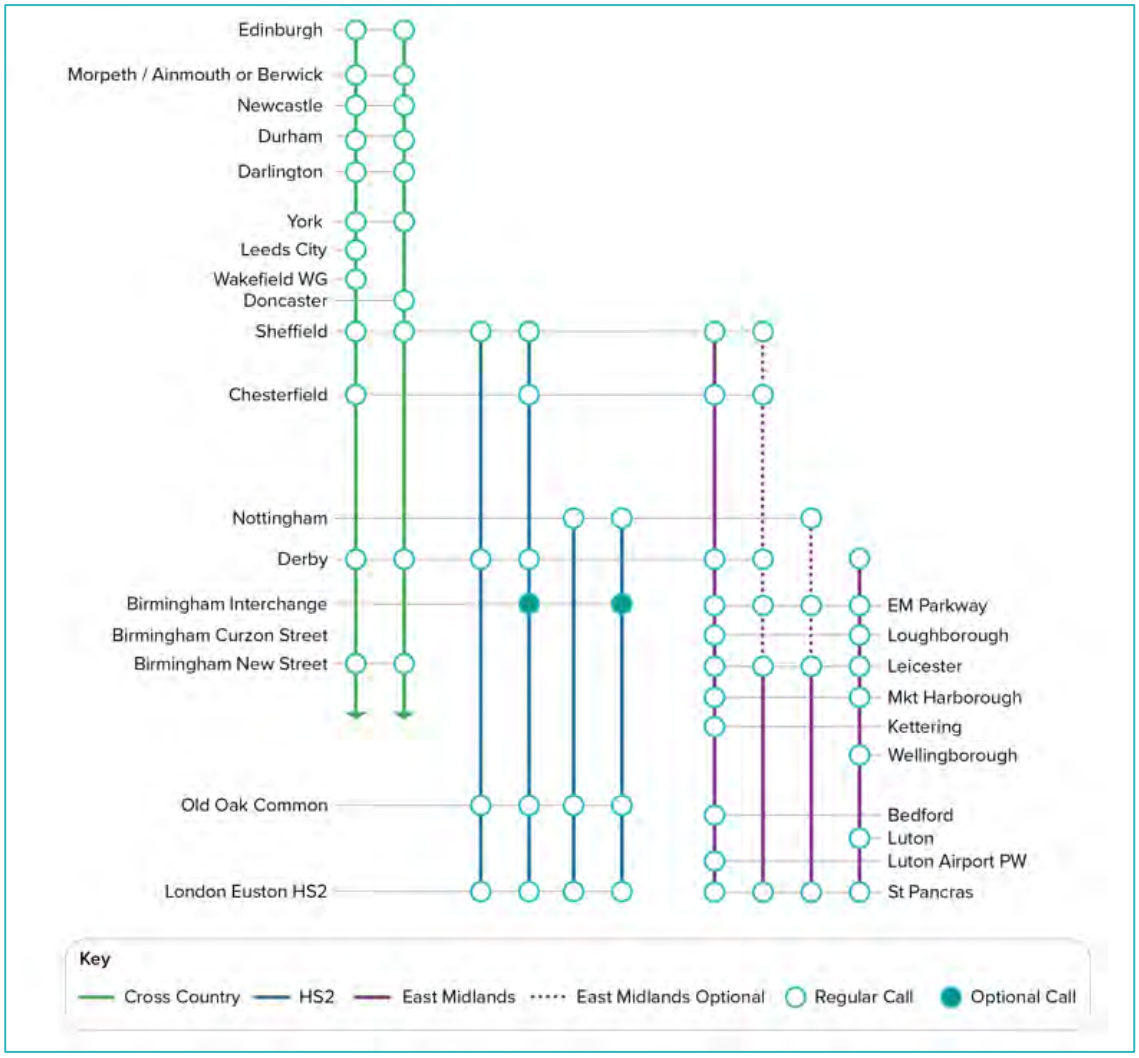
The quantum of MML services to and from London St Pancras would remain broadly as per the Do-Minimum scenario with four trains per hour serving Leicester (with at least one extending to/from each of Sheffield and Nottingham) Under our TSS, stopping patterns would be adjusted to provide better connectivity to and from smaller locations, taking advantage of the capacity released by serving Derby, Sheffield and Nottingham principally via HS2. However, downstream choices exist on the quantum and stopping pattern of trains north of Leicester providing different trade-off between journey times, capacity and punctuality.

Two London St Pancras – Corby services are assumed, although for simplicity this has not been shown in our TSS, in the way that we have not showed other trains on the route.

The quantum of other services has been agreed with DfT and is consistent with current rail industry planning assumptions.

Figure 4 below shows the indicative hourly LDHS calling pattern.

Figure 4. MML upgrade only indicative LDHS calling pattern, some stations are not shown



Note: While no calling pattern has been defined in this study, the intervention packages make pathing provision for a second train per hour between Leicester and Nottingham / Derby. This could be provided either via St Pancras services or via standalone shuttles to/from Leicester (although this latter option implies a high number of terminating trains at Leicester which may have its own implications).

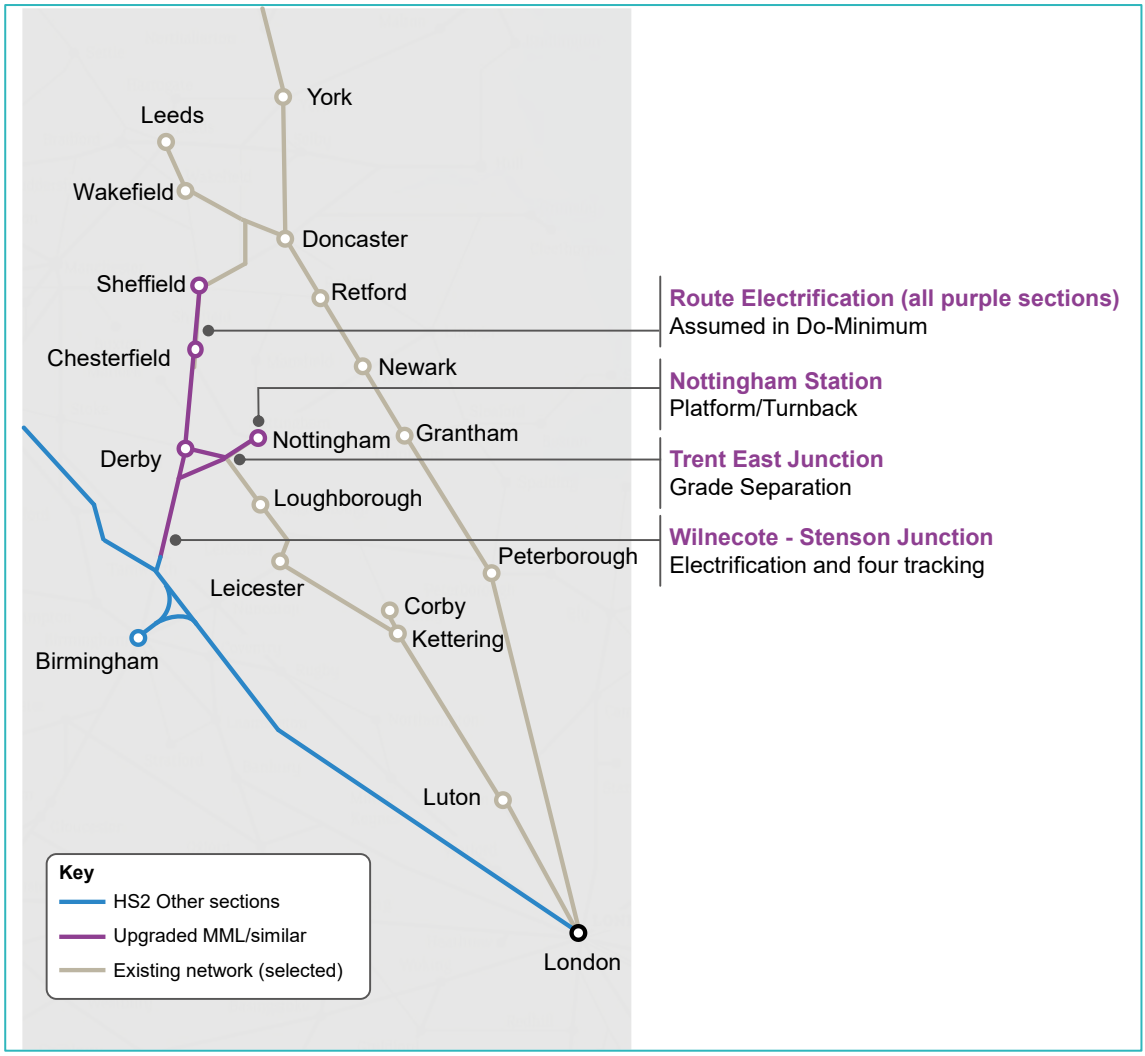
3.3.4 Infrastructure Interventions

In this section we provide a summary of the infrastructure interventions to deliver the proposed TSS. Figure 5 shows a simplified map of the work required, with the subsequent text describing each intervention.

Given the early stage nature of our work we have not undertaken quantitative modelling of the impact of this strategic alternative on operational punctuality (referred to as performance). Instead we have identified a package of improvements which would lead to a TSS which in

principle is operable based on typical planning assumptions. We understand the key performance pinch points both currently and in the future scenarios considered, and have looked to include mitigations which would result in performance that in principle should not deteriorate below broadly the levels seen in the December 2019 timetable. Choices to add additional performance resilience are less clear cut than for the ECML Strategic Alternative, so we have not added further options for the MML. It may be that subsequent development work identifies additional interventions, not included in our assessment.

Figure 5. Infrastructure MML Intervention, replacing the HS2 Phase 2b Eastern Leg



3.3.4.1 Wilnecote – Stenson Jn

This intervention comprises four-tracking for much of this corridor, as well as upgrading the junction layouts at North Staffordshire Junction and Stenson Junction. The proposal at Stenson Junction would enable improved segregation of traffic flows as well as enabling freight services to be held at Stenson Junction to enable high speed services to access/egress the Castle Donington route. The option developed is as per the scheme proposed by Atkins.

3.3.4.2 Trent Junction (Trent East Junction Grade Separation)

Given the importance of the Trent Junction area as a major route capacity constraint, we undertook a new assessment rather than taking the Atkins work as a starting point.

Our analysis indicated that the most problematic conflict in the Trent Junctions area under this TSS is where the Down (Nottingham) Fast Line crosses the Nottingham – Derby line towards Derby, and that the TSS is operable with grade separation of this junction by placing both the up fast and down fast lines on a new viaduct allowing a realigned Nottingham – Derby line to pass underneath.

Increasing the maximum permitted speed of trains over Sheet Stores junction would be desirable but is not strictly required for this TSS.

3.3.4.3 Nottingham Station.

The TSS would introduce more services into Nottingham Station. There is unlikely to be sufficient capacity to accommodate the resultant number of terminating and through trains.

We have identified two ways to deliver additional capacity. They are:

- A new (bay) platform and track layout to enable better segregation of high speed and regional/local traffic.
- New turnback sidings to the East of the station.

Both schemes are likely to have a similar cost and provide comparable levels of capacity. We have assumed that the platform works would be selected if only one scheme was required, however this may not necessarily be the case.

3.3.4.4 Route Electrification

Several sections of route would require electrification to enable HS2 services to operate. As noted above this electrification is assumed in the Do-Minimum scenario and is reported here for completeness. Sections requiring electrification are:

- Wilnecote to Derby. Broadly the whole (new) layout is assumed, but it may be possible to reduce this to two tracks only.
- Derby – Sheffield. Inclusive of any capacity work required to deliver the TSS.
- Stenson Junction – Trent Junctions area (Castle Donington Line).
- Derby – Trent Junctions area.
- Trent Junctions area – Nottingham.

3.3.5 Performance

The infrastructure interventions presented here are based on a comparison of the December 2019 service levels and those presented in the ITSS, which identified both existing performance ‘hotspots’ and the locations with the biggest increment in train service. Therefore, performance would be expected to be in line with the December 2019 timetable once the interventions have been included.

By far the largest constraint identified was the Trent Junctions area, and a study of train routeings and interactions was undertaken to understand how the area would work under the future ITSS. The intervention selected will tackle the most significant timetable and performance constraints, although smaller constraints will remain. An upgrade to a larger-scale intervention would provide an incremental benefit and could also be considered further.

Nottingham was identified as a constraint based on the increase in the number of services terminating compared to today. The interventions proposed aim to improve performance by either segregating High Speed and local services better, or by providing turnback sidings to reduce platform use across the hour. Both of these solutions are likely to achieve this aim, although which option is preferred would need to include additional factors such as the likelihood of extending services across Nottingham compared to today.

It should be noted that although the Sheffield area was also identified as a constraint, it is assumed that this constraint is fully or partially resolved through proposed schemes delivered in the meantime (such as those part of NPR).

3.3.6 Costs

The estimated infrastructure costs are shown below in Table 5. The total cost of this Strategic Alternative is approximately £3.3bn, of which the Wilnecote - Stenson Junction upgrade comprises the majority.

Table 5. MML Strategic Alternative. Total infrastructure costs, £m 4Q2019

Infrastructure Scheme	Cost
Wilnecote - Stenson Junction Upgrade	1,418
Trent East Junction Grade Separation	265
Nottingham Station Platform or Turnback	22
Route Electrification (not in Do-Minimum) **Wilnecote to Derby.** **Stenson Junction – Trent Junctions area**	1,572
Total Cost	**3,277**

3.3.7 Outputs

In this section we present estimated journey times for the MML Strategic Alternative, focussing on key destinations which would see service improvements over the Do-Minimum scenario. A longer list of locations is provided in the conclusion to this report.

Table 6 shows headline journey times between selected origin - destination pairs for the Do-Minimum scenario, HS2 Phase 2b and the MML Strategic Alternative. Table 7 compares train service frequencies, and Table 8 compares the number of indicative seats per hour.

Under the Strategic Alternative, both London – Derby and London - Nottingham would be served by direct HS2 services, rather than passengers being required to change trains at Toton in the Phase 2b TSS. This would result in faster direct journey times than HS2 Phase 2b, as well as up to two additional trains per hour with a resultant capacity benefit.

London – Sheffield and London Chesterfield would receive broadly equivalent journey times, frequencies and capacity under Phase 2b and the Strategic Alternative.

In the MML upgrade, connectivity from the Midlands and Sheffield to Birmingham is similar to today, and so is significantly worse than the HS2 Eastern Leg. However, Cross Country services would likely benefit from upgrades to the conventional route via Burton and Tamworth with the current LDHS rolling stock able to take advantage of the increased line speed. This

improvement in journey time would be likely to improve further if electric and/or hybrid diesel/electric rolling stock was introduced in the future.

Table 6. Fastest direct journey times, indicative standard hour, off peak, northbound

	London – Derby	London – Nottingham	London – Chesterfield	London – Sheffield
Do-Minimum*	1 hr 23 mins	1 hr 38 mins	1 hr 45 mins	1 hr 59 mins
HS2 Phase 2b**	**1 hr 31 mins	**1 hr 29 mins	1 hr 12 mins	1 hr 27 mins
MML Alternative	57 mins	1 hr 20 mins	1 hr 15 mins	1 hr 26 mins

** Broadly as per Dec 19 (pre Covid), although some benefits will be realised through committed rolling stock changes which is not captured here.*
***Journey times derived from 'Phase 2B 2RS02 East Midlands Hub Operability Report' 2019. Includes an interchange*

Table 7. Direct trains per hour, indicative standard hour, off peak, northbound

	London – Derby	London – Nottingham	London – Chesterfield	London – Sheffield
Do-Minimum*	2	2	2	2
HS2 Phase 2b	2**	2**	2***	3****
MML Alternative	3-4****	3-4****	2-3***	3-4****

** Broadly as per Dec 19 (pre Covid)*

***HS2 Phase 2b requires passengers to change trains at Toton. MML conventional services would continue to call at Derby and Nottingham hourly.*

**** Chesterfield would receive 1 HS2 call per hour and 1 conventional call*

***** One conventional service per hour.*

Table 8. Indicative seats per hour - key flows, indicative standard hour, off peak, northbound (total standard and first class seats)

	London – Derby	London – Nottingham	London – Chesterfield	London – Sheffield
Do-Minimum[a]	758	758	758	758
HS2 Phase 2b	379 - 758	379 - 758	907 - 1,286	1,435 - 1,814
MML Alternative	1,435 - 1,814	1,435 - 1,814	907 - 1,286	1,435 - 1,814

[a] Broadly as per Dec 19 (pre Covid), although some benefits will be realised through committed rolling stock changes
Notes:
Conventional routes assumed to be served by 7-car Meridians at 379 seats as per PFMv9 assumptions
HS2 routes assumed at single unit 200m conventional compatible at 528 seats

3.4 MML and ECML Conclusions

This final section of the chapter sets out some key conclusions on the alternatives considered. Figure 6 shows both upgrade options in a simplified map, and Figure 7 shows the combined TSS.

In isolation both Strategic Alternatives provide some benefits to a limited set of locations, but overall provide significantly less benefits than the Phase 2b Eastern Leg in full ,as set out below.

ECML Alternative

- London – Newcastle. Comparable improvements to Phase 2b albeit with slightly slower journey times.
- London – York and London - Leeds. ECML upgrades provides some capacity and journey time benefits, but less so than under Phase 2b (especially for Leeds where journey times are significantly less than 2b).
- Improved connectivity between smaller locations on the ECML, albeit likely to be on a smaller scale then under Phase 2b.
- No improvement to connectivity between locations served by the ECML and Birmingham.

MML Alternative

- London – Derby. More direct services and faster direct journey time than Phase 2b.
- London – Nottingham. More direct services and faster direct journey time than Phase 2b.
- London – Chesterfield. Comparable improvements to Phase 2b.
- London – Sheffield. Comparable improvements to Phase 2b.
- Limited improvement in connectivity to East Midlands from Birmingham compared to Phase 2b
- No improvement to connectivity between the East Midlands with West Yorkshire and the Northeast.

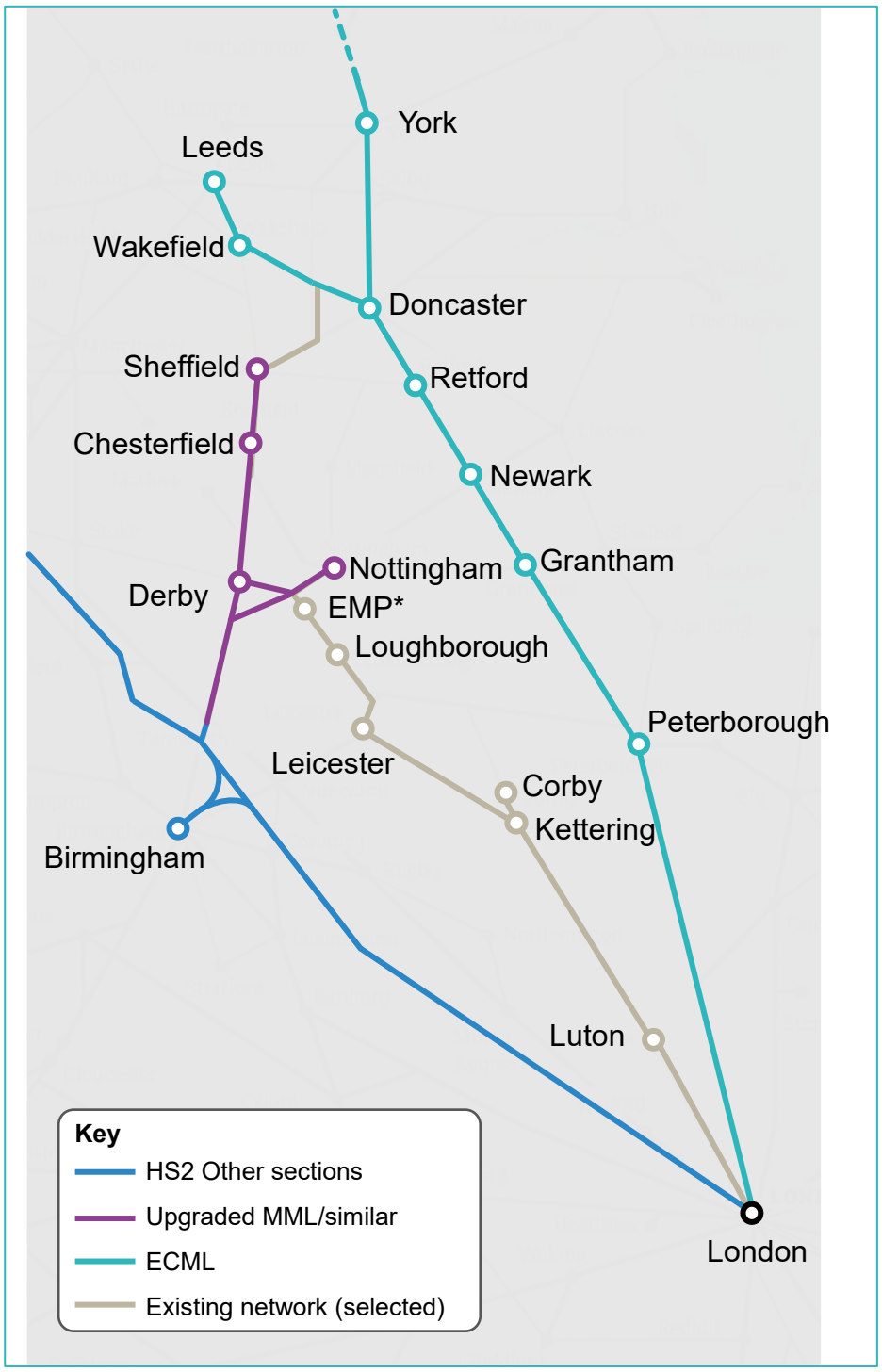
Implementation of both Strategic Alternatives as a single package would combine the benefits to both routes and prevent either route seeing no benefits. However, a number of the transformational benefits of the Eastern Leg would be lost. In particular, the proposals would provide little opportunity to improvement connectivity between the West Midlands, the East Midlands and locations further north.

Table 9 below shows the estimated combined cost of the ECML and MML upgrade packages. The total cost of the MML Package and the ECML Package (Core Option) is estimated at £5.8bn. Addition of the Performance or the Performance Plus infrastructure for the ECML increases the estimated cost to £6.2bn and £7.2bn, respectively.

We understand that the cost of the full Eastern Leg is currently estimated to cost up to £32bn in 2019 prices. Therefore, despite the early stage nature of our assessment, the cost of the upgrade package(s) would seem to be several times less than the cost of the Eastern Leg.

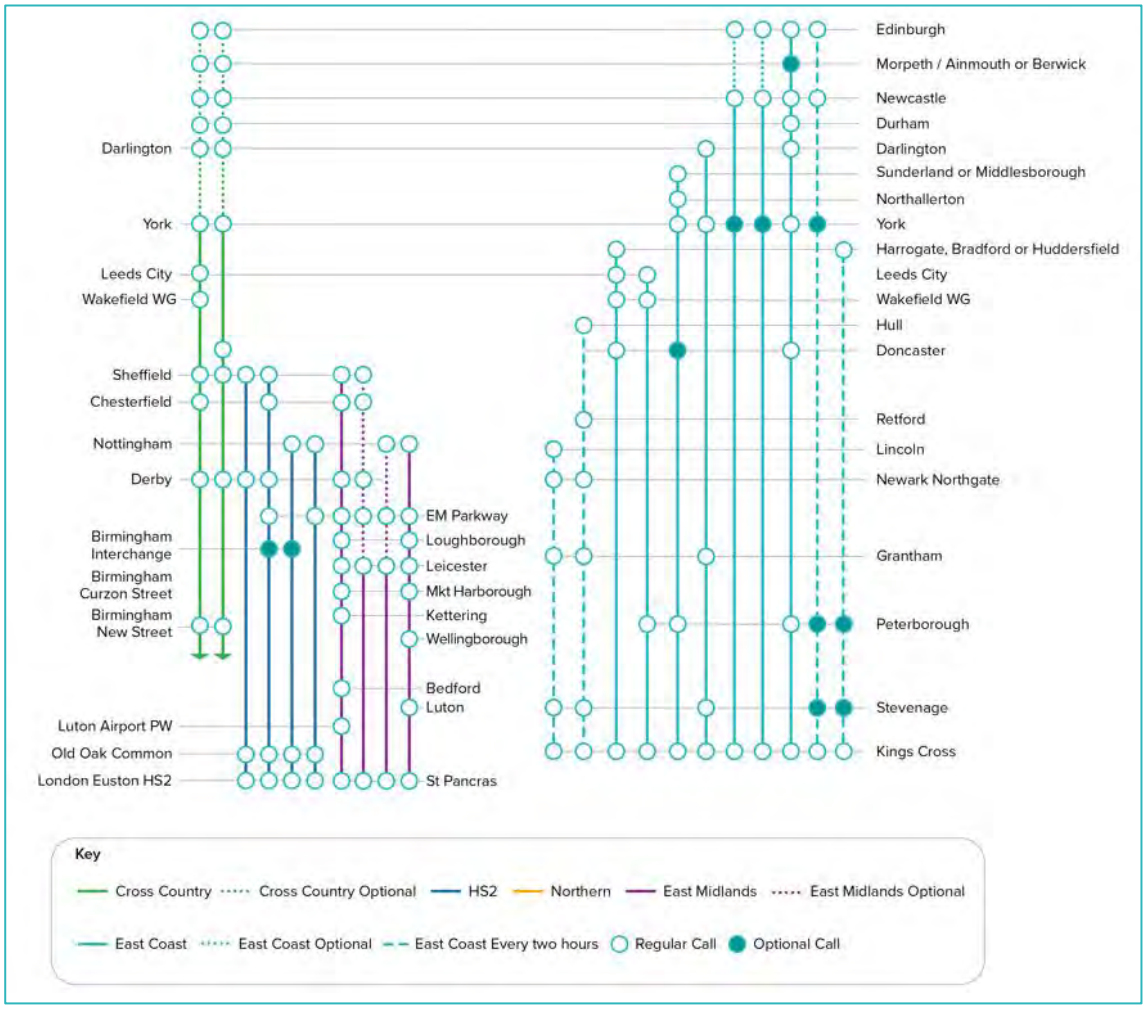
In summary, replacement of the Eastern Leg with a package of conventional network upgrades would save the bulk of the cost of the Eastern Leg, but would also forgo the transformational benefits of the scheme, with most locations receiving modest improvements in journey time and frequency versus the Do-Minimum situation. This package would therefore seem not to meet Government's strategic priorities.

Figure 6. Combined MML and ECML Strategic Alternative to the Eastern Leg



* East Midlands Parkway

Figure 7. Combined MML and ECML Strategic Alternative Standard Hour LDHS calling pattern, some stations are not shown



Note. Harrogate, Bradford and Huddersfield are shown as a single location to keep the illustration legible. The third train from the left would terminate at Bradford Forster Square one hour and Harrogate the next. The closest train to the right of the graphic would terminate at Bradford Interchange or Huddersfield depending on the time of day.

Table 9. Combined Upgrades Only Package Costs, £m 4Q2019 prices

Infrastructure Scheme	Cost
MML Upgrade Package	3,277
ECML Upgrade Package (Core)	2,487
ECML Upgrade Package (Performance)	2,907
ECML Upgrade Package (Performance Plus)	3,942
Total MML + ECML	**5,764* -7,219****

* MML + ECML Core

** MML + ECML Performance Plus

4 First phase to Sheffield

4.1 Introduction

Under this Strategic Alternative the HS2 Eastern Leg would be replaced by a hybrid package of infrastructure interventions comprising:

- A new high speed route between HS2 Phase One north of Birmingham Interchange and the MML just south of East Midlands Parkway station.
- An electrified MML with some targeted capacity interventions
- The ECML upgrades described in the previous chapter.

HS2 services from London Euston and Birmingham Curzon Street would serve Nottingham, Derby, Chesterfield and Sheffield. ECML locations would continue to be served by conventional services, albeit with enhanced journey times and capacities.

Variants of this package were also considered:

- Addition of upgraded infrastructure between Nottingham and Lincoln to allow HS2 services to serve Lincoln via Newark Castle.
- A chord to the ECML to allow HS2 or MML trains to serve ECML locations.
- A new station at Toton, which could accommodate potential LDHS services from the MML, thereby enabling regeneration of the Toton area which is a benefit of the Eastern Leg. For simplicity, Toton station is not shown in this Train Service Specification (TSS), however a short Annex is included on Toton at the end of this report.

4.2 Assumptions

Assumptions are broadly as per the upgrade only alternatives.

Full electrification of the MML is assumed in the Do-Minimum (baseline) scenario.

Common with the other Strategic Alternatives, the Do-Minimum scenario also includes an assumption that HS2 Phase 2a is operational, with the quantum of other passenger services and freight services agreed with the Department.

Unlike the ECML, it is assumed that the MML will continue to be controlled using conventional signalling.

4.3 Train Service Specification

The infrastructure specification set out above would result in six HS2 services per hour comprising:

- Two London Euston – Sheffield;
- Two London Euston – Nottingham;
- Two Birmingham Curzon Street - Nottingham

The two Birmingham – Nottingham services are additional to the TSS in the MML Strategic Alternative, this is because Birmingham – Nottingham would see a significant reduction in journey time via this route. Under the optional upgrade to Lincoln, one of these services could extend beyond Nottingham providing a very large time saving between Birmingham and Lincoln and Nottingham and Lincoln, replacing the current service east of Nottingham. This service could also call at Newark Castle.

No HS2 services are included between Birmingham and Sheffield under this TSS as there would be a minimal time saving versus in the Do-Minimum scenario. We have, therefore, assumed that the current Cross Country services would continue to operate.

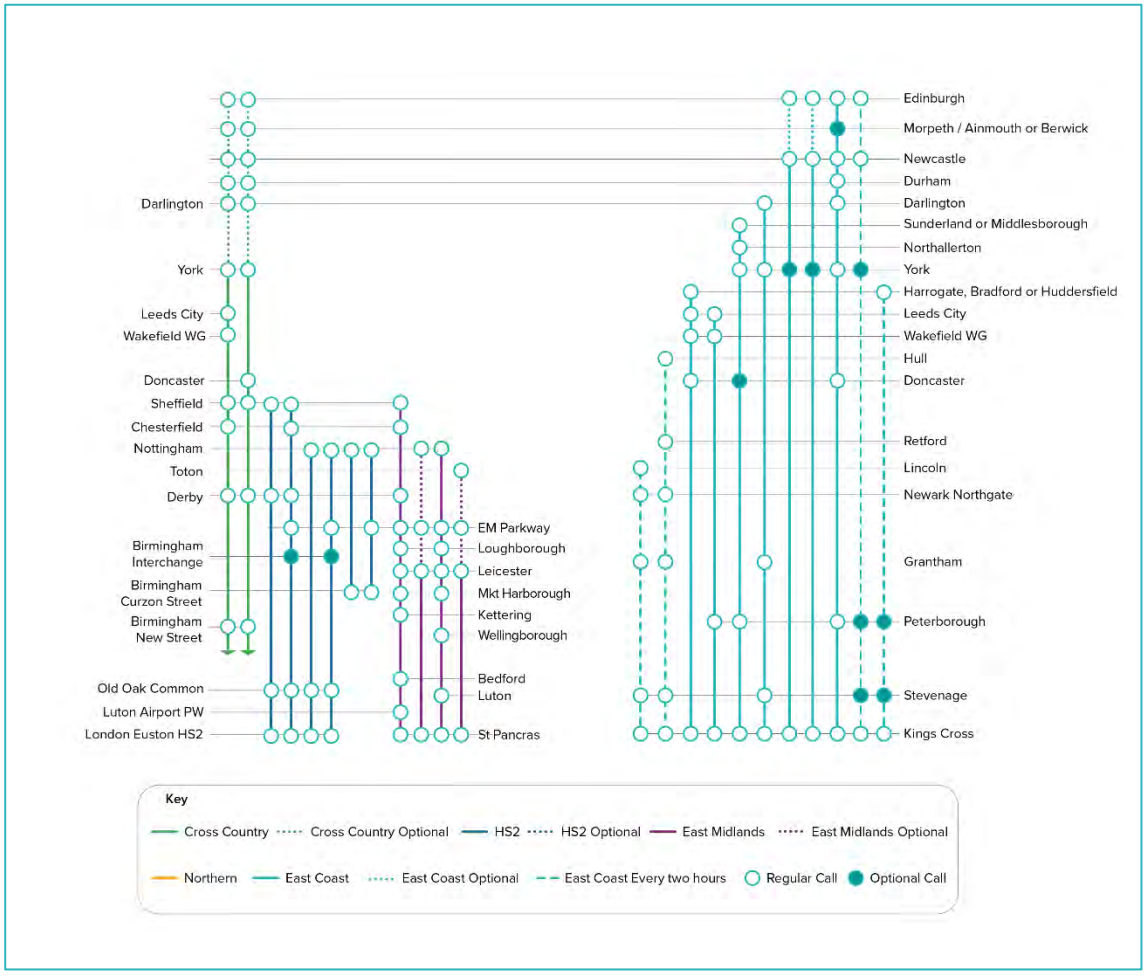
The quantum of MML services to and from London St Pancras would remain broadly as per the Do-Minimum scenario with four trains per hour serving Leicester (with at least one extending to/from each of Sheffield and Nottingham). Under our TSS, stopping patterns would be adjusted to provide better connectivity to and from smaller locations, taking advantage of the capacity released by serving Derby, Sheffield and Nottingham principally via HS2. However, downstream choices exist on the quantum and stopping pattern of trains north of Leicester providing different trade-offs between journey times, capacity, and punctuality.

Two London St Pancras – Corby services are assumed, although for simplicity have not been shown in our TSS, in the way that we have not shown other trains on the route.

The quantum of other services has been agreed with DfT and is consistent with current rail industry planning assumptions.

Figure 8 below sets provides an illustration of the standard hour TSS, inclusive of the optional services described above.

Figure 8. First Phase to Sheffield: Indicative Standard Hour LDHS calling pattern, some stations are not shown



Note. Harrogate, Bradford and Huddersfield are shown as a single location to keep the illustration legible. The third train from the left would terminate at Bradford Forster Square one hour and Harrogate the next. The closest train to the right of the graphic would terminate at Bradford Interchange or Huddersfield depending on the time of day.

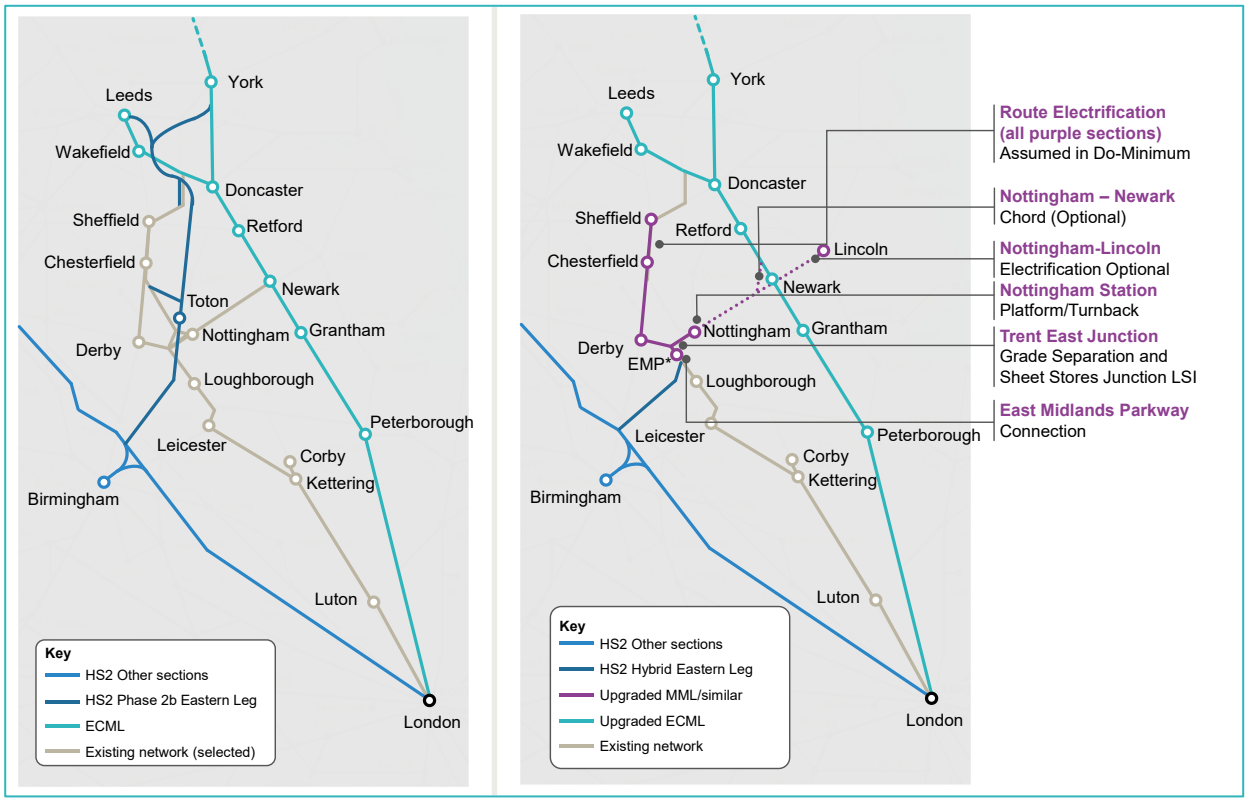
4.4 Infrastructure Interventions

In this section we provide a summary of the infrastructure interventions to deliver the proposed TSS. Figure 9 shows a simplified map of the work required, with the subsequent text describing each intervention.

Figure 9 below shows a simplified route map denoting the new hybrid alignment, as well as the proposed enhancements on the conventional network. ECML interventions are the same as under the enhancements only alternative and have not been shown individually.

Our approach to assessing the impact of the interventions on service punctuality is the same as described previously in Chapter 3.

Figure 9. First Phase to Sheffield: Simplified Schematic and Simplified HS2 Route Map (Current and Amended)



4.4.1 Eastern Leg Alignment to/from East Midlands Parkway

The HS2 Eastern Leg is constructed broadly as planned between Birmingham and the M1 (East Midlands), where the route then aligns to connect to the Midland Main Line south of East Midlands Parkway.

4.4.2 East Midlands Parkway HS2 connection (Current slow lines)

A grade separated junction from the southern section of the HS2 Phase 2b Eastern Leg, onto the MML. We considered several potential layouts and concluded that a connection onto the current slow lines would avoid some otherwise required capacity work in the Trent Junctions area which may not be deliverable from a construction perspective.

4.4.3 Trent Junction (Trent East Junction Grade Separation and Sheet Stores Junction Line Speed Improvement)

The proposed intervention is the same as under the MML Strategic Alternative. Namely, grade separation of Trent East Junction and an improvement of the line speed over Sheet Stores Junction. Unlike in the MML alternative where the Sheet Stores Junction work is desirable, in this Hybrid option the work is a key requirement.

4.4.4 Nottingham Station.

The proposed intervention is the same as under the MML Strategic Alternative. Namely:

- A new (bay) platform and track layout to enable better segregation of high speed and regional/local traffic.
- New turnback sidings to the East of the station.

Either of these schemes would be adequate, with a similar likely construction cost.

4.4.5 Route Electrification

The MML between the HS2 new line connection and Sheffield and Nottingham would require electrification. As noted above this electrification is assumed in the Do-Minimum scenario and is reported here for completeness. Government might choose to electrify the MML in full, to avoid a gap between Market Harborough and roughly East Midlands Parkway.

4.4.6 ECML interventions

The scope of work is identical to the programme set out in the previous chapter.

4.4.7 Optional items

As noted previously in this chapter, we have considered three variants of this Strategic Alternative where further infrastructure upgrades could provide benefit to a wider set of locations. These upgrades are:

- Electrification of the conventional route between Nottingham and Lincoln, to enable HS2 services to operate between Birmingham and Lincoln. A small capacity intervention at Lincoln station would also be required, extending the length of two platforms to accommodate 200m long trains.
- A new chord between the Nottingham Line and the ECML to enable HS2 and MML trains to service ECML locations and vice versa.
- A new station at Toton, which could accommodate potential LDHS services from the MML. This option is explored in Appendix B.

4.5 Outputs

The tables below show headline journey times between selected origin - destination pairs, together with a comparison of service frequencies against HS2 Phase 2b for each scenario. A

larger number of location pairs are shown than in the previous chapter as the benefits of the investment is spread over a wider geography. For several pairs of locations we have compared new direct journey times against time which would require passengers to change trains. In these instances we have compared the total journey start station – end station time inclusive of a time penalty equivalent to the inconvenience passengers face when changing trains. Inclusion of this penalty is consistent with the demand forecasting approach adopted by HS2 Ltd, as well as with the guidance set out in DfT's TAG publication[11]. This approach has been taken throughout the report.

This package would result in significant journey time saving versus the Do-Minimum scenario (HS2 Phase 2a) and in general the spread of locations which would benefit from significant journey time savings is higher than under HS2 Phase 2b.

Of all the locations considered, Nottingham would see the largest improvements in journey times. London – Nottingham and Birmingham – Nottingham journey times would see up to 41 minute and 48 minute journey time reductions versus the Do-minimum, respectively, and also deliver significantly better journey times than HS2 Phase 2b (which requires a change at Toton). Similarly, London – Derby would receive a significant reduction in journey times versus the Do-Minimum and Phase 2b. Like Nottingham a proportion of this saving is generated by the provision of direct services versus the concept of interchange at Toton in Phase 2b.

London – Sheffield and London – Chesterfield journey times are broadly comparable under the First Phase to Sheffield option and Phase 2b.

London – Leeds journey times would be circa 32 minutes slower under this package versus High Speed 2 Phase 2b, and Birmingham – Leeds would see no journey time benefit over the Do-Minimum scenario

For Nottingham – Sheffield, modest journey time improvements are estimated. There is minimal improvement based on existing stopping patterns and rolling stock, even with a line speed upgrade. Introducing a limited stop service, particularly if it could be electrified (i.e. including the route section between Nottingham and the Erewash) would likely bring some reasonable journey time benefits.

Inclusion of the optional infrastructure enhancement detailed would be likely to result in some substantial further time savings.

Birmingham – Lincoln would see a circa 1 hour 20 journey time improvement if the route between Nottingham and Lincoln is ungraded and electrified

Table 10. Indicative fastest journey times, northbound and/or eastbound

Service	Do Minimum[a]	HS2 Phase 2b	First Phase to Sheffield
London – EMP	1 hr 20 mins	1 hr 20 mins	51 mins
London – Derby	1 hr 23 mins	1 hr 23 mins**	58 mins
London – Nottingham	1 hr 38 mins	1 hr 23 mins**	57 mins
London – Sheffield	1 hr 59 mins	1 hr 27 mins*	1 hr 27 mins
London – Chesterfield	1 hr 45 mins	1 hr 12 mins	1 hr 20 mins
London – Leeds	2 hrs (2 hrs 13 mins in Dec 19)	1 hr 21 mins*	1 hr 53 mins
London – York	1 hr 46 mins	1 hr 24 mins	1 hr 38 mins

[11] Transport analysis guidance - GOV.UK (www.gov.uk)

London – Newcastle	2 hrs 34 min (2 hrs 49 mins in Dec 19)	2 hrs 17 mins	2 hrs 25 mins
Birmingham – Nottingham	1 hr 14 mins	55 mins**	26 mins
Birmingham – Newark+	2 hrs 01 min^^	2 hrs 01 min^^	45 mins with optional Nottingham – Lincoln electrification (or around 1h 11 mins with interchange at Nottingham)
Birmingham – Lincoln	2 hrs 28 mins^^	2 hrs 28 mins^^	1 hr 8 mins with optional Nottingham – Lincoln electrification (or around 1h 40 mins with interchange at Nottingham)
Birmingham – Leeds	1 hr 57 mins	49 mins*	1 hr 57 mins
Birmingham – Newcastle	3 hrs 14 mins	1 hr 57 mins*	3 hrs 14 mins
Nottingham – Sheffield	**45 mins**	**42 mins**	**42 mins**

[a] *Broadly as per Dec 19 (pre Covid) unless stated, although some benefits will be realised through committed rolling stock changes*
* Journey times derived from PFM
** Journey times derived from 'Phase 2B 2RS02 East Midlands Hub Operability Report' 2019.
^ Hypothetical direct journey time achievable with existing rolling stock enabled the optional Nottingham – Newark (-Lincoln) electrification and the Nottingham line – ECML chord near Newark. We have not attempted to fit this service into the ECML TSS, therefore the journey time would require significant validation.
^^ Requires interchange.
^^^ Hypothetical via Erewash (i.e. with no call in the East Midlands).
^^^^ This could reduce further to 27 mins if the same NPR enhancements included in the First Phase to Leeds package are adopted.
[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.
[++] Calls at Rotherham have not been included in these figures but would be expected to add circa 4 mins to journey time estimates.

Notes:

- Assumptions from PFM v9 were used in calculating interchange journey times penalties for indicative comparison purposes - 30 mins
- EMH to Nottingham transfer time assumptions taken from PFMv9 - 6 mins wait and 25 mins connection time
- Other journeys requiring interchanges include existing minimum connection times (5 mins Chesterfield and EMP, 6 mins Derby, 7 mins Sheffield and an assumed 15 mins at Leeds HS2 - Conventional station)
- HS2 Phase 2a and Phase 2b Journey times have been taken from the HS2 OBC Strategic Alternatives paper 'OBC Strategic Alternatives cost and JT 251119' and as such we assume that these represent the fastest possible

Table 11. Indicative train service frequency comparison versus HS2 Phase 2b, direct trains per hour in each direction

Service	Do Minimum[a]	HS2 Phase 2b	First Phase to Sheffield
London – EMP	2	2	4 to 7
London – Derby	2	1 to 2	3
London – Nottingham	2	1 to 2	3 to 4
London – Sheffield	2	3 to 4	3
London – Chesterfield	2	2 to 3	2
London – Leeds	2 to 3	4	2
London – York	4	6 to 7	4
London – Newcastle	3 to 4	3 to 4	3 to 4
Birmingham – Nottingham	2 (regional)	2 (regional)	2 to 4 (incl. 2 regional)

Service	Do Minimum[a]	HS2 Phase 2b	First Phase to Sheffield
Birmingham – Newark[+]	-	-	1 (optional variant)
Birmingham – Lincoln	-	-	1 (optional variant)
Birmingham – Leeds	1	4	1
Birmingham – Newcastle	2	1	2
Leicester – Leeds	-	-	-
Nottingham – Sheffield	**1 (regional)**	**1 (regional)**	**1 (regional)**

[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Table 12. Indicative seats per hour comparison versus HS2 Phase 2b, direct trains per hour in each direction

Service	HS2 Phase 2a (Do Min)	HS2 Phase 2b	First Phase to Sheffield
London – EMP	758	758	1,814 to 2,951
London – Derby	758	379 to 758	1,435
London – Nottingham	758	379 to 758	1,435 to 1,814
London – Sheffield	758	1,435 to 1,814	1,435
London – Chesterfield	758	907 to 1,286	907
London – Leeds	1,398 to 2,097	3,443 (Peak) / 2,335 (Off-peak)	1,398
London – York	2,796	3,681 to 4,380	2,796
London – Newcastle	2,097 to 2,399	1,755 to 2,057	2,097 to 2,399
Birmingham – Nottingham	404	404	404 to 1,460
Birmingham – Newark[+]	-	-	528
Birmingham – Lincoln	-	-	528
Birmingham – Leeds	200	1,862	200
Birmingham – Newcastle	400	528	400
Leicester – Leeds	-	-	-
Nottingham – Sheffield	**204**	**204**	**204**

[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Notes:

- *HS2 services based on 554 (captive) and 528 (conventional-compatible) seats per 200m unit*
- *ECML*
  - *Do Minimum: ECML services based on 10-car IEPs (currently supported maximum train lengths) at 699 seats or 5-car IEPs at 302 seats per unit. WCML services based on 11-car Class 390 Pendolinos assumed at 591 seats.*
  - *HS2 Phase 2b assumptions*
    - *Leeds: Peak - 4 Captive and 1 CC unit per hour, Off-peak - 2 Captive and 1 CC unit.*
    - *York: 3 CC units per hour all day. ECML King's Cross London - York current assumption adopted from NPR Full EL scenario 2tph (1 Scotland, and 1 Middlesbrough/Sunderland, both assumed to be 10-car IEP).*
    - *Newcastle: 2 CC units per hour all day. 10-car IEP assumed on residual LNER, and 5-car on the Open Access.*
  - *Strategic alternative: 10-car IEPs assumed as core scenario. Illustrative additional 'theoretical maximum' scenario shows capacities assuming 11-car IEPs on all services (except the 2 fast Scotland services, assuming 12-car). This is intended to set out the maximum feasible capacity without reconfiguring the interior of the trains.*

- *London – York may receive a moderate further capacity uplift under the Strategic Alternatives, depending on the eventual stopping pattern selected.*

- *EM conventional routes assumed to be served by 7-car Meridians at 379 seats as per PFMv9 assumptions.*
- *CrossCountry Birmingham-Leeds/Nottingham services assumed to be served by 3-car Class 170s at 202 seats.*
- *CrossCountry Derby/Sheffield-Leeds and Birmingham-Newcastle services assumed to be served by 4-car Voyager Class 220s at 200 seats.*
- *Northern regional Nottingham-Sheffield/Leeds services assumed to be served by Class 195/0 trains at 204 seats.*

4.6 Performance

The infrastructure interventions presented here are based on a comparison of the December 2019 service levels and those presented in the ITSS, which identified both existing performance 'hotspots' and the locations with the biggest increment in train service. Therefore, performance would be expected to be in line with the December 2019 timetable once the interventions have been included.

By far the largest constraint identified was the Trent Junctions area, and a study of train routeings and interactions was undertaken to understand how the area would work under the future ITSS. The intervention selected will tackle the most significant timetable and performance constraints, although smaller constraints will remain. An upgrade to a larger-scale intervention would provide an incremental benefit and could also be considered further.

Nottingham was identified as a constraint based on the increase in the number of services terminating compared to today. The interventions proposed aim to improve performance by either segregating High Speed and local services better, or by providing turnback sidings to reduce platform use across the hour. Both of these solutions are likely to achieve this aim, although which option is preferred would need to include additional factors such as the likelihood of extending services across Nottingham compared to today.

It should be noted that although the Sheffield area was also identified as a constraint, it is assumed that this constraint is fully or partially resolved through proposed schemes delivered in the meantime (such as those part of NPR).

4.7 Costs

Table 12 below shows the estimated infrastructure costs. The total cost is forecast to range between £10.0bn and £11.4bn depending on the variant of the ECML package selected (see the previous chapter).

The new high speed route between HS2 Phase One and East Midlands Parkway would account for significantly more than half of the total cost of the First Phase to Sheffield Package at around £6.7bn, plus a further £0.5bn for the connection onto the MML.

Table 12. First Phase to Sheffield. Estimated Infrastructure Costs. £m, 4Q2019 prices

Infrastructure Scheme	Cost
HS2 new line Birmingham - EMP	6,665
East Midlands Parkway HS2 connection	549
Trent East Junction Grade Separation and Sheet Stores Jn LSI	265
Nottingham Station Platform or Turnback	22
ECML Interventions (range)	2,487 – 3,942
Total Cost	**9,988 - 11,443**

Nottingham – Lincoln Electrification (optional)	*986*
Nottingham Line – ECML chord (optional)	*130-372**
Toton Station (optional)	*220*

* Range explained by a one or two chord solution

4.8 Conclusions

Locations on the ECML would receive the same TSS and therefore the same benefits as under the Upgrade Package. To recap:

- London – Newcastle. Comparable improvements to Phase 2b albeit with slightly slower journey times.
- London – York and London - Leeds. ECML upgrades provides some capacity and journey time benefits, but less so than under Phase 2b (especially for Leeds where journey times are significantly less than 2b).
- Improved connectivity between smaller locations on the ECML, albeit likely to be on a smaller scale then under Phase 2b.
- No improvement to connectivity between locations served by the ECML and Birmingham.

Locations on the MML and across the midlands would receive a better level of service than under the Upgrade Package(s).

Two rail corridors in particular would see transformational reductions in journey time:

- London – Nottingham and London - Derby journey times would be more than half an hour faster than under Phase 2b or the Do-Minimum scenario, with total journey times of less than one hour possible. This advantage over Phase 2b is because passengers would have direct trains to/from Nottingham and Derby, rather than having to change at Toton.
- Birmingham – Nottingham journey times would reduce to less than half an hour. This is more than half an hour faster than under Phase 2b and three quarters of an hour faster than under the Do-Minimum scenario. Locations beyond Nottingham would also see a significant improvement in connectivity to/from the West Midlands via an interchange at Nottingham.
- Addition of the optional infrastructure detailed para 4.4.7 would enable HS2 and potentially an MML service to route east of Nottingham. This could:
    - Provide transformational journey time improvements between Lincoln, Newark Nottingham and Birmingham, reducing total end to end journey times by around one hour and 20 minutes versus the other scenarios.
    - Enable fast direct train services between Leicester and Leeds

Other journeys such as London – Sheffield and London – Chesterfield would see comparable improvements to HS2 Phase 2b.

Journey times and capacity between Birmingham, Derby, Chesterfield, Sheffield and Leeds would be unlikely to improve beyond the Do-Minimum Scenario.

Noting the early stage nature of our work, the estimated cost of this infrastructure package at £10.0bn - £11.4bn would seem to be up to a third of the cost of the full Eastern Leg at up to £32bn. However, it would not deliver many of the benefits for locations further north that would

occur if the Eastern Leg went ahead as planned. It would therefore seem unlikely to meet governments Government's strategic priorities if adopted as the end state Eastern Leg.

As an interim state however this alternative may offer a good compromise of rail improvements and costs savings as well as lay the foundation towards implementation of either Newark or Erewash (subject to a review of scope) Eastern Leg as set out in Chapter 6.

5 First Phase to Leeds package

5.1 Introduction

Under this Strategic Alternative the HS2 Eastern Leg would be replaced by a Hybrid package of infrastructure interventions, enabling HS2 trains to serve all the locations under the First Phase to Sheffield Package, as well as Rotherham and Leeds. Other locations such as York and Newcastle would continue to be served via an upgraded ECML.

5.2 Assumptions

Assumptions are consistent with the other options. Namely,

- Full electrification of the MML.
- ETCS Level 2 signalling on the ECML (and HS2/ Hybrid High speed routes) and conventional signalling elsewhere.
- HS2 phase 2a and other the committed interventions listed in previous chapters are fully operational.

5.3 Train Service Specification

The infrastructure specification set out above would result in seven HS2 services per hour comprising:

- Two London Euston – Leeds via Sheffield;
- Two London Euston – Nottingham;
- Two Birmingham Curzon Street – Nottingham
- One Birmingham Curzon Street – Leeds via Sheffield

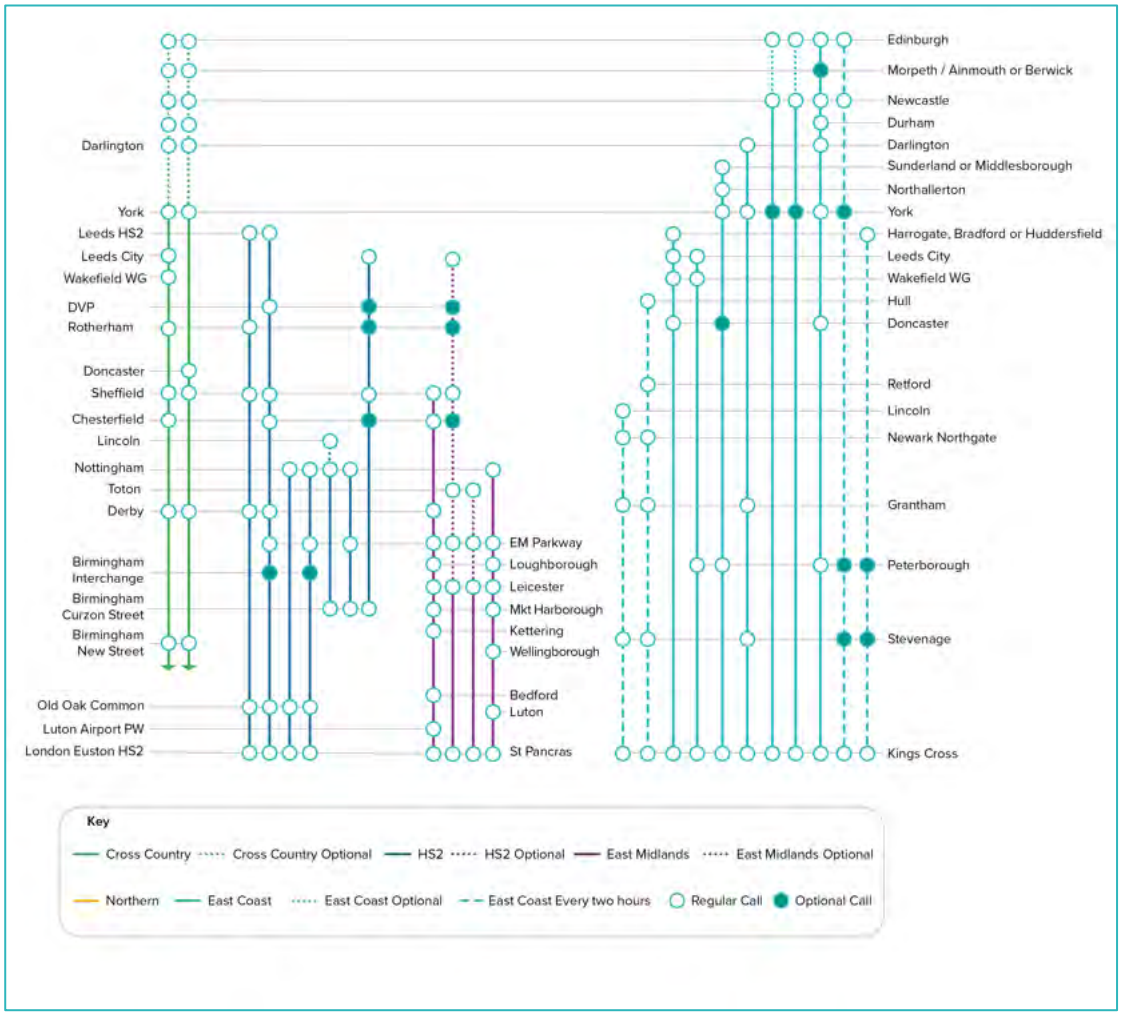
In this package we have included a HS2 service between Birmingham and Leeds via Sheffield, as this would provide journey time saving between Birmingham and Leeds. We have assumed that the current Cross Country service into Leeds would continue to operate.

The quantum of MML services to and from London St Pancras would remain broadly as per the previous infrastructure package, including one train per hour to/from Leeds via a potential conventional station at Toton (as described in Appendix B). The second St Pancras – Leeds service has not been included given the overall quantum of services to/from Leeds, however this could be investigated downstream.

The quantum of other services has been agreed with DfT and is consistent with current rail industry planning assumptions.

Figure 10 below provides an illustration of the standard hour TSS, inclusive of the optional services described above.

Figure 10. First Phase to Leeds: Indicative Standard Hour LDHS calling pattern, some stations are not shown



Note. Harrogate, Bradford and Huddersfield are shown as a single location to keep the illustration legible. The second train from the left would terminate at Bradford Forster Square one hour and Harrogate the next. The closest train to the right of the graphic would terminate at Bradford Interchange or Huddersfield depending on the time of day.

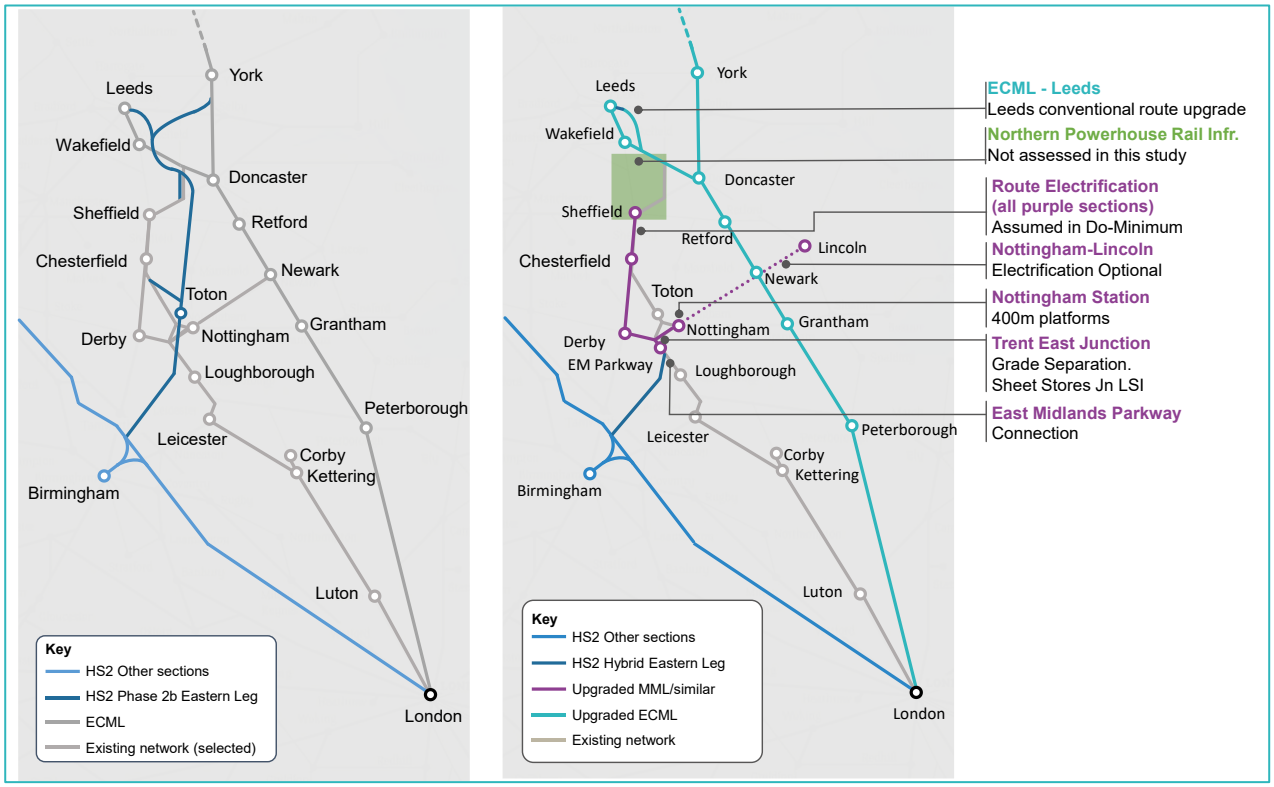
5.4 Infrastructure Interventions

In this section we provide a summary of the infrastructure interventions to deliver the proposed TSS in addition to the interventions set out in this infrastructure package.

Figure 11 below shows a simplified route map denoting the new hybrid alignment, as well as the proposed enhancements on the conventional network. ECML interventions are the same as under the upgrades only alternative and have not been shown individually.

Our approach to assessing the impact of the interventions on service punctuality is the same as described in Chapter 3.

Figure 11. First Phase to Leeds: Approach Option Simplified Schematic and Simplified HS2 Route Map (Current and Amended)



In addition to the interventions described in First Phase to Sheffield Strategic Alternative the following work would be undertaken.

5.4.1 ECML – Leeds (Adwick Junction – Hunslet Junction)

The route to Leeds would comprise a major upgrade of the conventional network, along with the final planned section of the Eastern Leg in Leeds city centre. Interventions would be as follows:

- South Kirby – Hare Park. Four tracking and electrification.
- Hare Park – Normanton. A short section of new (electrified) route.
- Normanton – Hunslet Junction. Upgrade of the existing rail alignment via Woodlesford. An upgraded layout, with electrification, re-signalling, and significant four tracking between Hare Park and broadly Hunslet Junction in Leeds.
- Hunslet Junction – Leeds. Construction of the planned HS2 T-Shaped station in Leeds along with the final stretch of the proposed approach route form Hunslet Junction.

5.4.2 Sheffield to South Kirby

Explicit assessment of emerging proposals for the NPR programme is outside of the scope of this study. However, DfT has asked us to consider how the developing NPR programme north of Sheffield might capitalise on our proposed infrastructure, assuming emerging NPR proposals between Sheffield and South Kirby are delivered.

This would likely include

- An upgrade and electrification of the route north of Sheffield
- A new station for Rotherham on the MML.

- A potential new Parkway station on the exiting line through the Dearne Valley.

We have not costed these interventions as part of our work, albeit have sought to show potential service opportunities north of Sheffield if this infrastructure was in place.

The Department asked us to assume that these emerging NPR proposals would enable 4tph (fast) between Sheffield and Leeds.

5.5 Outputs

The tables below show headline journey times between selected origin - destination pairs, together with a comparison of service frequencies against HS2 Phase 2b for each scenario. For several pairs of locations we have compared new direct journey times against time which would require passengers to change trains. In these instances we have compared the total journey start station – end station time inclusive of a time penalty equivalent to the inconvenience passengers face when changing trains. Inclusion of this penalty is consistent with the demand forecasting approach adopted by HS2 Ltd, as well as with the guidance set out inf DfT's TAG publication[12].

This infrastructure package would result in significant journey time saving versus the Do-Minimum scenario (HS2 Phase 2a) and in general the spread of locations which would benefit from significant journey time savings is higher than under HS2 Phase 2b.

In addition to the connectivity benefits set out in the previous chapter, Birmingham – Leeds would see a journey time benefit over the Do-Minimum scenario of 31 minutes. Whilst London – Leeds would be a similar journey time via an upgraded ECML, there would be additional connectivity benefits via a connection at Old Oak Common.

This option would also transform connectivity between the East Midlands and Leeds, cutting journey times to Derby and East Midlands Parkway by up to 19 and 67 minutes, respectively, and to Chesterfield and Sheffield by 11 minutes.

As per the previous infrastructure package, there are options to extend HS2 services from Nottingham towards Lincoln, subject to additional infrastructure.

Table 13. Indicative fastest journey times, northbound and/or eastbound

Service	HS2 Phase 2a (Do Min[a])	HS2 Phase 2b	First Phase to Leeds
London – EMP	1 hr 20 mins	1 hr 20 mins	51 mins
London – Derby	1 hr 23mins	1 hr 23 mins**	58 mins
London – Nottingham	1 hr 38 mins	1 hr 23 mins**	57 mins
London – Sheffield	1 hr 59 mins	1 hr 27 mins*	1 hr 27 mins
London – Chesterfield	1 hr 45 mins	1 hr 12 mins	1 hr 20 mins
London – Leeds	2 hrs (2 hrs 13 mins in Dec 19)	1 hr 21 mins*	1 hr 53 mins
London – York	1 hr 46 mins (1 hr 46 mins in Dec 19)	1 hr 24 mins	1 hr 38 mins
London – Newcastle	2 hrs 34 min (2 hrs 49 mins in Dec 19)	2 hrs 17 mins	2 hrs 25 mins
Birmingham – Nottingham	1 hr 14 mins**	55 mins**	26 mins

[12] Transport analysis guidance - GOV.UK (www.gov.uk)

Birmingham – Newark[+]	2 hrs 01 min^^	2 hrs 01 min^^	45 mins with optional Nottingham – Lincoln electrification (or around 1h 11 mins with interchange at Nottingham)
Birmingham – Lincoln	2 hrs 28 mins^^	2 hrs 28 mins^^	1 hr 8 mins with optional Nottingham – Lincoln electrification (or around 1h 40 mins with interchange at Nottingham)
Birmingham – Leeds	1 hr 57 mins	49 mins*	1hr 26 mins
EMP – Leeds	2 hrs 20 mins	48 mins^^	1 hr 13 mins[++]
Derby – Leeds	1 hr 15 mins	1 hr 15 mins	56 mins[++]
Sheffield – Leeds	40 mins	24 mins	28 mins[++]
Birmingham – Newcastle	3 hrs 14 mins	1 hr 57 mins *	3 hrs 14 mins
Leicester – Leeds	1 hr 55 mins	1 hr 28 mins**	Around 1 hr 20 mins
Nottingham – Sheffield	**45 mins**	**42 mins**	**42 mins**

[a] *Broadly as per Dec 19 unless stated, although some benefits will be realised through committed rolling stock changes*
* Journey times derived from PFM
** Journey times derived from 'Phase 2B 2RS02 East Midlands Hub Operability Report' 2019.
^^ Requires interchange.
^^^ Hypothetical via Erewash (i.e. with no call in the East Midlands).
[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.
[++] Calls at Rotherham have not been included in these figures but would be expected to add circa 4 mins to journey time estimates.

Notes:

- Assumptions from PFM v9 were used in calculating interchange journey times penalties for indicative comparison purposes - 30 mins
- EMH to Nottingham transfer time assumptions taken from PFMv9 - 6 mins wait and 25 mins connection time
- Other journeys requiring interchanges include existing minimum connection times (5 mins Chesterfield and EMP, 6 mins Derby, 7 mins Sheffield and an assumed 15 mins at Leeds HS2 - Conventional station)
- HS2 Phase 2a and Phase 2b Journey times have been taken from the HS2 OBC Strategic Alternatives paper 'OBC Strategic Alternatives cost and JT 251119' and as such we assume that these represent the fastest possible
- Journey times over NPR infrastructure have been provided by DfT

Table 14. Indicative train service frequency comparison versus HS2 Phase 2b, direct trains per hour in each direction

Service	HS2 Phase 2a (Do Min)	HS2 Phase 2b	First Phase to Leeds
London – EMP	2	2	4 to 6
London – Derby	2	1 to 2	3
London – Nottingham	2	1 to 2	3
London – Sheffield	2	3 to 4	3 to 4
London – Chesterfield	2	2 to 3	2 to 3
London – Leeds	2 to 3	4	4 to 5
London – York	4	6 to 7	3 to 6
London – Newcastle	3 to 4	3 to 4	3 to 4
Birmingham – Nottingham	2 (regional)	2 (regional)	4 (incl. 2 regional)
Birmingham – Newark[+]	-	-	1 (optional variant)

Birmingham – Lincoln	-	-	1 (optional variant)
Birmingham – Leeds	1	4	3
EMP – Leeds	0	0*	1 to 2
Derby – Leeds	1	1	3
Sheffield – Leeds	1 (fast) + local services	4 (fast) + local services	4 to 5 (fast) + local services
Birmingham – Newcastle	2	1	1 to 2
Leicester – Leeds	-	-	1
Nottingham – Sheffield	**1 (regional)**	**1 (regional)**	**1 (regional)**

* *5tph from Toton*
[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Table 12. Indicative seats per hour comparison versus HS2 Phase 2b, direct trains per hour in each direction

Service	HS2 Phase 2a (Do Min)	HS2 Phase 2b	First Phase to Leeds
London – EMP	758	758	1,814 to 2,572
London – Derby	758	379 to 758	1,435
London – Nottingham	758	379 to 758	1,435
London – Sheffield	758	1,435 to 1,814	1,435 to 1,814
London – Chesterfield	758	907 to 1,286	1,435 to 1,814
London – Leeds	1,398 to 2,097	3,443 (Peak) / 2,335 (Off-peak)	2,796 to 3,495
London – York	2,796	3,681 to 4,380	2,097 to 4,194
London – Newcastle	2,097 to 2,399	1,755 to 2,057	2,097 to 2,399
Birmingham – Nottingham	404	404	1,460
Birmingham – Newark[+]	-	-	528
Birmingham – Lincoln	-	-	528
Birmingham – Leeds	200	1,862	1,256
EMP – Leeds	-	-	528 to 907
Derby – Leeds	200	200	1,256
Sheffield – Leeds	200	1784	1,784 to 2,163
Birmingham – Newcastle	400	528	400
Leicester – Leeds	-	-	379
Nottingham – Sheffield	**204**	**204**	**204**

[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Notes:

- *HS2 services based on 554 (captive) and 528 (conventional-compatible) seats per 200m unit*
- *ECML*
  - *Do Minimum: ECML services based on 10-car IEPs (currently supported maximum train lengths) at 699 seats or 5-car IEPs at 302 seats per unit. WCML services based on 11-car Class 390 Pendolinos assumed at 591 seats.*
  - *HS2 Phase 2b assumptions*
    - *Leeds: Peak - 4 Captive and 1 CC unit per hour, Off-peak - 2 Captive and 1 CC unit.*

- *York: 3 CC units per hour all day. ECML King's Cross London - York current assumption adopted from NPR Full EL scenario 2tph (1 Scotland, and 1 Middlesbrough/Sunderland, both assumed to be 10-car IEP).*
- *Newcastle: 2 CC units per hour all day. 10-car IEP assumed on residual LNER, and 5-car on the Open Access.*

- *Strategic alternative: 10-car IEPs assumed as core scenario. Illustrative additional 'theoretical maximum' scenario shows capacities assuming 11-car IEPs on all services (except the 2 fast Scotland services, assuming 12-car). This is intended to set out the maximum feasible capacity without reconfiguring the interior of the trains.*
- *London – York may receive a moderate further capacity uplift under the Strategic Alternatives, depending on the eventual stopping pattern selected.*

- *EM conventional routes assumed to be served by 7-car Meridians at 379 seats as per PFMv9 assumptions.*
- *CrossCountry Birmingham-Leeds/Nottingham services assumed to be served by 3-car Class 170s at 202 seats.*
- *CrossCountry Derby/Sheffield-Leeds and Birmingham-Newcastle services assumed to be served by 4-car Voyager Class 220s at 200 seats.*
- *Northern regional Nottingham-Sheffield/Leeds services assumed to be served by Class 195/0 trains at 204 seats.*

5.6 Costs

Table 15 below shows the estimated infrastructure costs for the First Phase to Leeds infrastructure Package. The total cost is forecast to range between £12.9bn and £14.3bn depending on the variant of the ECML package selected (see the upgrades chapter). This does not include the cost of the NPR infrastructure between Sheffield and South Kirkby, which has not been provided to us.

Table 15. First Phase to Leeds: Estimated Infrastructure Costs. £m, 4Q2019 prices

Infrastructure Scheme	Cost
HS2 new line: Birmingham - EMP	6,665
East Midlands Parkway HS2 connection	549
Trent East Junction Grade Separation and Sheet Stores Jn LSI	265
Nottingham Station Platform or Turnback	22
ECML Interventions (range)	2,487 – 3,942
Adwick Jn – Hunslet Jn	1,879
Hunslet – Leeds HS2	1,000
Sheffield to South Kirby NPR**	Not provided
Total Cost	**12,876- 14,322**
Nottingham – Lincoln Electrification (optional)	*986*
Nottingham Line – ECML chord (optional)	*130-372**
Toton Station (optional)	*220*

* Range explained by a one or two chord solution

5.7 Conclusions

Locations on the ECML other than Leeds would receive the same TSS and therefore the same benefits as under the Upgrade Package. To recap:

- London – Newcastle. Comparable improvements to Phase 2b albeit with slightly slower journey times.

- London – York. ECML upgrades provides some capacity and journey time benefits, but less so than under Phase 2b (especially for Leeds where journey times are significantly less than 2b).
- Improved connectivity between smaller locations on the ECML, albeit likely to be on a smaller scale then under Phase 2b.
- No improvement to connectivity between locations served by the ECML (other than Leeds) and Birmingham.

Locations on the MML and across the midlands would receive the same level of service than under the First Phase to Sheffield infrastructure package, with additional benefits of improved connectivity between the Midlands and Leeds.

Rail corridors which would see transformational reductions in journey time:

- Birmingham – Leeds journey times would be 31 minutes faster than under the Do-Minimum scenario, albeit still 37 minutes slower than Phase 2b.
- Leeds to Derby and Chesterfield/Sheffield would see journey times reduce by up 19, 67 and 11 minutes, respectively versus the Do-Minimum, as well as additional services and more seats. Leeds – EMP would also see the introduction of regular direct services.
- Enable fast direct train services between Leicester and Leeds, reducing journey times by over 20 minutes versus today.

Noting the early stage nature of our work, the estimated cost of this package at £12.9bn - £14.3bn is less than half the cost of the full Eastern Leg at up to £32bn, noting that the cost of the required NPR infrastructure has not yet been included in the estimate.

In summary, this package can deliver transformational benefits to some places, particularly those in the East Midlands such as Nottingham and Derby and Sheffield. It also introduces additional benefits to Leeds over the First Phase to Sheffield infrastructure package, with improved connectivity with the between East and West Midlands and Leeds, as well access to Old Oak Common.

Other places, particularly those on the ECML and the wider network which connects with this route, would see more modest benefits.

This infrastructure package may therefore offer a good compromise of rail improvements and costs savings. However, it may fail to deliver all of Governments strategic priorities if adopted as the end state Eastern Leg.

Finally, it may be useful to note that this infrastructure package comprises several of the items required for the Eastern Leg Newark alignment described in the next chapter, as well as the new station at Toton requiring the Erewash alignment. If Government decided to proceed with the delivery of the First Phase to Leeds infrastructure package in advance of the Newark alignment, it could be a good way to deliver the end-stage scheme enabling a phased delivery of the journey time, capacity and connectivity benefits. It could also be phased into the Erewash alignment, if the scope of the initial intervention was reduced, though this would require further analysis which is not something we have considered for this report.

6 Alternatives forms of end-state Eastern Leg

6.1 Introduction

Under this Strategic Alternative the HS2 Eastern Leg would be replaced by a Hybrid package of infrastructure interventions, enabling HS2 trains to serve all of the locations under the previous packages, as well as other key locations including York and beyond.

We have developed two separate packages of options as set out below. Both share the same high speed alignment from HS2 Phase One to East Midlands Parkway, with alternative onward routes thereafter.

6.1.1 Variant A: Eastern Leg: Erewash alignment

Beyond the Trent Junctions area a series of conventional network enhancements would enable the onward operation of HS2 trains to Leeds. These interventions comprise:

- Upgraded and electrified Erewash Valley line
- Upgraded and electrified route between broadly Clay Cross Junction and Masborough Junction near Rotherham (the “Old Road”).

Beyond that a new alignment would connect to the northern leg of the currently proposed Eastern leg into Leeds, with the exception of the proposed Church Fenton Link which would not be constructed.

The majority of infrastructure from the ECML upgrade alternative would therefore be required to enable improvements to York and Newcastle, as well other ECML destinations, although some of the interventions could be avoided.

As with the First Phase to Sheffield infrastructure package, three variants comprising infrastructure upgrades east of Nottingham were considered:

- Addition of upgraded infrastructure between Nottingham and Lincoln to allow HS2 services to serve Lincoln.
- A chord to the ECML to allow HS2 or MML trains to serve ECML locations other than Leeds.
- A new station at Toton, which could accommodate passing HS2 service to/from Leeds and potential LDHS services to/from the MML, thereby enabling regeneration of the Toton area which HS2 which is a benefit of the Eastern Leg. For simplicity Toton station is not shown in this TSS, however a short Annex is included on Toton at the end of this report.

6.1.2 Variant B: HS2 Eastern Leg: Newark alignment

Beyond the Trent Junctions area some significant new sections of high speed line would be constructed, augmented by targeted upgrades of the conventional network. The programme of interventions comprises:

- Remodelling work at Nottingham station to build two 400m long platforms for full length HS2 serves, and more capacity generally.

- An upgrade of the conventional network between Nottingham and the Lowdham area.
- A new high speed bypass is constructed east of Nottingham (roughly parallel to the Nottingham to Lincoln line), crossing the ECML north of Newark, continuing in broadly the ECML corridor, passing round to the east and north of Doncaster. This route would have junctions to/from the conventional network west of Newark, north of Newark and just south of Doncaster near Bawtry. The route would re-join the ECML towards York and towards Leeds at Adwick Junction just to the north of Doncaster.
- Upgrade of the conventional route between Adwick Junction, Hare Park, Normanton, and Hunslet, just south of Leeds.

The final short section of track through central Leeds to a new HS2 terminal would be as per the current HS2 Phase 2b proposal.

This variant would also need the bulk of ECML interventions from the ECML Upgrade alternative, although more could be avoided than under the Erewash variant.

Common with several of the other packages, onward electrification of the conventional route to Lincoln is an optional addition to improve connectivity to/from Lincoln. The section of the conventional route between Lowdham and broadly Newark would be bypassed by HS2 services so electrification of that section would only be required to provide additional track capacity and resilience during disruption or route closures.

Although just off the HS2 network, Toton station could be constructed on the Erewash Valley, accommodating potential new services to/from the MML.

Unlike package A, the core infrastructure in this package enables HS2 services to a range of ECML destinations other than Leeds.

6.2 Assumptions

Assumptions are consistent with the other options. Namely,

- Full electrification of the MML.
- ETCS Level 2 signalling on the ECML (and HS2/ Hybrid High speed routes) and conventional signalling elsewhere.
- HS2 phase 2a and other the committed interventions listed in previous chapters are fully operational.

For the Eastern Leg Newark Alignment LDHS services on the ECML are assumed to be operated with trains that have the equivalent performance of Classic Compatible HS2 rolling stock.

6.3 Train Service Specifications

6.3.1 HS2 Eastern Leg: Erewash Alignment

Error! Reference source not found. below shows an illustration of the TSS under this a lternative.

This TSS would see 10 HS2 services per hour, comprising:

- Two London Euston – Leeds
- Two London Euston – Sheffield
- Two London Euston – Nottingham
- Two Birmingham Curzon Street – Nottingham

- Two Birmingham Curzon Street – Leeds

The quantum of MML services to and from London St Pancras would be broadly as per the MML Upgrade and other packages, comprising:

- One per hour to/from Derby (with at least one extending to/from Sheffield).
- One per hour to/from Nottingham.
- One per hour to Leicester with an optional extension to Leeds via the upgraded Erewash Valley route, thereby improving connectivity between West Yorkshire and the East Midlands.
- One per hour to Leicester with an optional extension to Toton

Stopping patterns would be adjusted to provide better connectivity to and from smaller locations, taking advance of the capacity released by serving Derby, Sheffield and Nottingham principally via HS2. Leicester would receive two non-stop services per hour to London St Pancras.

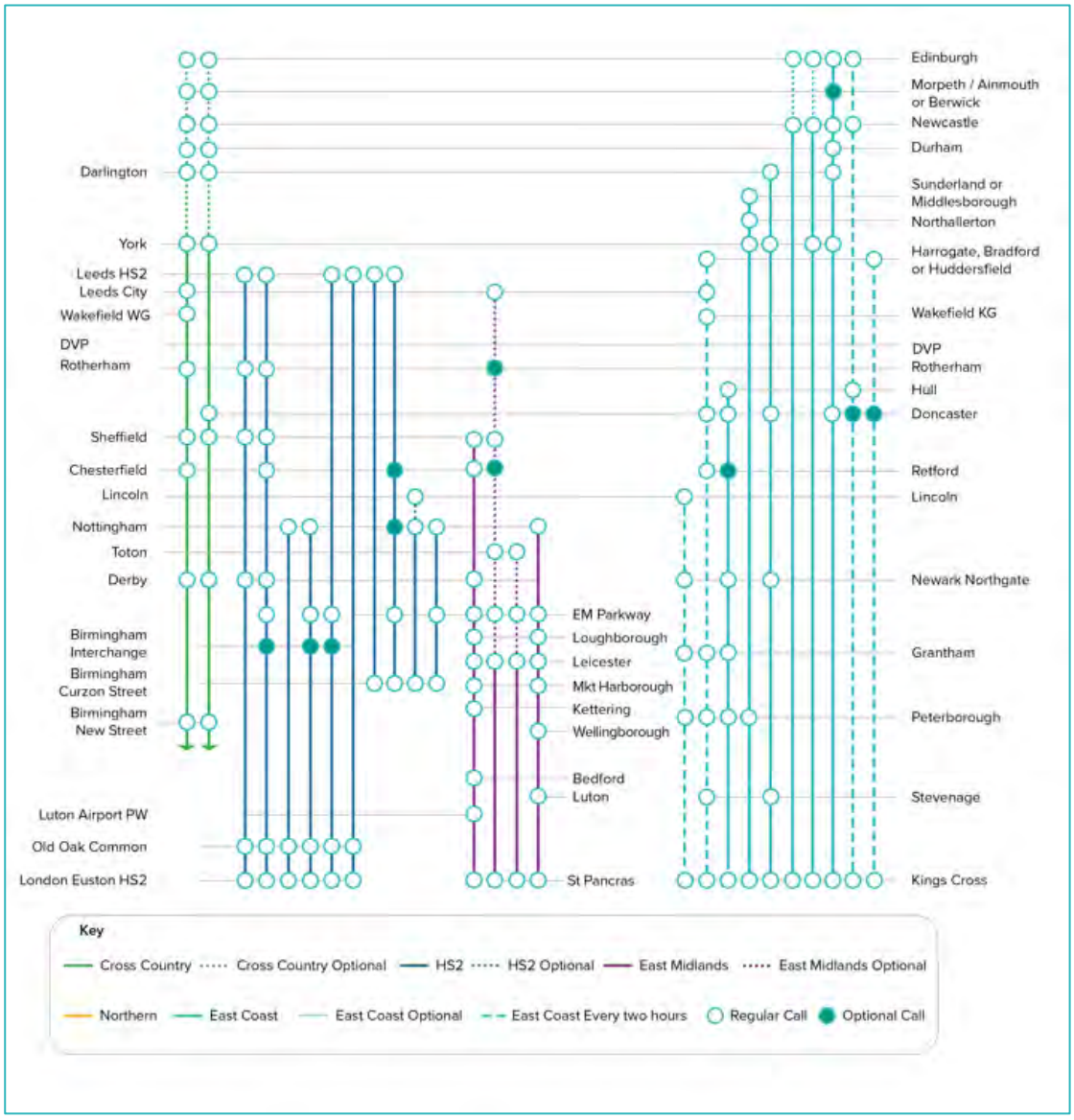
London St Pancras – Corby services are assumed but are not shown.

Two LDHS Cross Country services per hour would continue to serve Birmingham New Street as per the Do-Minimum Scenario, with the northern extent of these services determined by eventual market requirements, network capacity and interaction with NPR proposals. These services would continue to provide the principal connection between Birmingham and Sheffield as HS2 would not offer a material journey time saving and HS2 trains between Birmingham Curzon Street and Sheffield are therefore not included in the TSS.

Eight LDHS trains per hour would operate on the ECML to and from London King's Cross, i.e. two fewer than in the previous options as HS2 services would form the main connectivity between London and Leeds. As noted previously, the fastest London – Edinburgh services would primarily run via the HS2 Western Leg.

Similar to the previous infrastructure packages, an optional hourly service extension between Nottingham and Lincoln is included, should the enabling electrification scheme go ahead. Similarly, it would be possible to use this some of this optional infrastructure to provide a Birmingham – Nottingham - ECML (say Newcastle) service, thereby improving connectivity on this corridor.

Figure 12. HS2 Eastern Leg (Erewash Alignment): Indicative Standard Hour LDHS calling pattern, some stations are not shown



Note. Harrogate, Bradford and Huddersfield are shown as a single location to keep the illustration legible. The second train from the left would terminate at Bradford Forster Square one hour and Harrogate the next. The closest train to the right of the graphic would terminate at Bradford Interchange or Huddersfield depending on the time of day.

6.3.2 HS2 Eastern Leg: Newark Alignment

Under this package services between ECML locations such as Leeds, York and Newcastle would receive significant journey time benefits to/from London regardless of whether their initial route to/from the ECML bypass is via the ECML or via HS2 Phase 2a infrastructure, with journey times only four minutes different between the two routes (in favour of the ECML).

In this TSS HS2 services would provide the principal connections between London and Leeds, with London – York to Newcastle services using the ECML and the new bypass. In principle the opposite approach could be taken with no meaningful impact on cost and similar passenger benefits.

This TSS would see up to 8 HS2 services per hour, comprising:

- Two London Euston – Leeds via Derby and Sheffield
- Two London Euston – Leeds via Nottingham and the ECML
- One Birmingham Curzon Street – Newcastle via Nottingham
- Two Birmingham Curzon Street – Leeds via Nottingham, one of which would be optional and business case/market dependent
- One optional Birmingham – Lincoln via Nottingham, requiring a short chord from the Nottingham and Newark bypass back onto the Nottingham to Newark line, and onward electrification to Lincoln. Lincoln would also require work to extend two existing platforms to accommodate 200m long trains.

The ECML would also see 8 trains per hour, comprising:

- Two limited-stop services London King's Cross – Newcastle (and potentially Edinburgh)
- One London King's Cross – Leeds (conventional station), providing intermediate connectivity
- One London King's Cross – Edinburgh providing intermediate connectivity
- Four other services, providing additional connectivity.

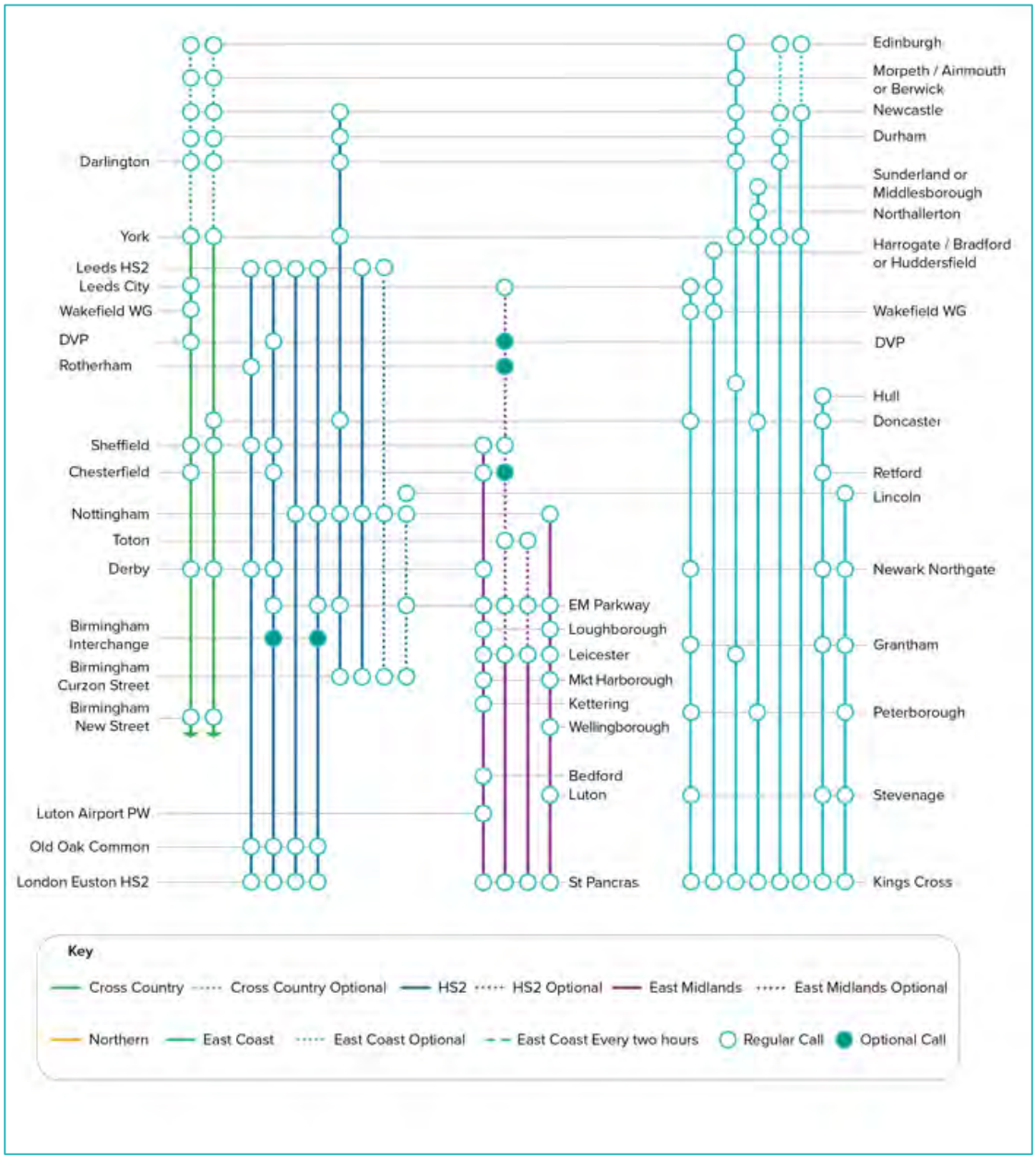
As per the other alternatives, the fastest London – Edinburgh services would be primarily operated via the HS2 Western Leg.

MML services would be similar to the HS2 Eastern Leg Erewash alignment.

Cross Country services would also be the same as under HS2 Eastern Leg Erewash alignment. Cross Country services would continue to provide the main connectivity between Birmingham and Sheffield, although the extent of the service beyond Sheffield would ultimately depend on market requirements, network capacity and interaction with NPR proposals.

Error! Reference source not found., below, illustrates this TSS.

Figure 13. HS2 Eastern Leg: Newark Alignment. Standard Hour Long Distance High Speed Service Pattern. Northbound, indicative



Note. Harrogate, Bradford and Huddersfield are shown as a single location to keep the illustration legible. Trains to Bradford Interchange and to Huddersfield would follow an alternative routeing to that which is shown in this graphic, potentially serviced with an alternative service developed at part of an eventual timetable optimisation process.

6.4 Infrastructure Interventions

Error! Reference source not found. and **Error! Reference source not found.**, respectively sh ow the interventions required for each Strategic Alternative.

6.4.1 Interventions Common to both alignments

6.4.1.1 Hybrid Eastern Leg Alignment to/from East Midlands Parkway

As per the First Phase to Sheffield / Leeds Package.

6.4.1.2 East Midlands Parkway HS2 connection (Current slow lines)

As per the First Phase to Sheffield / Leeds Package, this is a grade separated junction from the southern section of the HS2 Phase 2b Eastern Leg, onto the MML. We considered several potential layouts and concluded that a connection onto the current slow lines would avoid some otherwise required capacity work in the Trent Junctions area which may not be deliverable from a construction perspective.

6.4.1.3 Route Electrification

The MML between the HS2 new line connection and Sheffield and Nottingham would require electrification. As noted above this electrification is assumed in the Do-Minimum scenario and is reported here for completeness. Government might choose to electrify the MML in full, to avoid a gap between Market Harborough and roughly East Midlands Parkway.

6.4.2 HS2 Eastern Leg Erewash Alignment interventions

6.4.2.1 Trent Junctions Area

The required intervention in the Trent Junctions area is larger than under the previous alternatives. For this option we propose a major intervention to accommodate the TSSs which have a higher quantum additional services through the layout and which, coincidentally, also involve significant through running between EMP and the Toton area. The following changes are included:

- Separation Trent East Junction, this time through placing the Nottingham – Derby line on a viaduct and letting the fast lines pass underneath.
- Speed increases at Sheet Stores Junction.
- Line speed improvements on the high-level lines between EMP and the Toton area.
- A revised track layout in the Toton area.

6.4.2.2 Nottingham Station.

The proposed intervention is the same as under the MML and First Phase to Sheffield / Leeds Packages. Namely:

- A new (bay) platform and track layout to enable better segregation of high speed and regional/local traffic.
- New turnback sidings to the East of the station.

Either of these schemes would be adequate, with a similar likely construction cost.

6.4.2.3 Erewash Valley route upgrade and electrification

The Erewash Valley line is a two track route with sporadic sections of three tracks. The maximum permitted speed on the two main tracks is typically 80mph, with some sections limited to 70mph. The third line is typically 45mph.

Under this alternative the maximum permitted speed would increase to 115mph enabled in places by some four-tracking to allow HS2 trains to be segregated from slower traffic on the route. The route would be also electrified.

6.4.2.4 Chesterfield to Masborough Jn upgrade and electrification

The Chesterfield – Masborough Junction route section is a predominantly two track railway. At the south end it has a maximum permitted speed of 60mph, increasing to 70mph at the north end. Masborough Junction itself is limited to 40mph.

Under this alternative the line would be upgraded and electrified enabling mainly 115mph running, with two short sections of 100mph. The transition onto the HS2 M18 Short alignment (see below) would be at 125mph.

The main interventions required to achieve an increased in the maximum line speed are track alignment changes to straighten some of the tighter curves on the route, and the changes to the layout of Clay Cross Junction common to the Erewash Valley intervention.

6.4.2.5 HS2 Short M18 Link (to/from Leeds)

The final section of infrastructure towards Leeds would comprise a link from the conventional route near Rotherham (Masborough Junction) to the original section of the planned HS2 Eastern leg alignment into Leeds, including the planned HS2 terminus in Leeds. However, the planned spur to the East Coast Mainline would not be constructed.

6.4.2.6 ECML interventions

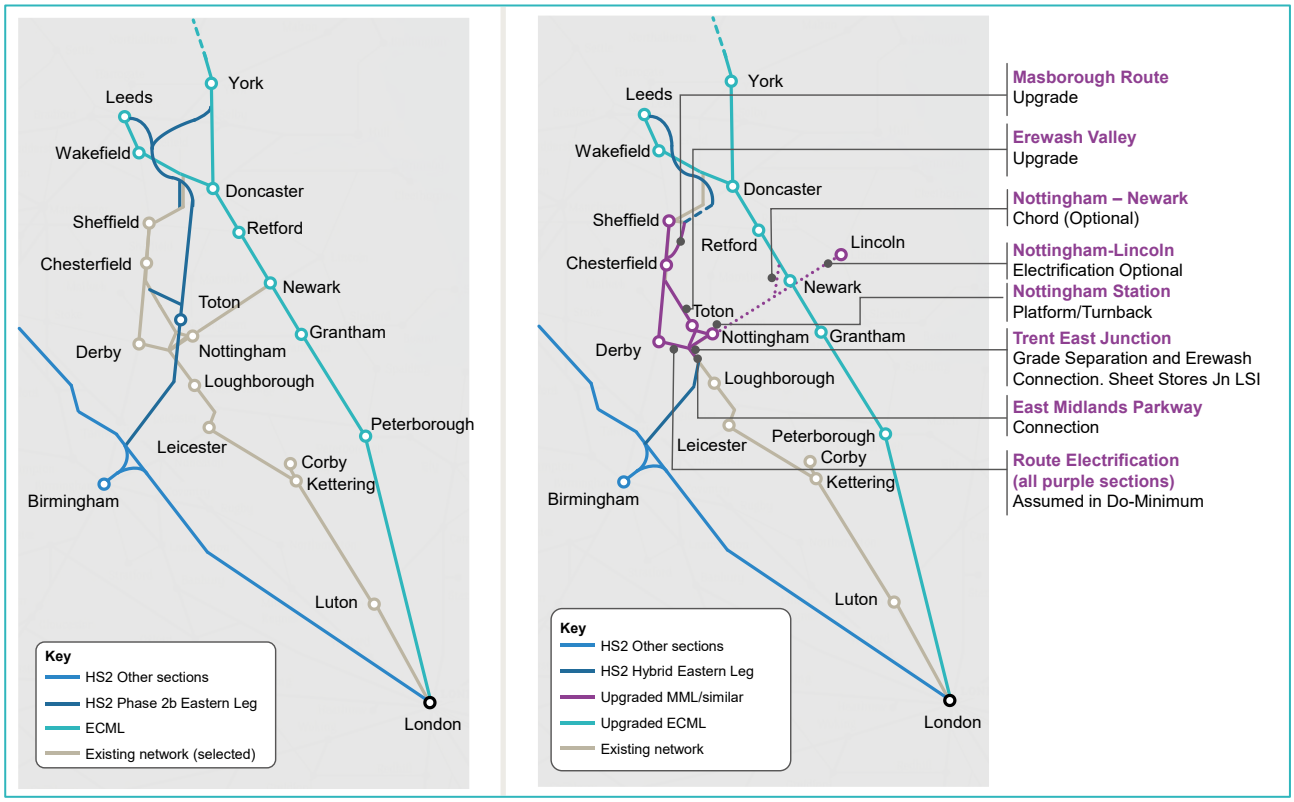
The scope of work is similar to the programme set out in the previous chapter however a reduced version of the Core Option would be sufficient as there would be two fewer trains per hour than in the previous Strategic Alternatives. In particular, the major work at Welwyn would not be required, and the scheme at Darlington would also not be needed (depending on the optional extension of services beyond Leeds/York).

6.4.2.7 Optional items

We have considered three variants of this Strategic Alternative where further infrastructure upgrades could provide benefit to a wider set of locations. These upgrades are:

- Electrification of the conventional route between Nottingham and Lincoln, to enable HS2 services to operate between Birmingham and Lincoln. This includes a small capacity intervention at Lincoln station.
- A new chord between the Nottingham Line and the ECML to enable HS2 and MML trains to service ECML locations and vice versa.
- A new station at Toton as set out in Appendix B.

Figure 14. HS2 Eastern Leg: Erewash Alignment. Simplified map of the and the interventions required



6.4.3 HS2 Eastern Leg: Newark Alignment

6.4.3.1 Trent Junctions Area

The scheme in the Trent Junctions area is similar to the intervention required under the Erewash Alignment. The only differences are:

- An additional crossover at EMP.
- Retention of the junction between the south end of the high level lines and the Nottingham lines.
- High Level lines and the Toton area would remain as per the current infrastructure as HS2 services would not use the Erewash Valley Line.

6.4.3.2 Nottingham Station

Work would be required at Nottingham station, and on the approaches to the east and the west, as follows:

- Western approaches. Potential replacement of three level crossings between Trent Junctions and Nottingham station, subject to downstream risk assessments.
- Station area. Platform extensions to provide two platforms with 400m capability and provision of additional lengthened turnback sidings to the east of the station. Increase the speed limit of 15mph to 40mph through some limited interventions.
- Eastern approaches. Upgrade and/or closure of the level crossings between Nottingham Station and Lowdham.

6.4.3.3 Alignment between Nottingham and the ECML

At Lowdham a new high speed route would diverge from the Nottingham - Lincoln line, crossing the ECML just north of Newark.

6.4.3.4 ECML Bypass and Junctions

A new high speed bypass route would run from the Newark area round to the east and north of Doncaster. This route would broadly follow the ECML corridor.

Junctions on/off the ECML bypass would be included enabling services to switch between the high speed route and the ECML as required. Specific junctions would comprise:

- A grade separated junction layout just north of Newark, so that ECML trains from London King's Cross can join the ECML bypass and take advantage of the faster line speeds on this route.
- A grade separated junction would also be included just south of Doncaster near Bawtry, so that the fastest trains could either serve or bypass Doncaster as appropriate.
- A connection with the ECML north of Doncaster providing on onward route to York and beyond.
- A connection to/from Leeds via a remodelled Adwick Junction.

6.4.3.5 ECML – Leeds (Adwick Junction – Hunslet Junction)

The route to Leeds would comprise a major upgrade of the conventional network, along with the final planned section of the Eastern Leg in Leeds city centre. Interventions would be as follows:

- South Kirby – Hare Park. Four tracking and electrification.
- Hare Park – Normanton. A short section of new (electrified) route.
- Normanton – Hunslet Junction. Upgrade of the existing rail alignment via Woodlesford. An upgraded layout, with electrification, re-signalling, and significant four tracking between Hare Park and broadly Hunslet Junction in Leeds.
- Hunslet Junction – Leeds. Construction of the planned HS2 T-Shaped station in Leeds along with the final stretch of the proposed approach route form Hunslet Junction.

6.4.3.6 ECML interventions

The scope of work is similar to the programme set out in the previous chapter, however the Core Option would be likely to be sufficient, in particular with no requirement for the proposed major intervention at Welwyn. This is because there would be two fewer trains per hour than in the previous Strategic Alternatives. The work at Darlington would also not be needed (depending on the optional extension of services beyond Leeds/York), and the ECML bypass round Doncaster would remove the need for the freight interventions set out in the ECML alternative option. There may also be an opportunity to avoid the grade separation of Newark Flat Crossing, however this would need significant further investigation and grade separation is included in this alternative.

It may also be possible to avoid some of the line speed increases included under all of the other options as most of the fastest trains would use the bypass route between the Newark area and the Doncaster area. At this stage all of the options include the same scope of work.

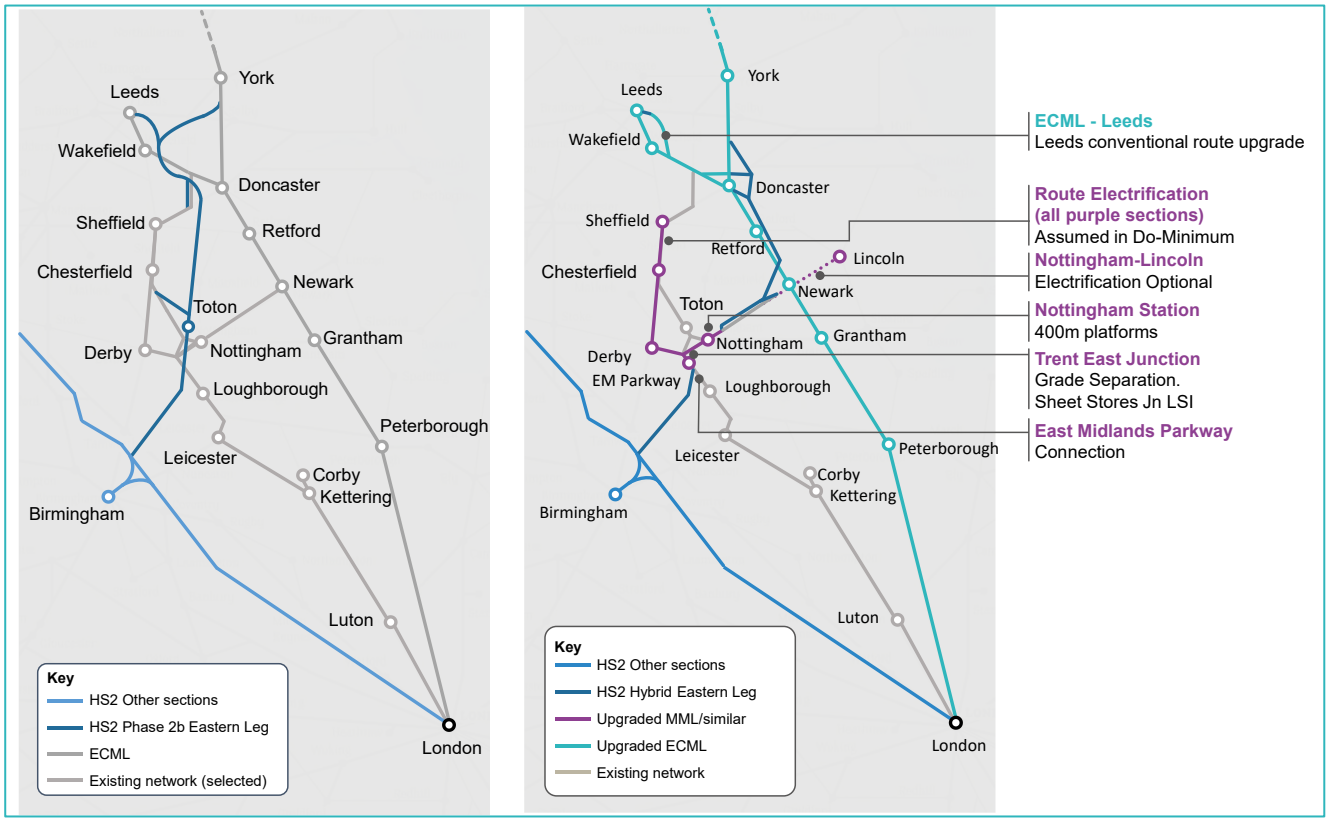
6.4.3.7 Optional items

We have considered an optional variant of this Strategic Alternative, with electrification of the conventional route between Nottingham and Lincoln, a short chord from the new route to enable

HS2 services to operate between Birmingham and Lincoln and a small capacity intervention at Lincoln station. In principle the bypassed section would not need to be electrified to enable the optional TSS, however this short section of additional electrification would provide useful resilience during planned or unplanned disruption.

A new station at Toton has also been considered as set out in Appendix B.

Figure 15. HS2 Eastern leg: Newark Alignment. Simplified map of the route and the interventions required



6.5 Costs

Table 16 below shows the estimated cost of the Eastern Leg Erewash and Newark alignments. The cost of the Erewash alignment is forecast at £22.9bn, versus £18.7bn for the Newark Alignment. The former is therefore forecast to be around £4.4bn (roughly 18%) more expensive.

Just over half of the cost of the Erewash Alignment is the route between the East Midlands and Leeds. Namely, the Erewash route upgrade, the Chesterfield – Masborough Junction upgrade and the M18 Short Alignment inclusive of the new HS2 station in Leeds. The combined cost of these interventions is forecast at approximately £12.7bn.

Similarly, a little over half of the Newark Alignment is in the section heading north from the East Midlands. In this case the work in and around Nottingham, the Lowdham – Newark route, the ECML bypass and the route into Leeds inclusive of the station have an estimated total cost of around £10.7bn. The key difference is that the latter alignment provides a high speed route to both Leeds and ECML locations such as York and Newcastle, whereas the former would need further optional infrastructure to achieve the same thing.

Both infrastructure packages are forecast to have a lower ECML cost than the first phase infrastructure packages (£2.5bn Erewash, £2.4bn Newark, up to £3.9bn others) as the resultant ECML train service frequency would be lower and less enabling infrastructure would be required.

Table 16. Erewash and Newark alignments. Estimated Infrastructure Costs. £m, 4Q2019 prices

	Erewash Alignment	Newark Alignment
HS2 new line: Birmingham – EMP	6,665	6,665
East Midlands Parkway HS2 connection	549	549
Trent Junctions Area	615	605
Nottingham Station	22	133
Erewash Route Upgrade	2,457	-
Chesterfield – Masborough Junction Upgrade	1,228	-
M18 Short HS2 Alignment	8,978	-
Lowdham - ECML HS route	-	1,152
Newark – Doncaster N ECML Bypass	-	4,448
Adwick Jn – Hunslet Jn	-	1,879
Hunslet – Leeds HS2	-	1,000
ECML Interventions (core package)	2,463	2,243
Total Cost	**22,977**	**18,674**
Nottingham – Lincoln Electrification (Optional)	*986*	*1,003***

Nottingham – ECML (Newark) Chord (Optional)	*130-372****	-
Toton Station (Optional)	*220-344**	*220*

** Depending on the station specification*

*** Including chord back from the HS route*

**** Range explained by a one or two chord solution*

6.6 Outputs

This section briefly sets out the trade-offs on journey time, frequency and estimated infrastructure cost of the Strategic Alternatives versus HS2 Phase 2a and Phase 2b.

Table 17 shows journey times for selected origin-destination pairs, including some locations which are not specifically connected in our TSSs, but which the proposed infrastructure work would provide the potential to serve. As previously, HS2 journey times are generally taken from the figures used in the Planet Forecasting Model used to produce demand forecasts for HS2 Ltd.

All of the transformational journey time improvements from the previous infrastructure packages would be delivered. Specifically, London – Derby, London - Nottingham and Birmingham – Nottingham would all be over half an hour faster than under the Phase 2b TSS, driven principally by direct services rather than a requirement to interchange.

Also similar to the previous packages, the Erewash and Newark alignments would enable a step change in the Birmingham – Lincoln and Nottingham – Lincoln journey times if the option to extend HS2 services to Lincoln was also pursued.

The infrastructure beyond the East Midlands would also lead to some very large journey time improvements, outperforming Phase 2b for some locations, whilst also improving train frequencies and capacities significantly. The key differences between the two alignments are the spread of improvements between various locations.

London - Leeds is slightly faster via the Erewash Alignment (1 hour 32 minutes) versus the Newark Alignment (1 hour 37 mins), with both slower than HS2 Phase 2b at 1 hour 21 mins.

The Erewash Alignment results in the fastest journey times between Birmingham and Leeds (61 minutes). This time is around 12 minutes slower than what could be achieved with the full Eastern Leg. Conversely the Nottingham – Leeds journey time is faster under the Newark Alignment, with a journey time of circa 38 minutes possible. This is versus 50 minutes with the Erewash alignment and substantially faster than under Phase 2b, which includes an interchange.

London - Sheffield would be the same as Phase 2b, both at circa 1 hour 27 minutes.

London – Newcastle would have a journey time of 2 hours 20 minutes under the Newark Alignment versus 2 hours 25 minutes with the Erewash alignment. Both would be slightly slower than Phase 2b at 2 hours 17 minutes.

A similar story is true for London – York, with times of 1 hour 33 minutes under the Newark Alignment, 1 hour 38 minutes with the Erewash Alignment and 1 hour 24 minutes with HS2 Phase 2b.

Leicester – Leeds could potentially see a circa half hour journey time improvement under both Strategic Alternatives versus with Phase 2b, although services to achieve this would require adding to our TSS subject to further capacity analysis.

Birmingham – Newcastle journey times would improve under both alternatives with the Newark Alignment around eight minutes faster than the Eastern Leg and the Erewash Alignment 11 minutes slower and also requiring some of the optional infrastructure highlighted above.

Looking briefly at train service frequency, most locations have a comparable or better frequency to Phase 2b.

As per the first phase to Leeds package, if NPR proposals between Sheffield and Leeds were in place then Euston - Sheffield services could also be extended to Leeds, albeit it in slower journey times than via the ECML, and connectivity from Derby (and potentially Leicester) could be improved by extending services that would otherwise terminate at Sheffield.

Table 17. Journey Time Comparison. Indicative fastest hourly northbound times (rounded up to nearest full minute)

Service	HS2 Phase 2a (Do-min[a])	HS2 Phase 2b	Erewash alignment	Newark alignment
London – EMP	1 hr 20 mins	1 hr 20 mins	51 mins	51 mins
London – Derby	1 hr 23 mins	1 hr 23 mins**	58 mins	58 mins
London – Nottingham	1 hr 38 mins	1 hr 23mins**	57 mins	57 mins
London – Sheffield	1 hr 59 mins	1 hr 27 mins*	1 hr 27 mins	1 hr 27 mins
London – Chesterfield	1 hr 45 mins	1 hr 12 mins	1 hr 12 mins	1 hr 20 mins
London – Leeds	2 hrs (2 hrs 13 mins in Dec 19)	1 hr 21 mins*	1 hr 32 mins	1 hr 37 mins
London – York	1 hr 46 mins (1 hr 50 mins in Dec 19)	1 hr 24 mins	1 hr 38 mins	1 hr 33 mins
London – Newcastle	2 hrs 34 min (2 hrs 49 mins in Dec 19)	2 hrs 17 mins	2 hrs 25 mins	2 hrs 20 mins
Birmingham – Nottingham	1 hr 14 mins**	55 mins**	26 mins	26 mins
Birmingham – Newark[+]	2 hrs 01 min^^	2 hrs 01 min^^	45 mins with optional Nottingham – Lincoln electrification (or around 1h 11 mins with interchange at Nottingham)	45 mins with optional Nottingham – Lincoln electrification (or around 1h 11 mins with interchange at Nottingham)
Birmingham – Lincoln	2 hrs 28 mins^^	2 hrs 28 mins^^	1 hr 8 mins with optional Nottingham – Lincoln electrification (or around 1h 40 mins with interchange at Nottingham)	1 hr 7 mins with Nottingham – Lincoln infrastructure grade (or around 1h 40 mins with interchange at Nottingham)
Birmingham – Leeds	1 hr 57 mins	49 mins*	1 hr 1 min	1 hr 6 mins
Birmingham – Newcastle	3 hrs 14 mins	1 hr 57 mins*	2 hrs 11 mins	1 hr 52 mins
Leicester – Leeds	1 hr 55 mins	1 hr 28 mins**	Around 1hrs 20 mins	Around 1hrs 20 mins

Nottingham – Sheffield	45 mins	42 mins	42 mins	45 mins
Nottingham – Doncaster	1 hr 28 mins^^	1 hr 28 mins^^	1 hr 28 mins^^	23 mins
Nottingham – Leeds	1 hr 43 mins	51 mins	50 mins	38 mins
Nottingham – York	1 hr 54 mins^^	1 hr 54 mins^^	1 hr 54 mins^^	34 mins
Nottingham – Newcastle	**3 hrs 5 mins^^**	**2hs 15 mins^^**	**3 hrs 5 mins^^**	**1 hr 24 mins**

[a] *Broadly as per Dec 19 unless stated, although some benefits will be realised through committed rolling stock changes*
* Journey times derived from PFM
** Journey times derived from 'Phase 2B 2RS02 East Midlands Hub Operability Report' 2019.
^^ Requires interchange.
[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Notes:

- Assumptions from PFM v9 were used in calculating interchange journey times penalties for indicative comparison purposes - 30 mins
- EMH to Nottingham transfer time assumptions taken from PFMv9 - 6 mins wait and 25 mins connection time
- Other journeys requiring interchanges include existing minimum connection times (5 mins Chesterfield and EMP, 6 mins Derby, 7 mins Sheffield and an assumed 15 mins at Leeds HS2 - Conventional station)
- Quoted journey times assume 115mph Erewash upgrade where applicable (100mph is 1.5 mins slower)
- Quoted journey times assume HS2 Short Link where applicable (Long Link is 2.5 minutes quicker)
- Birmingham - Sheffield/Derby and Derby-Sheffield excluded from table (59 mins, 27 mins and 31 mins respectively)- best journey time in all scenarios is as per today
- Option off-route HS2 journey times have been taken from the HS2 OBC Strategic Alternatives paper 'OBC Strategic Alternatives cost and JT 251119' and as such we assume that these represent the fastest possible

Table 18. Frequency Comparison. Direct services per hour, indicative standard hour

Service	HS2 Phase 2a (Do-min)	HS2 Phase 2b	Erewash alignment	Newark alignment
London – EMP	2	2	5 to 8	4 to 6
London – Derby	2	1 to 2	3 to 4	3
London – Nottingham	2	1 to 2	3 to 4	3
London – Sheffield	2	3 to 4	3 to 4	3 to 4
London – Chesterfield	2	2 to 3	3 to 5	2 to 3
London – Leeds	2 to 3	4	2 to 4	5
London – York	4	6 to 7	4	4
London – Newcastle	3 to 4	3 to 4	3 to 4	3
Birmingham – Nottingham	2 (regional)	2 (regional)	6 (incl. 2 regional)	5 to 7 (incl. 2 regional)
Birmingham – Newark[+]	-	-	1 (optional variant)	1 (optional variant)
Birmingham – Lincoln	-	-	1 (optional variant)	1 (optional variant)
Birmingham – Leeds	1	4	4	2 to 3
Birmingham – Newcastle	1 to 2	1	1 to 2	1 to 2
Leicester – Leeds	-	-	1	1
Nottingham – Sheffield	1 (regional)	1 (regional)	1 (regional)	1 (regional)
Nottingham – Doncaster	-	-	-	1
Nottingham – Leeds	1 (regional)	1 (regional)	2 (incl. 1 regional)	2 to 3 (incl. 1 regional)

Nottingham – York	-	-	-	1
Nottingham – Newcastle	**-**	**-**	**-**	**1**

[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Table 19. Capacity Comparison. Seats per hour, indicative standard hour

Service	HS2 Phase 2a (Do-min)	HS2 Phase 2b	Erewash alignment	Newark alignment
London – EMP	758	758	2,640 to 3,777	1,814 to 2,572
London – Derby	758	379 to 758	1,435 to 1,814	1,435
London – Nottingham	758	379 to 758	1,435 to 1,814	1,435
London – Sheffield	758	1,435 to 1,814	1,435 to 1,814	1,435 to 1,814
London – Chesterfield	758	907 to 1,286	1,435 to 2,342	907 to 1,286
London – Leeds	1,398 to 2,097	3,443 (Peak) / 2,335 (Off-peak)	1,398 to 2,796	3,495
London – York	2,796	3,681 to 4,380	2,796	2,796
London – Newcastle	2,097 to 2,399	1,755 to 2,057	2,097 to 2,399	1,755
Birmingham – Nottingham	404	404	2516	1,988 to 3,044
Birmingham – Newark[+]	-	-	528	528
Birmingham – Lincoln	-	-	528	528
Birmingham – Leeds	200	1,862	1,862	728 to 1,256
Birmingham – Newcastle	400	528	400	400
Leicester – Leeds	-	-	379	-
Nottingham – Sheffield	204	204	204	204
Nottingham – Doncaster	-	-	-	528
Nottingham – Leeds	204	204	732	732 to 1,260
Nottingham – York	-	-	-	528
Nottingham – Newcastle	**-**	**-**	**-**	**528**

[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Notes:

- *HS2 services based on 554 (captive) and 528 (conventional-compatible) seats per 200m unit*
- *ECML*
  - *Do Minimum: ECML services based on 10-car IEPs (currently supported maximum train lengths) at 699 seats or 5-car IEPs at 302 seats per unit. WCML services based on 11-car Class 390 Pendolinos assumed at 591 seats.*
  - *HS2 Phase 2b assumptions*
    - *Leeds: Peak - 4 Captive and 1 CC unit per hour, Off-peak - 2 Captive and 1 CC unit.*
    - *York: 3 CC units per hour all day. ECML King's Cross London - York current assumption adopted from NPR Full EL scenario 2tph (1 Scotland, and 1 Middlesbrough/Sunderland, both assumed to be 10-car IEP).*
    - *Newcastle: 2 CC units per hour all day. 10-car IEP assumed on residual LNER, and 5-car on the Open Access.*
  - *Strategic alternative: 10-car IEPs assumed as core scenario. Illustrative additional 'theoretical maximum' scenario shows capacities assuming 11-car IEPs on all services (except the 2 fast*

Scotland services, assuming 12-car). This is intended to set out the maximum feasible capacity without reconfiguring the interior of the trains.
    - *London – York may receive a moderate further capacity uplift under the Strategic Alternatives, depending on the eventual stopping pattern selected.*
- *EM conventional routes assumed to be served by 7-car Meridians at 379 seats as per PFMv9 assumptions.*
- *CrossCountry Birmingham-Leeds/Nottingham services assumed to be served by 3-car Class 170s at 202 seats.*
- *CrossCountry Derby/Sheffield-Leeds and Birmingham-Newcastle services assumed to be served by 4-car Voyager Class 220s at 200 seats.*
- *Northern regional Nottingham-Sheffield/Leeds services assumed to be served by Class 195/0 trains at 204 seats.*

6.7 Performance

Performance considerations are the same as described for previous options, i.e. at worst maintaining existing (December 2019) levels of performance, although this would need to be confirmed through further modelling at a later stage.

Similar to First Phase infrastructure packages, the key constraint for both the Erewash and Newark options is in the Trent Junctions area. Analysis has been undertaken to identify the key constraining parts of the junction, and appropriate interventions developed which provide the maximum benefit to relieving those constraints and improving performance.

Nottingham station is also still a key constraint location, although the intervention required will change depending on the option. For the Eastern Leg Erewash alignment, the same choices around Nottingham station exist as in the First Phase infrastructure packages. For the Newark routeing, the number of through services at Nottingham increases, and therefore the option is focussed around providing additional platform capacity suitable for the longer HS2 trains. These additional platforms will also bring a performance benefit.

It should be noted that although the Sheffield area was also identified as a constraint, it is assumed that this constraint is fully or partially resolved through proposed schemes delivered in the meantime (such as those which form part of NPR).

For the Erewash routeing, the route will be shared for much of the length with existing Nottingham – Sheffield passenger services and relatively high levels of freight traffic. The interventions developed have taken this into account and sufficient four-tracking of the Erewash Valley and additional freight holding locations between Chesterfield and Masborough have been provided to take this into account. However, this routeing is likely to be higher risk in terms of performance than via Newark, and additional modelling is likely to be needed at a later stage to confirm these findings.

For the Newark routeing, similar interactions between Nottingham and the junction for the new line will occur, albeit to a reduced extent compared to the Erewash route. The location of the new junction has been chosen to ensure that existing freight and passenger services can operate on this route alongside HS2 trains with minimal impact, although further modelling will also be required at a later date to confirm this.

For both routeing options, the level of service on the ECML is similar to the ECML Enhancements Programme Outputs, with HS2 effectively serving as the ‘duplicate’ route accommodating the increased quantum of trains. Therefore, the scope of interventions can be decreased and even the reduced-scope Core Option would be expected to provide better performance than today.

The bypass between Newark and north of Doncaster in the Newark option will provide a significant benefit to Doncaster station by routeing all non-stop trains away from the station,

which will provide a significant performance benefit and open additional opportunities for freight and local passenger services.

Although additional services operate between the new junction north of Doncaster and Hare Park junction, there is sufficient capacity for them to do so. The proposed intervention at Hare Park has been designed to offer the maximum flexibility and could in itself provide a performance benefit by offering opportunities to hold and overtake slower services on what is today a two-track railway.

6.8 Conclusions

Both the Erewash and Newark Eastern Leg alignments would provide large reductions in journey time and significant improvements in capacity between London and locations at the north end of the planned Eastern Leg. While the Eastern Leg would be able to achieve larger journey time reductions for a greater number of northern locations than either the Erewash Alignment or the Newark alignment it is less beneficial to intermediate markets, and is likely to cost substantially more.

Both the Erewash and Newark Eastern Leg alignments generally provide better connectivity to/from the East Midlands, and arguably the West Midlands, than would be the case under the Eastern Leg. For example, London – Derby, London - Nottingham and Birmingham – Nottingham would all be over half an hour faster than under the Phase 2b TSS, driven principally by direct services rather than a requirement to interchange. Birmingham – Lincoln journey times could improve by more than an hour and 20 minutes with enabling onward electrification. Connectivity to Chesterfield and Sheffield from London would be comparable to Phase 2b.

For Leeds, the Erewash alignment is likely to offer faster journey times to Birmingham and London compared Newark, although both alternatives would provide slower journey times compared to the Eastern Leg.

The Newark Alignment could serve a wider spread of destinations compared to the current Eastern Leg and the Erewash alignment, and enable Nottingham – Leeds, Doncaster and York journey times of 38 minutes, 23 minutes and 34 minutes, respectively. All of these times are a significant improvement over the Eastern Leg, and over an hour faster than the Do-Minimum scenario.

The cost of these Strategic Alternatives at approximately £23.0bn (Erewash) and £18.7bn (Newark) look to be significantly lower than the full cost of the Eastern Leg at up to £32bn.

In summary, noting the early stage nature of our work, is seems reasonably likely that for around three to four fifths of the cost of the full Eastern Leg, either of the Erewash and Newark Eastern Leg alignments could deliver most of the benefits of Phase 2b to locations in the north of England and generally a better level of connectivity to/from the East Midlands and adjoining parts of the country.

All of the locations served by the Eastern Leg would or could potentially benefit under the Erewash and Newark Eastern Leg alignments , however the spread of benefits would differ with some locations receiving better or comparable journey times and capacity under one or both of the alternatives, and other places benefitting but not by as much as under Phase 2b.

The Erewash and Newark Eastern Leg alignments would therefore seem to meet Government’s priorities, whilst saving a considerable proportion of the cost of the full Eastern Leg.

Both the Erewash and Newark Eastern Leg alignments could be constructed under a phased approach. The Erewash alignment could see the ECML upgrades and the route between Birmingham and East Midlands Parkway built first, along with enabling infrastructure in the Trent Junctions area and at Nottingham. At this point something akin to the First phase to Sheffield TSS could operate. Thereafter, the remaining infrastructure to the north could be built.

The first stage of the via Newark alignment could be the ECML upgrades, the route to EMP, and the enabling work in the Trent area and at Nottingham. At this point the First Phase to Sheffield TSS could run.

A second stage could see construction of the HS2 station in Leeds as well as the upgrade of the Woodlesford corridor. This would deliver a next step of benefits to Leeds, and if NPR was approved and constructed via a separate process, would enable operation of the First Phase to Leeds TSS.

The ECML bypass could then be constructed as a third phase, delivering the end-state benefits of this option.

If the ultimate aim was earlier delivery of some of the key benefits to the East Midlands, Sheffield and Leeds, then the Newark alignment holds the advantage over the Erewash alternative as it can more easily be split into sub-phases, and the approach to Leeds would be common to both the intermediate and end stages.

7 Conclusions

7.1 Recap

In this summary report we have presented the results of our assessment of the Strategic Alternatives of the HS2 Phase 2b Eastern Leg as it is planned currently. We have considered in order:

- The potential to replace the whole of the Eastern Leg with an upgrade of the conventional network, specifically:
    - The East Coast Main Line (ECML). The potential Train Service Specifications (TSSs) and the enabling infrastructure required, if the Eastern Leg is truncated short of the ECML and improvements to/from key ECML locations such as Leeds, York, Newcastle and potentially Edinburgh are instead enabled by infrastructure on the ECML.
    - The Midland Main Line (MML). The potential TSSs and the enabling infrastructure required to serve MML locations, given a specific truncation of the Eastern Leg at Wilnecote near Tamworth.
    - The Level of service provision possible when both of the above upgrades are combined.
- A First Phase to Sheffield Package. A Hybrid option with a new HS2 alignment from Birmingham to East Midlands Parkway. Leeds, York and Newcastle is served via upgrades to the ECML
- A First Phase to Leeds Package. As per the First Phase to Sheffield package but with the planned HS2 station at Leeds and major upgrades north of Sheffield. HS2 reaches Leeds but not other destinations on the ECML.
- Alternative forms of end-state Eastern Leg, Erewash and Newark alignments . Building on either of the First Phase packages, but assessing two broad route corridors between the East Midlands and Leeds and the North East:
    - Upgrades to the Erewash Valley Line, the Chesterfield – Masborough Junction route and then a new high speed line between broadly Rotherham and Leeds, known as the M18 Short Alignment. The majority of the M18 Short Alignment is as per the planned Eastern Leg, including the proposed HS2 terminal station in Leeds. The route to York and Newcastle would be via an upgraded ECML, similar to the other Strategic Alternatives.
    - A new high speed line east of Nottingham, crossing the ECML near Newark and bypassing the ECML to the east and north of Doncaster. This would be combined with junctions on/off the ECML at Newark, Bawtry and north of Doncaster as well as an upgraded conventional route to Leeds via Normanton and Woodlesford. The final approach in the centre of Leeds as well as the new terminal station would be the same as under the planned Eastern leg.

In this chapter we have attempted to set out some of the key trade-offs between the various options and the Eastern Leg of Phase 2b, to frame the choices for Government. We note at this stage demand forecasting and formal Value for Money is downstream, and that these considerations may form key evidence to support the ultimate decision.

7.2 Trade-Offs

The tables below show the key figures on journey time, frequency, capacity and cost. The following trade-offs are apparent:

- The ECML only investment has a comparatively low estimated infrastructure cost, avoiding almost all of the cost of the Eastern Leg. However, this near cancellation of the Eastern Leg would see many sizeable locations such as Nottingham, Sheffield, Leeds and Derby lose the bulk of journey time and frequency benefits. Some locations such as York and Newcastle would retain significant improvements albeit at a lower level than seen under Phase 2b.
- Similarly, replacement of the Eastern Leg with a package of upgrades only on the MML would save most of the Eastern leg cost and retain some important benefits to locations in the East Midlands and South Yorkshire, but would forgo all improvements for places on the ECML and the adjoining network.
- Combining the ECML upgrade with a truncation of HS2 near Wilnecote and an upgrade of the conventional route through Burton could cost several times less than the Eastern Leg, but is also next worst in term of service improvements. In particular the route to the north from Birmingham does not offer material benefits over the Do-Minimum scenario.
- The First Phase to Sheffield package with a new high speed route between Birmingham and East Midlands Parkway (EMP) would deliver some possibly transformational improvement to the East Midlands in particular, but also potentially to locations on the East - West rail corridor through Nottingham, in some cases enabled by further optional infrastructure investment. The connectivity benefits to the East Midlands from Birmingham and the South, on balance, look to outperform Phase 2b as it is currently planned. This Strategic Alternative would be potentially around a third of the cost of the Eastern Leg, however it does not deliver many of the benefits for locations further north that would occur if the Eastern Leg goes ahead as planned, including from the East Midlands.
- The First Phase to Leeds package would deliver all of the benefits of the previous package as well as additional connectivity benefits between Leeds and locations in the Midlands. It also comprises many of the interventions required for the HS2 Eastern Leg Newark alignment and could potentially form the initial phases of that scheme.
- The HS2 Eastern Leg Erewash and Newark alignments with significantly upgraded and new infrastructure beyond the East Midlands would deliver all of the benefits of the First Phase to Sheffield package. However, these alternatives would also substantially improve connectivity to/from locations further north, meaning that the places which benefit through Phase 2b would also see improvements under the Strategic Alternatives. On balance, the Eastern Leg offers the perhaps largest improvement in journey times to the locations in the north of England which are set to benefit from Phase 2b. The Newark variant in particular would lead to a greater spread of journey time and capacity benefits than the Eastern Leg in full, although the Erewash alternative variant delivers the greatest journey time saving to Leeds from Birmingham and London (and would route high speed services through Toton). Either alternative could be delivered for more than £9bn less than the cost of the Eastern Leg.

Considering all of the above, the Erewash or Newark alignments would seem to meet Government's priorities and offer a significant potential cost saving over the current proposal.

Comparing the Erewash and Newark alternative:

- The Newark Alignment is forecast to cost around £4.4bn (roughly 18%) less than the Erewash Alignment.

- The Erewash Alignment offers better overall longer distance journey times between London and Leeds, although London – York and London – Newcastle are slightly faster with the Newark Alignment.
- The Newark Alignment offers better connectivity between the East and West Midlands and places on the ECML, although inclusion of optional additional infrastructure in the Erewash alignment specification would narrow the gap. It also may provide downstream opportunities to descope the some of ECML infrastructure interventions thereby reducing cost.
- Both alignments could be constructed in a phased approach enabling earlier delivery of some benefits, with the option via Newark perhaps offering the better phased solution.

Table 20. Journey time comparison for key pairs of locations. Indicative fastest hourly, northbound

Service	HS2 Phase 2a (Do Min[a])	Upgrades only (MML and ECML)	First Phase to Sheffield	First Phase to Leeds	Erewash alignment	Newark alignment	HS2 Phase 2b
London – EMP	1 hr 20 mins	1 hr 20 mins	51 mins	51 mins	51 mins	51 mins	1 hr 20 mins
London – Derby	1 hr 23 mins	57 mins	58 mins	58 mins	58 mins	58 mins	1 hr 23 mins**
London – Nottingham	1 hr 38 mins	1 hr 20 mins	57 mins	57 mins	57 mins	57 mins	1 hr 23 mins**
London – Sheffield	1 hr 59 mins	1 hr 26 mins	1 hr 27 mins	1 hr 27 mins	1 hr 27 mins	1 hr 27 mins	1 hr 27 mins*
London – Chesterfield	1 hr 45 mins	1 hr 15 mins	1 hr 20 mins	1 hr 20 mins	1 hr 12 mins	1 hr 20 mins	1 hr 12 mins
London – Leeds	2 hrs (2 hrs 13 mins in Dec 19)	1 hr 53 mins	1 hr 53 mins	1 hr 53 mins	1 hr 32 mins	1 hr 37 mins	1 hr 21 mins*
London – York	1 hr 46 mins (1 hr 50 mins in Dec 19)	1 hr 38 mins	1 hr 38 mins	1 hr 38 mins	1 hr 38 mins	1 hr 33 mins	1 hr 24 mins
London – Newcastle	2 hrs 34 min (2 hrs 49 mins in Dec 19)	2 hrs 25 mins	2 hrs 25 mins	2 hrs 25 mins	2 hrs 25 mins	2 hrs 20 mins	2 hrs 17 mins
Birmingham – Nottingham	1 hr 14 mins**	1 hr 14 mins**	26 mins	26 mins	26 mins	26 mins	55 mins**
Birmingham – Newark[+]	2 hrs 01 min^^	2 hrs 01 min^^	45 mins with optional Nottingham – Lincoln electrification (or around 1h 11 mins with interchange at Nottingham)	45 mins with optional Nottingham – Lincoln electrification (or around 1h 11 mins with interchange at Nottingham)	45 mins with optional Nottingham – Lincoln electrification (or around 1h 11 mins with interchange at Nottingham)	45 mins with optional Nottingham – Lincoln electrification (or around 1h 11 mins with interchange at Nottingham)	1h 28 min^^
Birmingham – Lincoln	2 hrs 28 mins^^	2 hrs 28 mins^^	1 hr 8 mins with optional Nottingham – Lincoln electrification (or around 1h 40 mins with interchange at Nottingham)	1 hr 8 mins with optional Nottingham – Lincoln electrification (or around 1h 40 mins with interchange at Nottingham)	1 hr 8 mins with optional Nottingham – Lincoln electrification (or around 1h 40 mins with interchange at Nottingham)	1 hr 8 mins with Nottingham – Lincoln infrastructure upgrade (or around 1h 40 mins with interchange at Nottingham)	1 hrs 48 mins^^
Birmingham – Leeds	1 hr 57 mins	1 hr 57 mins	1 hr 57 mins	1hr 26 mins	1 hr 1 min	1 hr 6 mins	49 mins*
EMP – Leeds	2 hrs 20 mins	2 hrs 20 mins	2 hrs 20 mins	1 hr 13 mins[++]	47 mins	49 mins	1 hr 12 mins

Service	HS2 Phase 2a (Do Min[a])	Upgrades only (MML and ECML)	First Phase to Sheffield	First Phase to Leeds	Erewash alignment	Newark alignment	HS2 Phase 2b
Derby – Leeds	1 hr 15 mins	1 hr 15 mins	1 hr 15 mins	56 mins++	56 mins++	59 mins++	1 hr 15 mins
Sheffield – Leeds	40 mins	40 mins	40 mins	28 mins++	27 mins++	30 mins++/^^^^	24 mins
Birmingham – Newcastle	3 hrs 14 mins	3 hrs 14 mins	3 hrs 14 mins	3 hrs 14 mins	2 hrs 11 mins	1 hr 52 mins	1 hr 57 mins*
Leicester – Leeds	1 hr 55 mins	1 hr 55 mins	1 hr 55 mins	around 1h 20mins	around 1h 20mins	around 1h 20mins	1 hr 28 mins**
Nottingham – Sheffield	45 mins	42 mins	42 mins	42 mins	42 mins	42 mins	42 mins
Nottingham – Doncaster	1 hr 28 mins^^	1 hr 28 mins^^	1 hr 28 mins^^	1 hr 28 mins^^	1 hr 28 mins^^	23 mins	1 hr 28 mins^^
Nottingham – Leeds	1 hr 43 mins	1 hr 43 mins	1 hr 43 mins	1 hr 43 mins	50 mins	38 mins	51 mins
Nottingham – York	1 hr 54 mins^^	1 hr 54 mins^^	1 hr 54 mins^^	1 hr 54 mins^^	1 hr 54 mins^^	34 mins	1 hr 54 mins^^
Nottingham – Newcastle	**3 hrs 5 mins^^**	**3 hrs 5 mins^^**	**3 hrs 5 mins^^**	**3 hrs 5 mins^^**	**3 hrs 5 mins^^**	**1 hr 24 mins**	**2 hrs 15 mins^^**

[a] *Broadly as per Dec 19 unless stated, although some benefits will be realised through committed rolling stock changes*
* Journey times derived from PFM
** Journey times derived from 'Phase 2B 2RS02 East Midlands Hub Operability Report' 2019.
^^ Requires interchange.
^^^ Hypothetical via Erewash (i.e. with no call in the East Midlands).
^^^^ This could reduce further to 28 mins if the same NPR enhancements north of Sheffield are adopted.
+ Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.
++ Calls at Rotherham / Dearne Valley Parkway have not been included in these figures but would be expected to add circa 4 mins to journey time estimates.

Note. Journey times over NPR infrastructure have been provided by DfT

Table 21. Indicative train service frequency versus HS2 Phase 2b

Service	HS2 Phase 2a (Do Min)	Upgrades only (MML and ECML)	First Phase to Sheffield	First Phase to Leeds	Erewash alignment	Newark alignment	HS2 Phase 2b
London – EMP	2	2 to 4	4 to 7	4 to 6	5 to 8	4 to 6	2
London – Derby	2	3 to 4	3	3	3 to 4	3	1 to 2
London – Nottingham	2	3 to 4	3 to 4	3	3 to 4	3	1 to 2

Service	HS2 Phase 2a (Do Min)	Upgrades only (MML and ECML)	First Phase to Sheffield	First Phase to Leeds	Erewash alignment	Newark alignment	HS2 Phase 2b
London – Sheffield	2	3 to 4	3	3 to 4	3 to 4	3 to 4	3 to 4
London – Chesterfield	2	2 to 3	2	2 to 3	3 to 5	2 to 3	2 to 3
London – Leeds	2 to 3	2 to 3	2	4 to 5	2 to 4	5	4
London – York	4	4	4	3 to 6	4	4	6 to 7
London – Newcastle	3 to 4	3 to 4	3 to 4	3 to 4	3 to 4	3	3 to 4
Birmingham – Nottingham	2 (regional)	2 to 3 (incl. 2 regional)	2 to 4 (incl. 2 regional)	4 (incl. 2 regional)	6 (incl. 2 regional)	5 to 7 (incl. 2 regional)	2 (regional)
Birmingham – Newark+	-	-	1 (optional variant)	1 (optional variant)	1 (optional variant)	1 (optional variant)	-
Birmingham – Lincoln	-	-	1 (optional variant)	1 (optional variant)	1 (optional variant)	1 (optional variant)	-
Birmingham – Leeds	1	1	1	3	4	2 to 3	4
EMP – Leeds	0	0	0	1 to 2	3 to 4	2 to 3	0*
Derby – Leeds	1	1	1	3	4	3	1
Sheffield – Leeds	1 (fast) + local services	1 (fast) + local services	1 (fast) + local services	4 to 5 (fast) + local services	3 to 4 (fast) + local services	3 to 4 (fast) + local services	4 (fast) + local services
Birmingham – Newcastle	2	2	2	1 to 2	1 to 2	1 to 2	1
Leicester – Leeds	-	-	-	1	1	1	1
Nottingham – Sheffield	1 (regional)	1 (regional)	1 (regional)	1 (regional)	1 (regional)	1 (regional)	1 (regional)
Nottingham – Doncaster	-	-	-	-	-	1	-

Service	HS2 Phase 2a (Do Min)	Upgrades only (MML and ECML)	First Phase to Sheffield	First Phase to Leeds	Erewash alignment	Newark alignment	HS2 Phase 2b
Nottingham – Leeds	1 (regional)	1 (regional)	1 (regional)	1 (regional)	2 (incl. 1 regional)	2 to 3 (incl. 1 regional)	1 (regional)
Nottingham – York	-	-	-	-	-	1	-
Nottingham – Newcastle	-	-	-	-	-	1	-

* *5tph from Toton*
[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Table 22. Indicative train capacity (seats) versus HS2 Phase 2b

Service	HS2 Phase 2a (Do Min)	Upgrades only (MML and ECML)	First Phase to Sheffield	First Phase to Leeds	Erewash alignment	Newark alignment	HS2 Phase 2b
London – EMP	758	758 to 1,516	1,814 to 2,951	1,814 to 2,572	2,640 to 3,777	1,814 to 2,572	758
London – Derby	758	1,435 to 1,814	1,435	1,435	1,435 to 1,814	1,435	379 to 758
London – Nottingham	758	1,435 to 1,814	1,435 to 1,814	1,435	1,435 to 1,814	1,435	379 to 758
London – Sheffield	758	1,435 to 1,814	1,435	1,435 to 1,814	1,435 to 1,814	1,435 to 1,814	1,435 to 1,814
London – Chesterfield	758	907 to 1,286	907	1,435 to 1,814	1,435 to 2,342	907 to 1,286	907 to 1,286
London – Leeds	1,398 to 2,097	1,398 to 2,097	1,398	2,796 to 3,495	1,398 to 2,796	3,495	3,443 (Peak) / 2,335 (Off-peak)
London – York	2,796	2,796	2,796	2,097 to 4,194	2,796	2,796	3,681 to 4,380
London – Newcastle	2,097 to 2,399	2,097 to 2,399	2,097 to 2,399	2,097 to 2,399	2,097 to 2,399	1,755	1,755 to 2,057
Birmingham – Nottingham	404	404 to 932	404 to 1,460	1,460	2516	1,988 to 3,044	404
Birmingham – Newark[+]	-	-	528	528	528	528	-
Birmingham – Lincoln	-	-	528	528	528	528	-

Service	HS2 Phase 2a (Do Min)	Upgrades only (MML and ECML)	First Phase to Sheffield	First Phase to Leeds	Erewash alignment	Newark alignment	HS2 Phase 2b
Birmingham – Leeds	200	200	200	1,256	1,862	728 to 1,256	1,862
EMP – Leeds	-	-	-	528 to 907	1,584 to 1,963	1,056 to 1,435	-
Derby – Leeds	200	200	200	1,256	1,784	1,256	200
Sheffield – Leeds	200	200	200	1,784 to 2,163	1,256 to 1,784	1,256 to 1,635	1784
Birmingham – Newcastle	400	400	400	400	400	400	528
Leicester – Leeds	-	-	-	379	379	-	-
Nottingham – Sheffield	204	204	204	204	204	204	204
Nottingham – Doncaster	-	-	-	-	-	528	-
Nottingham – Leeds	204	204	204	204	732	732 to 1,260	204
Nottingham – York	-	-	-	-	-	528	-
Nottingham – Newcastle	-	-	-	-	-	**528**	-

[a] *Broadly as per Dec 19 unless stated, although some benefits will be realised through committed rolling stock changes*
[+] Newark Castle Station – note we have not assessed any interventions at this station to enable calls of 200m trains.

Notes:

- *HS2 services based on 554 (captive) and 528 (conventional-compatible) seats per 200m unit*
- *ECML*
  - *Do Minimum: ECML services based on 10-car IEPs (currently supported maximum train lengths) at 699 seats or 5-car IEPs at 302 seats per unit. WCML services based on 11-car Class 390 Pendolinos assumed at 591 seats.*
  - *HS2 Phase 2b assumptions*
    - *Leeds: Peak - 4 Captive and 1 CC unit per hour, Off-peak - 2 Captive and 1 CC unit.*
    - *York: 3 CC units per hour all day. ECML King's Cross London - York current assumption adopted from NPR Full EL scenario 2tph (1 Scotland, and 1 Middlesbrough/Sunderland, both assumed to be 10-car IEP).*
    - *Newcastle: 2 CC units per hour all day. 10-car IEP assumed on residual LNER, and 5-car on the Open Access.*
  - *Strategic alternative: 10-car IEPs assumed as core scenario. Illustrative additional 'theoretical maximum' scenario shows capacities assuming 11-car IEPs on all services (except the 2 fast Scotland services, assuming 12-car). This is intended to set out the maximum feasible capacity without reconfiguring the interior of the trains.*
  - *London – York may receive a moderate further capacity uplift under the Strategic Alternatives, depending on the eventual stopping pattern selected.*
- *EM conventional routes assumed to be served by 7-car Meridians at 379 seats as per PFMv9 assumptions.*

- *CrossCountry Birmingham-Leeds/Nottingham services assumed to be served by 3-car Class 170s at 202 seats.*
- *CrossCountry Derby/Sheffield-Leeds and Birmingham-Newcastle services assumed to be served by 4-car Voyager Class 220s at 200 seats.*
- *Northern regional Nottingham-Sheffield/Leeds services assumed to be served by Class 195/0 trains at 204 seats.*

Table 23. Estimated infrastructure cost comparison. £bn 4Q2019

Option	Cost
Full Eastern Leg	32.0 (at maximum contingency)
ECML Upgrade Alternative	2.5-3.9*
MML Upgrade Alternative	3.3
Combined (ECML + MML) Upgrade Alternative	5.8-7.2
First Phase to Sheffield	10.0 – 11.4*
First Phase to Leeds	12.9-14.3* (excludes NPR costs)
HS2 Eastern Leg: Erewash Alignment	23.0 (excludes NPR costs)
HS2 Eastern Leg: Newark Alignment	18.7 (excludes NPR costs)

* Depending on the ECML package selected

A. Variants considered and not taken further

A.1.1 Introduction

During this study we have identified some variants or sub-options of Strategic Alternatives presented which we have not developed fully as they did not seem to improve the alternative in question and/or were a broadly comparable way of achieving the same outcome. We have listed these variants/sub-options in this Annex should DfT or other stakeholders wish to develop them further at a later date.

A.1.2 Reinstatement of the Church Fenton section of the Eastern Leg

All of the Strategic Alternative options include removal of the section of the Eastern Leg towards York at the point that the planned route diverges to Leeds and York. We have not investigated this further, in particular due to perceived connectivity benefits of our proposed ECML upgrade work. However, in principle if would be possible to reinstate this section of the Eastern leg in the Eastern Leg Erewash Alignment. Some services towards York and Newcastle could therefore use HS2 and hybrid infrastructure rather than the ECML, though further work would be needed to understand the feasibility of this.

A.1.3 HS2 Eastern Leg: Erewash and Pinxton Alignment)

The upgrade of the Chesterfield – Masborough Junction route and the southern section of the M18 Short Alignment could be replaced with a new high speed route from the Erewash Valley starting in very broadly the Pinxton area. The concept of this routeing is the same as the suggested Erewash alignment, with cost, journey time and other practical considerations driving the ultimate decision.

A.1.4 HS2 Eastern Leg: West of Newark Alignment

The ECML bypass in this Strategic Alternative could be constructed to the west of Newark. Our indicative assessment suggested this would be significantly more expensive, yielding few connectivity benefits.

B. Options for a new Station at Toton

B.1.1 Introduction

We have investigated two types of station at Toton, they are:

- Variant 1. A basic two platform station suitable for the Strategic Alternatives such as the first phase packages and the Eastern Leg Newark Alignment where the passing traffic would be principally services to and from the MML. The anticipated service frequency would be in the region of 1-2 LDHS trains per hour, plus limited number of local services.
- Variant 2. A larger four platform station with the ability to call more services than under the previous option and also with infrastructure to bypass the station as required. This type of station and layout could be used under the Eastern Leg Erewash Alignment, where the main HS2 route to/from Leeds is the Erewash Valley Line.

7.3 Variant 1. Basic HS2 station

Error! Reference source not found. below shows the proposed station layout in a simplified form.

DfT has suggested that the station is located to the east of the current alignment to avoid disrupting active freight sidings to the west. We agree that this is the best location for the station.

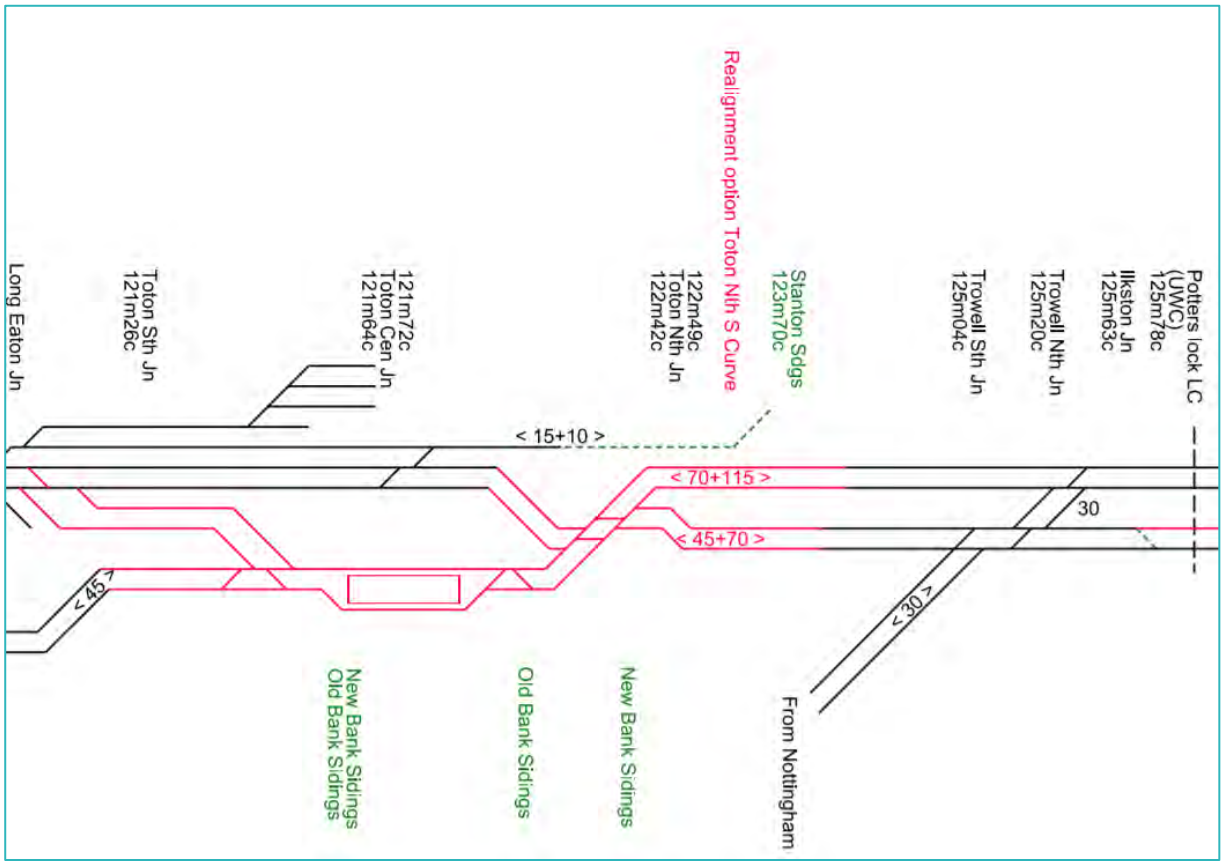
Under this option we would expect an eventual TSS to include calls at Toton for LDHS services to and from the MML.

The layout therefore comprises two lines via platforms for use by trains to/from the MML, and two through lines to/from the Derby direction.

We have added functionality to call trains to/from the Derby direction, however in our opinion a better way to enable this movement would be to instead include platforms on the Derby (west) side of the layout. This is the approach we have taken in Variant 2.

The estimated cost of the two platform station, including the associated amendments to the adjoining infrastructure is approximately £220m.

Figure 16. Toton Variant 1. Simplified Schematic (revised Trent Junctions area layout not shown)



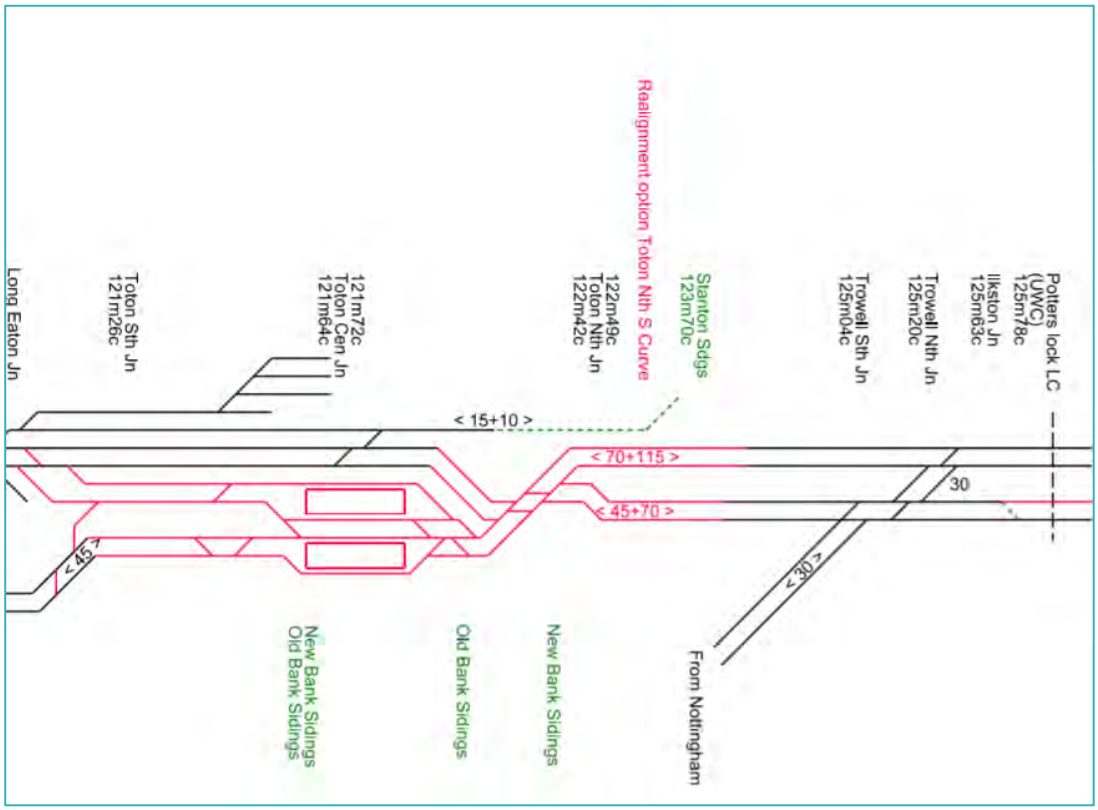
7.4 Variant 2. Basic HS2 station and National Rail station

Error! Reference source not found. below shows the proposed station layout in a simplified form.

Under this layout we have added two platforms on the HS2 (east) side, and two platforms on the Derby (west) side. When combined with the upgraded layout in the Trent Junctions area, HS2 and MML services could operate through any of the four platforms/running lines, therefore providing resilience if any of platforms are out of use.

The estimated cost of the two platform station, including the associated amendments to the adjoining infrastructure is approximately £293m.

Figure 17. Toton Variant 2. Simplified Schematic (revised Trent Junctions area layout not shown)



C. Service Improvement Comparison: Location Perspective

This appendix sets out the level of service improvement from the under the various options which would be seen by individual selected locations. Note HS2 journey times to/from London refer to to/from London Euston. Times to/from Old Oak Common will be around seven minutes faster.

C.1.1 Derby

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Journey time to/from London	1 hr 23 mins	57 mins	58 mins	58 mins	58 mins	58 mins	1 hr 23 mins**
Frequency to/from London vs P2b	N/A	↑	↑	↑	↑	↑	N/A
Journey time to/from Leeds	1 hr 15 mins	1 hr 15 mins	1 hr 15 mins	56 mins	56 mins	56 mins	1 hr 15 mins
Frequency to/from Leeds vs P2b	N/A	-	-	↑	↑	↑	N/A

C.1.2 Nottingham

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Journey time to/from London	1 hr 38 mins	1 hr 20 mins	57 mins	57 mins	57 mins	57 mins	51 mins
Frequency to/from London vs P2b	N/A	↑	↑	↑	↑	↑	N/A

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Journey time to/from Birmingham	1 hr 14 mins	1 hr 14 mins	26 mins	26 mins	26 mins	26 mins	57 mins
Frequency to/from Birmingham vs P2b	N/A	↑	↑	↑	↑	↑	N/A
Journey time to/from Doncaster	1 hr 28 mins	1 hr 28 mins	1 hr 28 mins	1 hr 28 mins	1 hr 28 mins	23 mins	1 hr 28 mins
Frequency to/from Doncaster vs P2b	N/A	-	-	-	-	↑	N/A
Journey time to/from Leeds	1 hr 43 mins	1 hr 43 mins	1 hr 43 mins	1 hr 43 mins	50 mins	38 mins	51 mins
Frequency to/from Leeds vs P2b	N/A	-	-	-	↑	↑	N/A
Journey time to/from York	1 hr 54 mins	1 hr 54 mins	1 hr 54 mins	1 hr 54 mins	1 hr 54 mins	34 mins	1 hr 54 mins
Frequency to/from York vs P2b	N/A	-	-	-	-	↑	N/A
Journey time to/from Newcastle	3 hrs 5 mins	3 hrs 5 mins	3 hrs 5 mins	3 hrs 5 mins	3 hrs 5 mins	1 hr 24 mins	2 hrs 15 mins
Frequency to/from Newcastle vs P2b	N/A	-	-	-	-	↑	N/A

C.1.3 Sheffield

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Journey time to/from London	1 hr 59 mins	1 hr 26 mins	1 hr 27 mins	1 hr 27 mins	1 hr 27 mins	1 hr 27 mins	1 hr 27 mins
Frequency to/from London vs P2b	N/A	-	-	-	-	-	N/A
Journey time to/from Leeds	39 mins	39 mins	39 mins	28 mins	27 mins	30 mins	24 mins
Frequency to/from Leeds vs P2b	N/A	🡻	🡻	-	🡻	🡻	N/A

C.1.4 Leeds

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Journey time to/from London	2 hrs (2 hrs 13 mins in Dec 19)	1 hr 53 mins	1 hr 53 mins	1 hr 53 mins	1 hr 32 mins	1 hr 37 mins	1 hr 21 mins*
Frequency to/from London vs P2b	N/A	🡻	🡻	🡹	-	🡹	N/A
Journey time to/from Birmingham	1 hr 57 mins	1 hr 57 mins	1 hr 57 mins	1hr 26 mins	1 hr 1 min	1 hr 6 mins	49 mins*

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Frequency to/from Birmingham vs P2b	N/A	↓	↓	↓	-	□	N/A
Journey time to/from Nottingham	1 hr 43 mins	1 hr 43 mins	1 hr 43 mins	1 hr 43 mins	50 mins	38 mins	1 hr 43 mins
Frequency to/from Nottingham vs P2b	N/A	-	-	-	↑	↑	N/A
Journey time to/from EMP	2 hrs 20 mins	2 hrs 20 mins	2 hrs 20 mins	1 hr 13 mins	47 mins	49 mins	1 hr 12 mins
Frequency to/from EMP vs P2b	N/A	-	-	↑	↑	↑	N/A
Journey time to/from Derby	1 hr 15 mins	1 hr 15 mins	1 hr 15 mins	56 mins	56 mins	59 mins	1 hr 15 mins
Frequency to/from Derby vs P2b	N/A	-	-	↑	↑	↑	N/A
Journey time to/from Sheffield	39 mins	39 mins	39 mins	28 mins	27 mins	30 mins	27 mins
Frequency to/from Sheffield vs P2b	N/A	↓	↓	-	□	□	N/A
Journey time to/from Leicester	1 hr 55 mins	1 hr 55 mins	1 hr 55 mins	around 1hr 20 mins	around 1 hr 20 mins	around 1h 20 mins	1 hr 28 mins
Frequency to/from Leicester vs P2b	N/A	-	-	↑	↑	↑	N/A

C.1.5 York

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Journey time to/from London	1 hr 46 mins (1 hr 50 mins in Dec 19)	1 hr 38 mins	1 hr 38 mins	1 hr 38 mins	1 hr 38 mins	1 hr 33 mins	1 hr 24 mins
Frequency to/from London vs P2b	N/A	↓	↓	↓	↓	↓	N/A
Journey time to/from Nottingham	1 hr 54 mins	1 hr 54 mins	1 hr 54 mins	1 hr 54 mins	1 hr 54 mins	34 mins	1 hr 54 mins
Frequency to/from Nottingham vs P2b	N/A	-	-	-	-	↑	N/A

C.1.6 Newcastle

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Journey time to/from London	2 hrs 34 min (2 hrs 48 mins in Dec 19)	2 hrs 25 mins	2 hrs 25 mins	2 hrs 25 mins	2 hrs 25 mins	2 hrs 20 mins	2 hrs 17 mins
Frequency to/from London vs P2b	N/A	-	-	-	-	↓	N/A
Journey time to/from Birmingham	3 hrs 14 mins	3 hrs 14 mins	3 hrs 14 mins	3 hrs 14 mins	2 hrs 11 mins	1 hr 52 mins	1 hr 57 mins
Frequency to/from	N/A	□	□	□	□	□	N/A

	HS2 Phase 2a (Do-Min)	Upgrades Only	First Phase to Sheffield	First Phase to Leeds	Eastern Leg: Erewash	Eastern Leg: Newark	HS2 Phase 2b
Birmingham vs P2b							
Journey time to/from Nottingham	3 hrs 5 mins	3 hrs 5 mins	3 hrs 5 mins	3 hrs 5 mins	3 hrs 5 mins	1 hr 24 mins	3 hrs 5 mins
Frequency to/from Nottingham vs P2b	N/A	-	-	-	-	↑	N/A

D. Construction Disruption

At this stage of development (as is typical at pre-GRIP), no detailed construction programme has been developed as part of this study. The following high-level summary describes the types of issues each major intervention may involve.

For each intervention we have set out an approximate and first order estimate of the duration of the disruption required for each construction activity. Some of these activities could potentially be undertaken under the same engineering possessions, so it is not possible to sum the total number of days to understand the total impact.

The environmental impact of these interventions will be primarily limited to existing railway corridors. For new railway routes we have attempted to avoid selecting alignments through important features. We have also considered the impact of flooding on construction and the subsequent operation of the railway regardless of whether the route is adjacent to an existing corridor or entirely new.

D.1 East Coast Main Line Upgrade (See Figure 2)

D.1.1 Welwyn Viaduct Area (refer to 3.2.4.2)

- Construction Disruption. We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption, Medium Disruption and Minimum Disruption**

  Core Option. No construction required, signalling solution only ETCS.

  Performance Package. Welwyn North 4 track extension.

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
CPO property and land SE of London Road bridge		-
Construct site compound off Robbery Bottom Lane utilising the existing NR access track		4 Weeks
Clear proposed rail alignment from tunnel portal to Heath Road		12 Weeks
Construct a new viaduct over Robbery Bottom Lane to the east of the existing viaduct		26 Weeks
Construct a new over-bridge south of London Road bridge with a diversion route in place during construction		26 Weeks
Construct a new twin span over-bridge for Heath Road with a diversion route in place during construction		26 Weeks
Undertake earthworks (cutting up to 12m deep and embankment up to 8m high)		26 Weeks
Divert the existing bridleway path east of its existing position clear of the new cutting off London Road		8 Weeks
Widen existing under-bridge (Bridge Road) to accommodate the new alignment		26 Weeks
Widen existing embankment west from Heath Road to 24.5 MP		12 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Excavate new track bed, install drainage and bottom ballast and OLE masts		6 weeks
Install plain-line track and concrete sleepers on new section of the new alignment including OLE		4 Weeks
Install S&C, OLE wiring and associated signalling system including test and commission OLE, track and signalling system. Use Hartford Loop as a potential diversion route.		9 Day Blockade
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound, install new fencing and make good		6 Weeks

Performance Plus Package. Welwyn Light Scheme.

- **Note: this option involves tunnelling at the side of an existing tunnel, which we would normally consider to be high risk**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Close Welwyn North Station with a rail replacement bus service and construct access points and construction compounds in the west and east station car parks		4 Weeks
Clear rail corridor to existing tunnel portal		2 Weeks
Construct an access road from the A1000 Hertford Road existing roundabout		2 Weeks
Construct laydown area and clear area between existing tunnels and build TBM		6 Weeks
Install monitoring equipment within the existing tunnels (possession working required) – tunnelling at the side of the existing tunnels is high risk!		8 Weeks
Complete the west tunnel towards Welwyn North Station using a TBM (assume 15m per day) and transport back to laydown area via Station Road/Hertford Road		8 Weeks
Complete the east tunnel towards Welwyn North Station using a TBM (assume 15m per day) and transport back to laydown area via Station Road/Hertford Road		8 Weeks
Construct temporary haul road above existing North tunnels to recover the TBM to bring back to the laydown area		8 Weeks
Complete the west tunnel towards Knebworth Station using a TBM (assume 15m per day) and transport back via the temporary haul road to laydown area		10 Weeks
Complete the east tunnel towards Knebworth Station using a TBM and transport back via the temporary haul road to laydown area		10 Weeks
Dismantled the TBM and remove from site		4 Weeks
Construct a new viaduct over Robbery Bottom Lane to the east of the existing viaduct (undertaken at the same time as the tunnelling)		26 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Construct a new bridge for Heath Road north of existing and demolish old bridge (undertaken at the same time as the tunnelling)		26 Weeks
Excavate new track bed, install drainage and bottom ballast		6 weeks
Install plain-line track and concrete sleepers from north of Digswell Viaduct trough the new tunnels to Woolmer Green Junction		8 Weeks
Install S&C and associated signalling system		2no. Possessions 2 Weeks
Rebuild Welwyn North Station with two outside single face platforms including a footbridge, lifts and new station building (undertaken at the same time as the tunnelling)		26 Weeks
Test and commission new station, track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove haul roads and laydown area, install new fencing and make good		6 Weeks

D.1.2 Huntingdon – Woodwalton (refer to 3.2.4.3)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption,** **Medium Disruption and** **Minimum Disruption**

  Core Option. No construction required.

  Performance Package and Performance Plus Package. Various levels of four tracking between Huntingdon and Woodwalton (full four tracking is assumed below).

- **Assume all under and overbridges are clear for 4no. tracks.**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Clear rail corridor on the east side from Huntingdon North Junction to Woodwalton Junction total length 6m 23ch		12 Weeks
Review existing access points along the affected route and upgrade, if necessary		2 Weeks
Excavate new track bed, install drainage and bottom ballast (assume 3no. work sites with trains running)		10 Weeks
Install plain-line track and concrete sleepers		3no. Possessions 3 Weeks
Remove S&C and install associated signalling system		2no. Possessions 2 Weeks
Assume that the existing OLE is not affected and a single track OLE cantilever is installed for the new track		3no. Possessions 3 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Wire the new track, test and commission new track and signalling system layout and hand back and open to traffic		4 Day Blockade
Make good any works to access points		2 weeks

D.1.3 Grantham Area (refer to 3.2.4.4)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption, Medium Disruption and Minimum Disruption**

  Core Option. No construction required.

  Performance Package. Additional line through the station.

  Performance Plus Package. As per the Performance Package.

- **Assume that existing track is in a good condition and suitable for a higher speed**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Construct new access point from High Dike B6043 to existing Highdyke Junction		2 Weeks
Install new OLE portals		6no. Possessions 6 Weeks
Install new S&C for a re-modelled Highdyke junction and utilise the existing access point from Springfield Road to install new S&C for a re-modelled Grantham South Junction, modify the signalling system to suit the new layouts. Test and commission new junction layouts and signalling system then hand back the junctions and open to traffic		5 Day Blockade

D.1.4 Newark Flat Crossing (refer to 3.2.4.5)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption, Medium Disruption and Minimum Disruption**

  Core Option. Grade separation of the flat junction, and an at grade chord from the Lincoln line to the ECML up line.

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Create a temporary access road via the widened north bound verge over the existing railway bridge to provide construction access between the A46 and the existing Nottingham to Lincoln line		6 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Create a temporary south bound access road under the A46 viaduct and merge into the south bound carriageway		6 Weeks
Construct a compound and laydown area between the A46 and the existing Nottingham to Lincoln Line		4 Weeks
Create a temporary access north of the River Trent from Quibell's Lane adjacent to Crankley Point LC		4 Weeks
Construct an offline viaduct south of the River Trent in the space between the A46 and the existing Nottingham to Lincoln Line		26 weeks
Construct an1no. 80m span steel warren truss over the River Trent weir basin		26 Weeks
Construct 2no. bridge spans over the ECML and Newark Chord Line		26 Weeks
Construct embankment from Newark Line to new viaduct		12 Weeks
Construct viaduct from the Newark Chord Line to the existing culvert that is to be widened to the south		20 Weeks
Install plain-line track and concrete sleepers, install new S&C on Nottingham to Lincoln Line at both ends		5 Day Blockade
Test and commission new junction layout and signalling system		2no. Possessions 2 Weeks
Recover redundant track and diamond form ECML		2no. Possessions 2 Weeks
Remove haul roads and laydown area, install new fencing and make good		4 Weeks

Performance Package. Newark North Gate is reconfigured to allow to separate down direction stopping and through services

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Utilise the existing access point off Northern Road and construct site compound		4 Weeks
Build up S&C adjacent to existing track and sidings		4 Weeks
Install OLE stanchions in the new locations		4 Weeks
Close station and arrange rail replacement bus service		-
Recover trackwork and excavate for concrete foundation to platform riser wall modification. Extend platform 2 to the north and install new S&C with associated signalling alterations.		5 Day Blockade
Excavate new track bed, install drainage and bottom ballast and install new track and sleepers to new alignment		5 Day Blockade
Test and commission new junction layouts and signalling system		2no. Possessions 2 Weeks
Hand back the junctions and open to traffic		2no. Possessions 2 Weeks
Remove site compound and make good		2 Weeks

Performance Plus Package. As per the Performance Package.

D.1.5 Doncaster Area (refer to 3.2.4.6)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption, Medium Disruption and Minimum Disruption**

  Core Option. South Kirby and Ferrybridge freight diversion, and limited Doncaster remodelling.

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
South Kirby		
Establish site compound off Minsthorpe Lane and clear site		4 Weeks
Close Minsthorpe Road at the railway bridge and implement a diversion via South Elmsall		-
Construct a new bridge to the northside of the existing for a single track		20 Weeks
De-vegetation of the proposed alignment (1.8km)		8 Weeks
Modify the existing footbridge from Beamount Avenue		4 Weeks
Install two new junctions		2no. Possessions 2 Weeks
Install twin track cantilever OLE supports to DOWN & UP line for approximately 300m and rewire and remove existing stanchions		2no. Possessions 2 Weeks
Excavate new track bed, install drainage and bottom ballast and install new track and sleepers to new alignment		12 Weeks
Test and commission new junction layouts and signalling system		2no. Possessions 2 Weeks
Hand back the junctions and open to traffic		2no. Possessions 2 Weeks
Remove site compound and make good including new access track to the existing sub-station		4 Weeks
Doncaster Station		
Establish compound next to sidings to the west of the station		4 Weeks
Modify the existing headspans to accommodate a new wire layout		1no. Possessions 1 Weeks
Install 2no. crossovers to Platform 3		6no. Possessions 6 Weeks
Install new OLE support structures		2 Weeks
Signal modifications to clear new track alignment and remodel the south approach junction		2 Day Blockade
Test and commission new junction layouts and signalling system		2no. Possessions 2 Weeks
Hand back the junctions and open to traffic		1no. Possessions 1 Weeks
Remove site compound and make good		! Week

Performance Package. South Kirby and Ferrybridge freight diversion, and extensive Doncaster remodelling

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
South Kirby		
Establish site compound off Minsthorpe Lane and clear site		4 Weeks
Close Minsthorpe Road at the railway bridge and implement a diversion via South Elmsall		-
Construct a new bridge to the northside of the existing for a single track		20 Weeks
Devegation of the proposed alignment (1.8km)		8 Weeks
Modify the existing footbridge from Beamount Avenue		4 Weeks
Install two new junctions		2no. Possessions 2 Weeks
Install twin track cantilever OLE supports to DOWN & UP line for approximately 300m and rewire and remove existing stanchions		2no. Possessions 2 Weeks
Excavate new track bed, install drainage and bottom ballast and install new track and sleepers to new alignment		12 Weeks
Test and commission new junction layouts and signalling system		2no. Possessions 2 Weeks
Hand back the junctions and open to traffic		2no. Possessions 2 Weeks
Remove site compound and make good including new access track to the existing sub-station		4 Weeks
Doncaster Station (High Level Review Only)		
Establish compound next to sidings to the west of the station		4 Weeks
Modify the existing headspans to accommodate a new wire layout		2no. Possessions 2 Weeks
Install 2no. crossovers to Platform 3		6no. Possessions 6 Weeks
Install new OLE support structures		2 Weeks
Signal modifications to clear new track alignment and remodel the south approach junction		10 Day Blockade
Remove affected track sections and OLE structures to extend subway from platform 8 to new island platform 9/10		10 Day Blockade
Extend subway into platform 9/10 and backfill and make good		10 Day Blockade
Reinstate affected track to platform 8 and G1		10 Day Blockade
Construct new island platform with stairs and lift to subway		10 Day Blockade
Install platform 9 and 10 track		10 Day Blockade
Test and commission new junction layouts and signalling system		2no. Possessions 2 Weeks
Hand back the junctions and open to traffic		1no. Possessions 1 Weeks
Remove site compound and make good		4 Weeks

Performance Plus Package. As per the Performance Package.

D.1.6 York-Skelton 3rd line (refer to 3.2.4.7)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

  Core Option. North station throat layout is reconfigured to provide additional parallel moves by provision of an additional line.

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Utilise the existing access point off Aldborough Way and Waterend Road		-
Modify affected OLE structures		3no. Possessions 6 Weeks
Rebuild the redundant span over Leeman Road (North)		8 Weeks
Excavate new track bed, install drainage and bottom ballast along the redundant track bed		6 Weeks
Install new single-track cantilever structure for OLE		6 Weeks
Install new UP track and sleepers to new alignment (1Km)		3 Weeks
Undertake associated signalling alterations.		1 Week
Relay tie-ins at each end		1no. Possessions 1 Weeks
Install crossover DOWN track to track 3 and a plain line tie in		1no. Possessions 1 Weeks
OLE adjustments and signal amendments		1no. Possessions 1 Weeks
Modify York Yard North sidings track adjacent to main line only		2no. Possessions 2 Weeks
Remodel Skelton Junction and twin track the Harrogate Line for approximately 300m and associated signalling and OLE amendments		6no. Possessions 12 Weeks
Railway Museum line and 3rd line installation in final position		6no. Possessions 12 Weeks
Re-modelling of track off platforms 9, 10 and 11 with associated OLE and signalling amendments		6no. Possessions 12 Weeks
Test and commission new junction layouts and signalling system		2no. Possessions 2 Weeks
Hand back the junctions and open to traffic		2no. Possessions 2 Weeks
Remove site compound and make good		2 Weeks

Performance Package. As per the Core Option.

Performance Plus Package. As per the Core Option.

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D.1.7 Darlington Station (refer to 3.2.4.8)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

  Core Option. A scheme to reduce the number of crossing moves at Darlington is required.

  – **This work will be undertaken as the major station upgrade and the constructability will be assessed during the design.**

  Performance Package. As per the Core Option

  Performance Plus Package. As per the Core Option.

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D.2 Midland Main Line Upgrades (See Figure 4)

D.2.1 Wilnecote – Stenson Jn (refer to 3.3.4.1)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

- **Note: Electrifcation not included in the current construction disruption tables**
- **Wilnecote Station to be relocated north of Watling Street to make room for passing loops**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Create a new access from Watling Street via the old goods yard entrance and deveg and establish a site compound		10 Weeks
Construct 2no. new 3.5m wide platforms 100m long with space for two passing loops		20 Weeks
Install passenger footbridge with stairs and lifts between platforms and construct new station car park		26 Weeks
Excavate new loop track beds, install drainage and bottom ballast		8 Weeks
Install plain-line track and concrete sleepers		2no. Possessions 2 Weeks
Install new S&C on the main line for the loops with associated signalling alterations		2no. Possessions 2 Weeks
Test and commission new station, track and signalling system		2no. Possessions 2 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Hand back and open to traffic		2no. Possessions 2 Weeks
Recover the old station infrastructure		4 Weeks
Remove site compound and laydown area, install new fencing and make good		4 Weeks

- **Commence 4 track section after Syerscote Lane (OB62) and clear of FTN mast**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Clear rail corridor on the west and east sides to Stenson Junction total length 17m 30ch		26 Weeks
Widen embankment and cuttings including farm access bridges along the whole route		52 Weeks
Replace substandard overbridges at Main Road (OB58) and Willow Bottom Lane (OB57)		26 Weeks
Incorporate Elford Loop into the 4-track section		8 Weeks
Three span arch UB54 over A513, Couplands(Oakley) Farm access UB49 and three span arch UB 47 to be widened to accommodate 4 tracks		26 Weeks
Leeks Cattle Creep UB46 to be widened to accommodate 4 tracks		26 Weeks
Construct temporary haul road from the A513 to access the River Tame / Trent viaduct		10 Weeks
Construct compound and laydown area close to the river crossing		4 Weeks
Construct a new twin track river crossing viaduct adjacent to the existing viaduct and relocate a footbridge impacted by the works		52 Weeks
Rebuild Catholme Lane OB44 and widen Dunstall Cattle Creep UB38, Culvert UB37A, Wards Cattle Creep UB 36 and Culverts 35A +B		26 Weeks
Rebuild Main Street B5018 OB35 with an implemented diversion route		26 Weeks
Re-modelled Burton-on-Trent Station with new slow single face platforms north of Borough Road bridge with associated passenger footbridge and lifts		52 Weeks
Existing pipe bridge to be relocated or installed as a UTX		26 Weeks
Claymills level crossing (Meadow Lane) to be closed and replaced with an offline overbridge		26 Weeks
Culvert 25A to be widened and Mill Stream Lane UWC to be closed and footbridge to be demolished and replaced		26 Weeks
River Fleam UB24, River Dove UB22, Bullocks Cattle UB21 and Flood Arches UB20 all to be widened to accommodate 4 tracks		26 Weeks
Rebuild Hargate Road OB19 currently used as access to CEMEX Willington Quarry		26 Weeks
Hargate Brook Culvert UB18, Hibbets Cattle Creep UB17 and Eggington Brook culvert UB16 all to be widened		26 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Construct new footbridge south of Willington Station		26 Weeks
Willington Station pedestrian subway, Repton Road UB15, UB14C, Twyford Road UB14 all require widening including embankment works		26 Weeks
Construct a new chord from the Castle Donington Line to Uttoxeter Line on an earth embankment including the construction of 2no. underbridges over the Burton Line, Trent & Mersey Canal and Findern Lane		52 Weeks
Buckford Lane OB13 to be closed and replaced with a footbridge. A new diversion route approximately 1Km to be constructed including a new twin span bridge over the Burton Line and Trent & Mersey Canal		26 Weeks
Construct a RC flyover box over the Burton Line with reinforced earth approach and exit ramps to carry the chord over towards Castle Donington		26 Weeks
Excavate new track beds (17m 30ch), install drainage and bottom ballast		52 Weeks
Install plain-line track and concrete sleepers (17m 30ch)		52 Weeks
Install new S&C on the main line for the new track with associated signalling alterations		2no. Possessions 2 Weeks
Test and commission track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area, install new fencing and make good		4 Weeks

D.2.2 Trent Junction [Trent East Junction Grade Separation] (refer to 3.3.4.2)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

- **Note: Electrifcation not included in the current construction disruption tables**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Use Trent Lane for site access and construct passing laybys		4 Weeks
Construct site compound and laydown area north of Cranfleet Farm		4 Weeks
Divert Trent Lane to provide space for realigned embankment		12 Weeks
Utilise Trent Cottages lane for access between tracks		-
Widen embankment opposite Ludford Close		12 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Excavate new high-level track beds, install drainage and bottom ballast		4 Day Blockade
Slew high-level lines onto widened embankment to create space to construct RC flyover box		4 Day Blockade
Construct RC Flyover box over main line to Nottingham		8 Weeks
Install a RRAP to access the triangle to construct the single lane viaduct		2no. Possessions 2 Weeks
Construct a temporary ramp down from RRAP into the triangle		4 Weeks
Construct ramp and single lane viaduct		26 weeks
Construct the reinforced earth 350m long ramp down from the box		26 weeks
Install ballast sleepers and track over the viaduct box and ramp		4 Weeks
Install S&C at Sheet Stores junction with associated signalling alterations		4 Day Blockade
Remodel Sheet Stores junction with embankment widening		4 Day Blockade
Test and commission new track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area, install new fencing and make good		4 Weeks

D.2.3 Nottingham Station (refer to 3.3.4.3)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

- **We have assumed that the platform works would be selected, if only one scheme was required**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish site compound north east of Nottingham Station in NR compound off Station Street		4 Weeks
Install new signal post for Platform 4 & 3C starter signals		6 Weeks
Install new track between platform 3 and 5 and install new buffer stop to platform 3 and new S&C and construct new platform edge to create Platform 3C		4 Day Blockade
Test and commission new track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area and make good		2 Weeks

D.3 First Phase to Sheffield infrastructure package (See Figure 8)

D.3.1 East Midlands Parkway HS2 connection (Current slow lines) (refer to 4.4.2)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

Key: Major Disruption, Medium Disruption and Minimum Disruption

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish site compound off Kingston Lane/Kegworth Road		4 Weeks
Establish a satellite compound to the east of the railway via Kegworth Lane		4 Weeks
Construct west wall of RC flyover box on the Midland Main Line (MML) similar to Bletchley Flyover and west side earthworks		12 Weeks
Widen & re-deck bridge over Kegworth Road		20 Weeks
Construct RC culverts over Kingston Brook		12 Weeks
Construct an embankment for the slow lines and bridge over Kegworth Road adjacent to existing underbridge		20 weeks
Slew all 4no. tracks west and associated signalling amendments		5no. Possessions 10 Weeks
Construct east wall to RC box and north elevated reinforced earth ramp		20 weeks
Construct RC culverts over Kingston Brook		16 Weeks
Protect Pylon with RC retaining wall		4 Weeks
Install ballast sleepers and track over the flyover box and ramp		2 Weeks
Tie into HS2 viaduct		-
Remodel and extend East Midlands Parkway Station (EMP) with associated signalling alterations		2no. Possessions 2 Weeks
Remodel junction ladder south of EMP		4 Day Blockade
Remodel junction ladder north of EMP		4 Day Blockade
Test and commission new track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compounds, install new fencing and make good		4 Weeks

D.3.2 Trent Junction (Trent East Junction Grade Separation and Sheet Stores Junction Line Speed Improvement) (refer to 4.4.3)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

Key: **Major Disruption, Medium Disruption and Minimum Disruption**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Use Trent Lane for site access and construct passing laybys		4 Weeks
Construct site compound and laydown area north of Cranfleet Farm		4 Weeks
Divert Trent Lane to provide space for realigned embankment		12 Weeks
Utilise Trent Cottages lane for access between tracks		-
Widen embankment opposite Ludford Close		12 Weeks
Excavate new high-level track beds, install drainage and bottom ballast		4 Day Blockade
Slew high-level lines onto widened embankment to create space to construct RC flyover box		4 Day Blockade
Construct RC Flyover box over main line to Nottingham		8 Weeks
Install a RRAP to access the triangle to construct the single lane viaduct		2no. Possessions 2 Weeks
Construct a temporary ramp down from RRAP into the triangle		4 Weeks
Construct ramp and single lane viaduct		26 weeks
Construct the reinforced earth 350m long ramp down from the box		26 weeks
Install ballast sleepers and track over the viaduct,box and ramp		4 Weeks
Install S&C at Sheet Stores junction with associated signalling alterations		4 Day Blockade
Remodel Sheet Stores junction with embankment widening		4 Day Blockade
Test and commission new track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area, install new fencing and make good		4 Weeks

D.3.3 Nottingham Station (refer to 4.4.4)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption, Medium Disruption and Minimum Disruption**

- **We have assumed that the platform works would be selected, if only one scheme was required**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish site compound north east of Nottingham Station in NR compound off Station Street		4 Weeks
Install new signal posts for Platform 4 & 3C starter signals		6 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Install new track between platform 3 and 5 and install new buffer stop to platform 3 and new S&C and construct new platform edge to create Platform 3C		4 Day Blockade
Test and commission new track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area and make good		2 Weeks

D.4 First Phase to Leeds infrastructure package (See Figure 10)

D.4.1 ECML – Leeds (Adwick Junction – Hunslet Junction) (refer to 5.4.1)

D.4.1.1 Adwick Junction

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

Key: **Major Disruption,** **Medium Disruption and** **Minimum Disruption**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish a site compound in land of Skellow Road		4 Weeks
Divert Old EA Beck to allow for embankment widening		12 Weeks
Extend existing culverts for Old Ea Beck and Mill Dike		20 weeks
Widened embankment for new rack alignment		12 weeks
Modify OLE structures to install new junction		6no. Possessions 6 Weeks
Install ballast sleepers and track over the new embankment		2 Weeks
Install new ladder junctions		2no. Possessions 2 Weeks
Swap tracks over to new position		2 Day Blockade
Test and commission new layout		2 Day Blockade
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound, install new fencing and make good		2 Weeks

D.4.1.2 South Kirby – Hare Park

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

- Fitzwilliam Station Area

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish a site compound in car park off Wentworth terrace		4 Weeks
Establish a site compound off Holgate Avenue		4 Weeks
Relocate Fitzwilliam Station south of existing		26 weeks
Construct new platforms to slow line		20 Weeks
Construct new footbridge and lifts		20 Weeks
Test and commission new station		2no. Possessions 2 Weeks
Demolish old platforms and footbridge		12 Weeks
Install ballast sleepers and track for fast lines north of existing		4 weeks
Install S&C with associated signalling alterations		2no. Possessions 2 Weeks
Test and commission new track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound, install new fencing and make good		2 Weeks

- Nostell Area

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish a site compound adjacent to existing bridge at Swine Lane		4 Weeks
Close Swine Lane and demolish existing bridge		12 weeks
Construct new bridge with longer span to accommodate 4 tracks		26 Weeks
Widened underbridge northwest of Swine Lane		26 Weeks
Undertake earthworks and install ballast, sleepers and track for new fast lines		20 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound, install new fencing and make good		2 Weeks

- Hare Park area

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
CPO existing properties and land		-
Establish a site compounds along the route		8 Weeks
Close Hare Park Lane and demolish existing bridge		8 Weeks
Construct new bridge with longer span to accommodate 4 tracks		26 Weeks
De-veg and clear new track alignment (5km)		52 Weeks
Construct new viaduct adjacent to Bombardier Depot over railway tracks and Doncaster Road (480m long)		52 Weeks
New bridge for Hell Lane over the new track alignment		26 Weeks
Construct Goosehill RC flyover box and ramps and close existing footbridges		26 Weeks
Divert existing railway through the RC flyover box		2no. Possessions 2 Weeks
Install track drainage, ballast sleepers and track (5km)		52 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compounds, install new fencing and make good		4 Weeks

D.4.1.3 Hare Park – Leeds

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

Key: **Major Disruption, Medium Disruption and Minimum Disruption**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Excavate new track beds, install drainage and bottom ballast (3km)		20 Weeks
Install ballast sleepers and track for fast lines (3km) to Altofts Junction		4 Weeks
Construct new chord line across Whitwood Golf course for freight including earthworks, access bridges and ballast & track		26 Weeks
Remodel Methley Junction and four tracks up to Woodklesford. Including embankment and underbridge widening (Barnsdale Road & Church Lane & Mulberry Bridge)		52 Weeks
Install footbridge for Station Road crossing and close to pedestrian traffic		20 weeks
Install S&C south of Woodlesford with associated signalling alterations		2 Day Blockade

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Excavate new track beds, install drainage and bottom ballast (3km)		20 Weeks
Excavate new track beds, install drainage and bottom ballast to M1 motorway bridge 2.5Km		20 weeks
Install ballast sleepers and track for fast lines (deliver materials by train)		6no. Possessions 6 Weeks
Install S&C north of Woodlesford with associated signalling alterations		2 Day Blockade
Excavate new track beds, install drainage and bottom ballast from M1 motorway bridge to Hunslet Junction 4.5Km		26 Weeks
Reconstruct the following overbridges: Pepper Road and Bezza Street		26 Weeks
Test and commission new track and signalling system		6no. Possessions 6 Weeks
Hand back and open to traffic		3no. Possessions 3 Weeks
Remove site compound, install new fencing and make good		2 Weeks

D.5 Alternative forms of the HS2 Eastern Leg Package

D.5.1 Variant A: Erewash alignment (See Figure 13)

D.5.1.1 Trent Junctions Area (refer to 6.4.2.1)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

Key: **Major Disruption, Medium Disruption and Minimum Disruption**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Use Trent Lane for site access and construct passing laybys		4 Weeks
Construct site compound and laydown area north of Cranfleet Farm		4 Weeks
Divert Trent Lane to provide space for realigned embankment		12 Weeks
Utilise Trent Cottages lane for access between tracks		-
Widen embankment opposite Ludford Close		12 Weeks
Excavate new high-level track beds, install drainage and bottom ballast		4 Day Blockade
Slew high-level lines onto widened embankment to create space to construct RC flyover box		4 Day Blockade
Construct RC Flyover box over main line to Nottingham		8 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Install a RRAP to access the triangle to construct the single lane viaduct		2no. Possessions 2 Weeks
Construct a temporary ramp down from RRAP into the triangle		4 Weeks
Construct ramp and single lane viaduct		26 weeks
Construct the reinforced earth 350m long ramp down from the box		26 weeks
Install ballast sleepers and track over the viaduct,box and ramp		4 Weeks
Install S&C at Sheet Stores junction with associated signalling alterations		4 Day Blockade
Remodel Sheet Stores junction with embankment widening		4 Day Blockade
Test and commission new track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area, install new fencing and make good		4 Weeks

D.5.1.2 Nottingham Station (refer to 6.4.2.2)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

- **We have assumed that the platform works would be selected, if only one scheme was required**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish site compound north east of Nottingham Station in NR compound off Station Street		4 Weeks
Install new signal posts for Platform 4 & 3C starter signals		6 Weeks
Install new track between platform 3 and 5 and install new buffer stop to platform 3 and new S&C and construct new platform edge to create Platform 3C		4 Day Blockade
Test and commission new track and signalling system		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area and make good		2 Weeks

D.5.1.3 Erewash Valley route upgrade and electrification (refer to 6.4.2.3)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

- Sandiarce to Stanton Gate Curves

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish a site compound off Station Road		4 Weeks
Set up diversion route for Station along Brian Clough Way		6 Weeks
Demolish Station Road bridge and construct a new bridge on existing alignment		26 Weeks
Establish a site compound at the end of Sandiacre Road		4 Weeks
Construct piped embankment across flood plain to River Erewash		26 Weeks
Construct a new footbridge over the new twin track railway		12 Weeks
Build a new four track bridge over the River Erewash		26 Weeks
De-veg abandoned sidings and clear site		12 Weeks
Install ballast sleepers and track over the new embankment and through old sidings and tie-in to existing track alignment with signalling alternations		4 Day Blockade
Demolish and replace Stanton Gate bridge		26 Weeks
Test and commission new track layout and associated signalling		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compounds, install new fencing and make good		4 Weeks

- Cotmanhay Curve

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Utilise existing railway for access to the site		-
Infill existing fish pond and widen embankment		12 Weeks
Construct a new bridge over the Erewash Canal		4 Day Blockade
Install ballast sleepers and track over the new embankment (1km)		3 Weeks
Tie-in with associated signalling alterations		1no. Possessions 1 Week
Test and commission new track layout		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Install new fencing and make good		3 Weeks

- Codnorpark Curve

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish a site compound on land south of Station Road		4 Weeks
Assess Station Road bridge for carrying construction traffic		4 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Build new bridge over Cromford Canal to accommodate the twin track alignment		20 Weeks
Construct a new footbridge at the end of Station Road to span over the new twin track		12 Weeks
Install ballast sleepers and track for new alignment (1km) including tie-in with associated signalling alterations		4 Day Blockade
Test and commission new track layout		2no. Possessions 2 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound, install new fencing and make good		4 weeks

- Pye Bridge Curve

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish a site compound on land north of Main Road		4 Weeks
Widen the existing Station Road bridge no. 56		26 Weeks
Construct a new embankment/cutting west of the existing to accommodate new track alignment 1.5km long incorporating a RC box for public footpath		20 Weeks
Install ballast sleepers and track over the new embankment/cutting		2 Weeks
Install S&C with associated signalling alterations		4no. Possessions 4 Weeks
Establish site compound for tunnel works off Clover Nook Road		4 Weeks
Undertake de-veg and site clearance		12 weeks
Re-open Alfreton Tunnel (East) after undertaking repairs		12 weeks
Install ballast sleepers and track over the new formation and through tunnel		8 Weeks
Test and commission new track layout		4no. Possessions 4 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound, install new fencing and make good		4 Weeks

- Clay Cross Curve

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish a site compound on land northwest of Market Street A6175		4 Weeks
Close Road and establish a diversion route via Pilsley Road		-
Demolish and construct a new Market Street bridge		26 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Divert River Rother east of new embankment		20 Weeks
Construct a new piped embankment east of the existing to accommodate new track alignment		26 Weeks
Install ballast sleepers and track over the new embankment		4 Weeks
Install S&C with associated signalling alterations		4no. Possessions 4 Weeks
Test and commission new track layout		4no. Possessions 4 Weeks
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound, install new fencing and make good		4 Weeks

D.5.1.4 Chesterfield to Masborough Jn upgrade and electrification (refer to 6.4.2.4)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: Major Disruption, Medium Disruption and Minimum Disruption

- Chesterfield Station enhancement

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish site compound and laydown area in park adjacent to Crow lane		4 Weeks
Relay Chesterfield North and Tapton Junction crossover ladders		4 Day Blockade
Close the UP and DOWN Barrow Hill lines – run as a twin-track railway between Chesterfield North and South Junctions		-
Profile cutting slope on north east to provide additional space to slew the track		Lines closed to train movements 12 Weeks
Widened embankment north of River Rother and install RC concrete retaining wall		Lines closed to train movements 12 Weeks
Demolish existing east bridge with temporary road closure of Crow Lane and diversion route down Piccadilly Road		Lines closed to train movements 6 Weeks
Construction a new 3 span bridge on new alignment		Lines closed to train movements 26 Weeks
Excavate and install subway extension to new platform 4		Lines closed to train movements 12 Weeks
Widened emabankment east of the rail corridor utilising RC Criblock retaining wall		Lines closed to train movements 20 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Construction new platform 4 3.5m wide and 240m long with lift & stairs access to subway		Lines closed to train movements 20 Weeks
Modify Platform 3 to new track alignment		Lines closed to train movements 20 Weeks
Relay track to new alignment		Lines closed to train movements 2 Weeks
Test and commission new track, platform 3 and platform 4		Lines closed to train movements 1 Week
Hand back and re-open the UP and DOWN Barrow Hill lines to traffic		Lines closed to train movements 1 Week
Remove site compound and laydown area, install new fencing and make good		4 Weeks

- Barrow Hill Area

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish site compound to rear of Whittington Industrial Estate off Station Road		4 Weeks
Modify abutment to UB adjacent to Anderson Close		12 Weeks
Install new bridge decks for additional tracks, excavate new track beds, install drainage and bottom ballast and remodel Barrow Hill connection and install new tracks and associated signalling		4 Day Blockade
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound, install new fencing and make good		2 Weeks

- Treeton and Masbourgh Area

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Upgarde existing freight loops		4no. Possessions 4 Weeks

D.5.1.5 HS2 Short M18 Link (to/from Leeds) (refer to 6.4.2.5)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption,** **Medium Disruption and** **Minimum Disruption**

  - **HS2 infrastructure**

D.5.2 Variant B: Newark alignment (see Figure 14)

D.5.2.1 Trent Junctions Area (refer to 6.4.3.1)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption, Medium Disruption and Minimum Disruption**

  – Refer to Section D.5.1.1

D.5.2.2 Nottingham Station (refer to 6.4.3.2)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption, Medium Disruption and Minimum Disruption**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Establish site compound north east of Nottingham Station in NR compound off Station Street		4 Weeks
Move the existing REB south west of its current location		8 Weeks
Install new pipe bridges and modify existing district heating scheme supply pipes		20 weeks
Phased reconstruction of the bridge spans over the Nottingham Canal		26 Weeks
Install new signal posts for Platform 4 & 3C starter signals		6 Weeks
Install new track between platform 3 and 5 and install new buffer stop to platform 3 and new S&C and construct new platform edge to create Platform 3C and demolish old platform 4 and merge into platform 5. Install platform 4 track		4 Day Blockade
Remodel east end tracks under London Road towards Eastcroft Depot with associated signalling alterations		4 Day Blockade
Extend island platform 5/6 to new alignment 400m long		20 Weeks
Test and commission new track and signalling system		4 Day Blockade
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area, install new fencing and make good		2 Weeks

D.5.2.3 Alignment between Nottingham and the ECML (refer to 6.4.3.3)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption, Medium Disruption and Minimum Disruption**

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Close the following level crossings: - Colwick Road LC - Victoria Road LC (Install ramped footbridge) - Stoke Lane LC (Install footbridge) Zulu's UWC (Install new highway bridge and access to Poplars Sports Pavilion) - Burton Joyce LC (Install ramped footbridge) - Chestnut Grove LC - Trent Lane LC (Install footbridge) - Criftin Farm UWC (Install footbridge) - Old Main Road LC (Install new highway bridge and road over the railway) - Lowdham LC (Install ramped footbridge) - Gonaston LC (Install an offline new highway bridge) - Thurgarton LC (Install an offline new highway bridge and ramped footbridge for passenger use) - Willow Lane LC - Railway LC (Install footbridge) - Crossing 500m south of Bleasby Station - Crossing 165m south of Bleasby Station - Bleasby LC (offline highway bridge with ramped footbridge for paasenger use) - Crossing 500m south of Gorsy Lane - Gorsy Lane LC - Crossing 260m south of Causeway Lane - Causeway Lane LC (Install an offline new highway bridge) - Crossing 300m north of Causeway lane - Fiskerton Station LC (offline highway bridge) - Rollaston LC (Install footbridge)		52 Weeks
Close Fiskerton Station and recover existing assets		12 weeks
Construct new twin track railway west of the existing on new formation with associated drainage works (5.5km)		52 Weeks
Modify Rollaston Station for new track alignment, new platforms with footbridge and lifts to access all platforms		26 Weeks
New cross-country alignment no longer impacts on the existing railway corridor		-

D.5.2.4 ECML Bypass and Junctions (refer to 6.4.3.4)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

Key: Major Disruption, Medium Disruption and Minimum Disruption

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
CPO the house adjacent to the crossing		-
Establish site compound off Norwell Lane in field south of the existing crossing		4 Weeks
Construct an overbridge with a ramped highway to replace the existing Cromwell Crossing		26 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Construct RC flyover box offline including down ramp		26 Weeks
Close Cromwell Crossing, recover equipment and fence off		2 Weeks
Construct an overbridge with a ramped highway to replace the existing Ossington Road Crossing		26 Weeks
Construct a 70m long RC box under the A1 – construct offline and slide under A1 during a weekend closure		2 Day Blockade
Re-construct Great North Road Bridge (Crow Park Bridge) with a wider span		26 weeks
Undertake de-veg and site clearance (6.75km)		26 Weeks
Excavate new track beds, install drainage and bottom ballast and OLE plus signalling structures (6.75km)		12 Weeks
Install ballast sleepers and track for the new alignment (6.75km) including OLE		6 Weeks
Tie in new alignment to ECML including testing and commissioning new track and signalling system		4 Day Blockade
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area, install new fencing and make good		2 Weeks
Establish site compound off Daneshill Road in field south of the existing crossing		4 Weeks
Construct an overbridge with a ramped highway to replace the existing Daneshill Road Crossing		26 Weeks
Construct RC flyover box offline including down ramp		26 Weeks
Close Daneshill Road Crossing, recover equipment and fence off		2 Weeks
Close Ranskill Crossing, recover equipment and fence off		2 Weeks
Re-construct Mattersey Road Bridge with a wider span		26 Weeks
Undertake de-veg and site clearance (3.25km)		16 weeks
Excavate new track beds, install drainage and bottom ballast and OLE plus signalling structures (3.25km)		8 weeks
Install ballast sleepers and track for the new alignment (3.25km) including OLE		4 Weeks
Tie in new alignment to ECML including testing and commissioning new track and signalling system		4 Day Blockade
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area, install new fencing and make good		2 Weeks
Establish site compound off Doncaster Road adjacent to the bridge		4 Weeks
Re-construct Doncaster Road Bridge with a wider span		26 weeks
Widen the existing railway corridor (1.2km)		20 Weeks

Construction Disruption	Major, Medium or Minimum Disruption	Construction Duration
Excavate new track beds, install drainage and bottom ballast and OLE plus signalling structures (1.2km)		8 weeks
Install ballast sleepers and track for the new alignment (1.2km) including OLE		4 Weeks
Move the existing freight line over to provide space including testing and commissioning new track and signalling system		2 Day Blockade
Hand back and open to traffic		2no. Possessions 2 Weeks
Remove site compound and laydown area, install new fencing and make good		2 Weeks

D.5.2.5 ECML – Leeds (Adwick Junction – Hunslet Junction) (refer to 6.4.3.5)

- Construction Disruption We have set out aspirations for offline construction opportunities where scope may exist, although it should be noted that this is an early stage of consideration and further detailed analysis would be required to identify construction risks and opportunities to a higher degree of confidence.

  Key: **Major Disruption,** **Medium Disruption and** **Minimum Disruption**

  – Refer to Section D.4.1

For interventions common to both refer to Section D.3.1

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