HS2 Strategic Alternatives

Final Report

Department for Transport

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ATKINS

Plan Design Enable

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Glossary of Terms

Abbreviation	Definition
AONB	Area of Outstanding Natural Beauty
APM	Association of Project Management
BCR	Benefit-Cost Ratio
CIOB	Chartered Institute of Building
DfT	Department for Transport
DM	Do Minimum
EAUC	Electrification Asset Usage Charge
ECML	East Coast Main Line
EPA	Estimated Population Annoyed
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
FZ	Flood Zone
GNER	Great North Eastern Railway
GRIP	Governance for Railway Investment Projects
HLOS	High Level Output Specification
HS2	High Speed 2
HSR	High Speed Rail
IEP	Intercity Express Programme
MML	Midland Main Line
NNR	National Nature Reserve
NPV	Net Present Value
NR	Network Rail
OB	Optimism Bias
OBR	Office for Budget Responsibility
OGC	Office of Government Commerce
ORR	Office of Rail Regulation
PFM	PLANET Framework Model
PLD	PLANET Long Distance
PVB	Present Value of Benefits
PVC	Present Value of Cost
RP2	Rail Package 2
RUS	Rail Utilisation Study
SAC	Special Area of Conservation
SFN	Strategic Freight Network
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TPH	Trains per hour
VfM	Value for Money
VTAC	Variable Track Access Charges
WCML	West Coast Main Line
WCRM	West Coast Route Modernisation
WEI	Wider Economic Impacts

1. Introduction

1.1. Purpose of this Report

This technical report describes the findings of a study undertaken by the Department for Transport (DfT) and Network Rail (NR), with technical support provided by Atkins, to provide additional evidence to support government's consideration of the investment case for High Speed 2 (HS2).

HS2 Ltd is currently planning HS2 to be delivered in two phases:

- Phase One – London-Birmingham
- Phase Two – extending the HS2 route north of Birmingham to serve Manchester and Leeds, to complete the HS2 "Full network" – also referred to as the "Y network".

Building on previous work and consultations, this study considered the extent to which capacity and connectivity upgrades to the conventional rail network – representing strategic alternatives to constructing HS2 - could meet the strategic objectives set for HS2. Consideration of alternative investment options is standard practice as guided by HM Treasury Green Book, and embodied in the DfT's guidance for assessing the case for investment in major transport projects.

It is not possible to make a complete like-for-like comparison with HS2; however the DfT has sought to establish as fair a comparison as is possible. Assessments of HS2 and its strategic alternatives have been undertaken against the same set of objectives, using the same tools and methodologies and - as far as is possible - across the same geographical areas.

For an upgrade package for the conventional rail network to be considered as a strategic alternative to HS2 it needs to meet the strategic objectives set by government for HS2. A strategic alternative is a set of upgrades to the conventional rail network that could: provide additional capacity and improved connectivity for the set of main centres that would directly benefit from HS2; and also provide benefit to those places from freed up capacity that would be created by HS2 on the conventional network.

1.2. HS2's Strategic Objectives

Government has identified two principal objectives for High Speed rail, as set out in the Strategic Case, published in October 2013[1], as follows:

- The **capacity** objective is to create sufficient capacity to provide for long term demand for rail travel and improve rail network resilience and reliability, ensuring that people and goods are able to make the journeys they want.
- The **connectivity** objective is to improve journey times, making travel quicker, easier, more punctual and more convenient for people and goods, including supporting end-to-end journeys with effective integration and interchange between transport modes and with good connections, including with major airports, for international travel.

These strategic objectives have guided the formulation of upgrade packages for the conventional rail network as strategic alternatives to HS2.

1.3. Overall Approach

The strategic alternative upgrade packages for the conventional rail network have been developed through a collaborative process between DfT and NR, supported by Atkins. The upgrade packages comprise a set of incremental capacity and connectivity improvements – termed interventions – focused on the three main north-south rail routes from London to the West and East Midlands and to the North and Scotland, as follows:

[1] The Strategic Case for HS2. October 2013

- The **West Coast Main Line (WCML)** from London Euston north to Birmingham and the north west of England;
- The **East Coast Main Line (ECML)** from London King's Cross north to the East Midlands and West Yorkshire; and
- The **Midland Main Line (MML)** from London St Pancras north to the East Midlands and South Yorkshire.

The packages have been developed in a structured and systematic manner taking into consideration current rail network improvements.

Five conventional rail upgrade packages have been developed to represent strategic alternatives to three different HS2 construction scenarios, as follows:

- **Package P1** – as a strategic alternative to providing the HS2 Phase One London-Birmingham route;
- **Packages YA and YB** – as strategic alternatives to providing the Phase One and Phase Two HS2 "full network"; and
- **Packages P2A and P2B** – as strategic alternatives to providing the HS2 Phase Two extension to Leeds and Manchester but with HS2 Phase One London-Birmingham in place.

NR has developed outline scheme concepts and supporting implementation costs for the required infrastructure at a very high level. Rail industry-standard approaches for estimating operating costs and passenger demand have been used to develop a set of costs and benefits that enable the likely scale and quantum of the contribution to achieving the HS2 strategic objectives to be estimated. The DfT's standard approach to transport infrastructure investment appraisal, which seeks to quantify costs and benefits, has been used, consistent with the approach employed by HS2 Ltd. However, cost estimates for the interventions making up the packages are preliminary and order of magnitude estimates only. Significant additional design development and feasibility work would be required to develop each upgrade package further and confirm the robustness of the figures. The cost estimates have not therefore been developed to the same level of design detail or been subject to the equivalent level of scrutiny as the designs and costs of the HS2 scheme being promoted by HS2 Ltd.

The study's findings provide additional evidence for government to use in considering the case for investment in HS2 and provide a level of detail sufficient in order to draw comparisons between investment in HS2 and investment in alternative enhancements to the existing rail network.

1.4. Previous Studies of Strategic Alternatives

Previous studies have been undertaken by the DfT since 2009 considering alternative investment approaches to HS2 to provide government with evidence to support decision-making. Following initial work which focused on alternatives to the original HS2 Phase One proposals, periodic updates have been undertaken in response to further developments of the HS2 proposal, and updates to the business case methodology supporting it. In each study the modelling and appraisal methodology has been consistent with the main HS2 appraisal.

This report can be read as a stand-alone document. However, it builds on previous HS2 alternatives studies and consultation responses, as follows:

- 'High Speed 2 Strategic Alternatives Study, Strategic Outline Case' (March 2010) which considered road and rail improvement alternatives to the High Speed Rail proposition between London and the West Midlands then being developed by HS2 Ltd. This study was undertaken by Atkins on behalf of the DfT. The study considered a range of rail packages as potential alternatives to HS2 Phase One, including options on the WCML and the Chiltern line. The analysis indicated that the best performing package in terms of value for money was "Rail Package 2" (RP2) focused on the WCML. Chiltern line and combined WCML and Chiltern line options were found to offer poor value for money;
- The 2010 study was updated by the DfT, with modelling and appraisal support by Atkins, in February 2011 to be consistent with the then latest assessment of the HS2 scheme and to also consider new rail

interventions and packages developed by the DfT (with some consultation with NR) as alternatives to the HS2 'Full network '; and

- 'High Speed 2 Strategic Alternatives Study- Update Following Consultation' (January 2012) which further updated the analysis of the rail-based strategic alternatives to HS2 to take account of feedback from the HS2 Phase One consultation process, as well as changes to the HS2 modelling methodology which had been updated to incorporate revised demand growth on the WCML following completion of the West Coast Route Modernisation (WCRM) programme and associated timetable changes. Modelling and appraisal work was undertaken by Atkins on behalf of the DfT. It also incorporated the findings of a review undertaken by NR (commissioned by DfT) of the strategic alternatives. The study examined only those packages identified from the earlier studies as likely to offer value for money as strategic alternatives to HS2 Phase One and the "Full network". For HS2 Phase One alternatives the study focused on RP2 (i.e. WCML) and variants of RP2 (including the testing and appraisal of proposals made by the 51M group as part of the HS2 consultation). Chiltern line options were not considered further based on the findings of the previous analyses. The RP2 package, taking into account consultation responses as a potential WCML strategic alternative to HS2 Phase One, has formed a key input to this latest study, as discussed further in Chapter 3.

The update process reported within this document has differed from the previous stages of work in two important respects:

- two alternative scenarios have been considered representing a future (a) with no HS2 scheme, and (b) with HS2 Phase One (from London to Birmingham only) in place; and
- changes to the HS2 modelling and appraisal methodology, including updated assumptions on schemes and services included in the Do-minimum[2] scenario (such as inclusion now in the Do-minimum of electrification of the MML and the introduction of the Intercity Express Programme – IEP - on the ECML which replaces all of the existing intercity trains). This has formed a new starting point from which alternative investment options have been developed.

1.5. Report Structure

The remainder of the report is structured as follows:

- Chapter 2 describes the overall approach adopted in developing upgrade packages that could deliver capacity increases and connectivity improvements that would contribute to the strategic objectives set for HS2;
- Chapter 3 describes the work undertaken by NR to define potential interventions on each of the three main north-south routes from London that could form a package of upgrades, and describes how these interventions have been combined to form five strategic alternative upgrade packages. This chapter draws upon Network Rail's report on 'Options for Potential Capacity and Connectivity Enhancements to the Existing Network' October 2013 which is included as Appendix A;
- Chapter 4 presents the five strategic alternative upgrade packages identifying the upgrade schemes that make up each package;
- Chapter 5 summarises the estimated costs of the strategic alternative upgrade packages; and
- Chapter 6 presents an analysis of the performance of each of the strategic alternative upgrade packages against the strategic objectives set for HS2, including NR's view on the deliverability of the upgrades.

[2] The 'Do-minimum' is defined in section 2.3.3.

2. Overall Approach to Development of Strategic Alternatives

This chapter describes the process by which strategic alternative upgrade packages for the conventional rail network have been developed. The outcome of this process was the development of five strategic alternative upgrade packages. Chapter 3 provides a detailed narrative of the construction of these packages and Chapter 4 presents each of the packages in detail.

2.1. Structured Approach to Upgrade Package Development

The approach to upgrade package development undertaken by the DfT and NR, supported by Atkins, involved a number of steps:

- Defining the objectives that an upgrade package for the conventional rail network is expected to achieve as a strategic alternative to investment in HS2 (section 2.2 below);
- Defining the scope of the upgrade packages, in terms of geographic scope and the scope of the interventions – i.e. the infrastructure schemes and related service improvements - that should be considered (section 2.3 below);
- Identifying route-based packages comprising a set of interventions for each of WCML, ECML and MML. Route-based packages were combined to create multi-route packages which could be considered as strategic alternatives to three different HS2 investment scenarios (section 2.4 below and described in detail in Chapter 3); and
- Analysis of the strategic alternative upgrade packages against the objectives set by government for HS2 using a set of metrics also employed to assess the strategic case for HS2 (Chapter 6).

Each stage is explained in more detail below.

2.2. Objectives for Strategic Alternative Upgrade Packages

An upgrade package comprises a set of infrastructure improvement projects - also termed interventions - to the conventional (i.e. non-high speed) rail network and corresponding changes to train services to benefit from the improved infrastructure. For an upgrade package for the conventional rail network to be considered as a strategic alternative to HS2 it needs to meet the strategic objectives set by government for HS2.

Government has identified two principal objectives:

- The **capacity** objective is to create sufficient capacity to provide for long term demand and improve network resilience and reliability, ensuring that people and goods are able to make the journeys they want; and
- The **connectivity** objective is to improve journey times, making travel quicker, easier, more punctual and more convenient for people and goods, including supporting end-to-end journeys with effective integration and interchange between transport modes and with good connections, including with major airports, for international travel.

Assessment of performance against these objectives drew on the approach taken by HS2. This considered performance for a range of journeys in the broad north-south corridor, including:

- Between London (and the south) and the cities and major centres of the Midlands, the North and Scotland;
- For commuters and other trips into city centres; and
- For regional and inter-regional travel, particularly Cross Country services north of Birmingham.

In terms of freight, the objective was to consider how future growth requirements might be accommodated.

HS2 Ltd has also considered a number of other factors in assessing options, both in terms of the benefits each option can achieve as well as wider impacts. These factors are described in Chapter 6.

2.3. Scope of the Upgrade Packages

2.3.1. Geographic Scope

The study examined alternatives to three possible HS2 scenarios:

- HS2 - Phase One only: London to Birmingham;
- HS2 - Phase One and Two, the "Full network", from London to Birmingham, Manchester and Leeds, with connections to the classic network in the North West and Yorkshire; and
- HS2 – Phase Two, from Birmingham to Manchester and Leeds, as an increment on Phase One (i.e. assuming Phase One is already constructed).

A strategic alternative is a set of upgrades to the conventional rail network that could: provide additional capacity and improved connectivity for the set of main centres that would directly benefit from HS2; and also provide benefit to those places from freed up capacity that would be created by HS2 on the conventional network.

Strategic alternatives to HS2 Phase One therefore focus on upgrades that increase capacity and connectivity between London and Birmingham and the north-west of England along the WCML corridor. This recognises that Phase One of HS2 not only provides faster journeys and increased capacity on the core HS2 network between London and Birmingham, but also to key destinations such as Manchester, Liverpool and Glasgow. A single package, denoted as Package P1, has been developed to represent a strategic alternative to HS2 Phase One, and is described in Chapter 4.

Strategic alternatives to HS2 Phases One and Two focus on upgrades that increase capacity and connectivity between London, Birmingham, Leeds and Manchester and other places served by HS2 services. Two packages, denoted as Package YA and YB have been developed to represent strategic alternatives to HS2 Phases One and Two, and are described in Chapter 4.

Alternatives to HS2 Phase Two, but assuming HS2 Phase One is in place, focus on upgrades that increase capacity and connectivity between Birmingham and Leeds/Manchester; though also considering whether London to Nottingham/Sheffield/Leeds could be served via HS2 Phase One or other (non-HS2) routes. Two packages, denoted as Package P2A and P2B have been developed to represent strategic alternatives to HS2 Phase Two assuming HS2 Phase One is in place, described in Chapter 4.

DfT and NR adopted an approach that the geographic scope of proposed interventions need not be limited by the geographic area where HS2 is planned to be built[3]. HS2 services would run beyond the HS2 network and help to deliver capacity and connectivity improvements across a much broader geographical area. As such the DfT concluded that the strategic alternative upgrade packages should have a similar broad scope. NR has proposed schemes north of Manchester on the WCML (the geographic limit of HS2) and north of Leeds/York (the geographic limit of HS2) on the ECML. It should be noted that some of these schemes could also enhance HS2 services and potentially be implemented in conjunction with HS2 to enhance the benefits of the HS2.

The geographic scope of potential interventions is therefore defined for each of the three routes, as follows:

- The **West Coast Main Line (WCML)** from London Euston north to Birmingham and the north west of England (including the Cross Country routes between Birmingham and Tamworth / Lichfield);

[3] This approach is consistent with that undertaken in earlier studies of strategic alternatives by the DfT which examined alternatives to Phase One of HS2 which included infrastructure schemes north of Birmingham to ensure that trains to Manchester could run faster and more frequently.

- The **East Coast Main Line (ECML)** from London King's Cross north to the East Midlands, West Yorkshire and beyond to the north-east of England (including the Cross Country routes between Leeds / Doncaster and Sheffield, and the routes between Nottingham and Grantham / Newark); and

- The **Midland Main Line (MML)** from London St Pancras north to the East Midlands and South Yorkshire (including the Cross Country routes between Tamworth / Lichfield and Nottingham/Sheffield).

HS2 would also provide additional capacity on the ECML and WCML (in particular) as existing intercity services are replaced by HS2 leaving residual capacity for other services. Therefore, measures relating to commuter capacity on lines around the major conurbations on routes potentially affected by HS2 were considered as within scope, for compatibility with the wider objectives of HS2 of increasing rail capacity for commuters.

The comparison between strategic alternatives packages and HS2 is not, therefore, directly like-for-like in terms of the geographic scope of the interventions considered. However, the interventions included in the strategic alternatives packages have been selected to meet the strategic objectives of increasing capacity and improving connectivity between the key centres that would be served by HS2, and therefore provide a fair comparison in considering the investment case for HS2.

2.3.2. Scope of Enhancement Interventions

The scope of potential enhancement interventions was confirmed by DfT to NR and Atkins. Potentially in scope were any enhancements to the existing conventional rail network infrastructure and to passenger and freight services within the relevant geographical areas (as defined above).

Potential enhancement options used a Do-minimum (comprising infrastructure enhancement schemes consistent with the HS2 Do-minimum and further defined below) as the starting point.

In scope were potential measures which achieve the following benefits:

- Improved interurban and long distance connectivity; and

- Improved rail capacity – for long distance, commuter and freight traffic.

Limited new sections of railway, including re-opened railway lines, have been considered as in scope where they deal with specific identified issues, such as by-passing network capacity constraints. In common with previous phases of this study and after confirmation with DfT, new railway for speeds of higher that 140 mph (225kph), or entirely new lengths of line connecting urban areas, were not considered.

2.3.3. Definition of the "Do-minimum"

The railway will evolve without either HS2 or the strategic alternative options being built. Trains services will change and some infrastructure schemes will be built irrespective of HS2. Defining these future changes has formed an important reference point for the study. This reference point is referred to as the "Do-minimum".

The Do-minimum is a representation of future rail network supply, demand and performance at 2026 and 2033 (the opening years for the respective two phases of HS2) based upon the schemes the DfT has previously advised HS2 Ltd should be assumed to progress.

The purpose of the Do-minimum is two-fold: it provides a basis for testing how the future network will perform against objectives based upon future growth in demand and schemes assumed to progress in the next few years, and therefore gives a starting point for identifying future constraints and issue, and the measures required to address these. It also provides a comparator (or baseline) for alternative investments and is a pre-requisite for standard economic appraisal approaches.

For this study, however, two Do-minimums have been defined to enable strategic alternatives to be defined for the three different HS2 scenarios defined above and to be compared against an appropriate Do-Minimum, as follows:

- Do-minimum 1 (DM1) assumes a set of schemes on the strategic network. This is the same Do-minimum as being employed by HS2 Ltd as a comparator to the case for investment in HS2; and
- Do-minimum 2 (DM2) is the same as DM1 but includes HS2 Phase One London-Birmingham and associated changes on the conventional network. This provides a starting point from which to develop strategic alternatives for HS2 Phase Two assuming Phase One is in place and provides the comparator for assessing the incremental impacts of these packages.

2.4. Package Development

The process by which strategic alternative upgrade packages were developed is described in detail in Chapter 3 and summarised below.

2.4.1. Development of Route-Based Packages

Potential interventions were identified and developed for each of ECML, WCML and MML by NR drawing upon knowledge of existing and future network constraints on a route section by route section basis. These constraints are set out in greater detail in the NR October 2013 report in Appendix A. NR – supported by DfT and Atkins – combined the interventions into route-specific packages representing Low, Medium and High capacity and connectivity outputs. The extent to which each of the Low, Medium and High route-based packages could deliver capacity and connectivity improvements was assessed. Some refinement of interventions was undertaken. This included introduction of some new schemes and removal of others, leading to the creation of refined route-based packages for each route. The development of the packages is described on a route-by-route basis in Chapter 3, and set out in detail in Appendix B.

It should be noted that a broadly similar strategic alternative upgrade package for HS2 Phase One had already been tested as part of the previous Strategic Alternatives study based upon the 'Rail Package 2' (RP2) developed originally as part of the 2010 Strategic Alternatives study. DfT and NR agreed that this should be used as a starting point for the WCML.

It is noted that:

- None of the single route packages were developed by NR to full GRIP 1 status (see panel);
- The packages represent the collective view of the NR, DfT and Atkins, and are "professional judgement" only; and
- Much further work would be required to develop each package to reach the level of certainty typically required for any rail projects before a decision would be made to proceed with them.

Governance for Railway Investment Projects (GRIP)

Network Rail has developed an approach to managing projects in order to minimise and mitigate the risks associated with delivering projects that enhance or renew the operational railway and projects in a High Street environment. This process, "Governance for Railway Investment Projects" (GRIP), is based on best practice within industries that undertake major infrastructure projects and practice recommended by the major professional bodies, including the Office of Government Commerce (OGC), the Association of Project Management (APM) and the Chartered Institute of Building (CIOB). GRIP allows projects to be categorised according to the level of their design development and project certainty from GRIP 0 (the lowest) to GRIP 5 (the highest level of design). Construction occurs at GRIP 6 following detailed design at GRIP5. Following this approach, Network Rail refers to the level of development of the various intervention packages described in this report as "Pre-GRIP" or "GRIP 0". This means that not only is the design at a very low level but that the other plans required to manage a complex project, such as environmental management plans, project management plans, selection between options of designs to deliver the required outputs, feasibility assessment, procurement plans, asset management plans and delivering work within possessions plans have also not been completed to enable the interventions/packages to be defined as GRIP 1 or beyond. As such, considerable more development would be required to take each individual intervention to a stage whereby construction could be confirmed; construction occurs at GRIP 6 following detailed design at GRIP5.

2.4.2. Combining Route-Based Packages into Strategic Alternative Upgrade Packages

It was concluded by the DfT and NR that only packages which included interventions on more than one of the three strategic rail routes would be likely to represent strategic alternatives to HS2 Phases One and Two. This is discussed further in Chapter 3, describing how route-based packages were combined into multi-route packages. These multi-route packages are defined as “strategic alternative upgrade” packages.

2.5. Analysis of Upgrade Packages

A number of criteria (and associated metrics) has been defined which, with reference to very specific aspects of network performance and impact, measure the extent to which packages meet the objectives set by government for HS2. These are set out in full in Chapter 6.

3. Development of Upgrade Packages

3.1. Introduction

As described in Chapter 2, a systematic and structured approach to the development of five strategic alternative upgrade packages was adopted, and the rationale by which packages have been defined and developed is explained.

This chapter, first, in section 3.2 presents an overview of current rail network performance for each of ECML, WCML and MML in terms of capacity and connectivity.

Section 3.3 describes how the capacity and connectivity performance of each route is expected to change in the future as a result of rail network enhancements and improvements (those assumed in the Do-minimum).

This frames the description of the development by NR of route-based packages for ECML, WCML and MML[4] (in section 3.4) that could potentially be implemented on each route to further increase capacity and connectivity over that expected in the Do-minimum. Three levels of route-based package were developed - Low (L), Medium (M) and High (H) – broadly representing different levels of output in terms of increasing capacity and improving connectivity. The Low output packages are predominantly based on train lengthening; whereas Medium and High output packages also include infrastructure measures focused on addressing capacity and connectivity constraints at key locations on the routes.

In addition, different packages were developed for WCML and MML to represent potential alternatives to the two HS2 scenarios described in Chapter 1 – i.e. with no HS2, and with HS2 Phase One (London-Birmingham). For ECML separate packages for the with and with no HS2 Phase One scenarios were not developed since there was little scope for HS2 Phase One to impact on ECML destinations.

Section 3.4 also describes how these L/M/H route-based packages have been refined jointly by NR and DfT supported by Atkins and taken forward for further analysis.

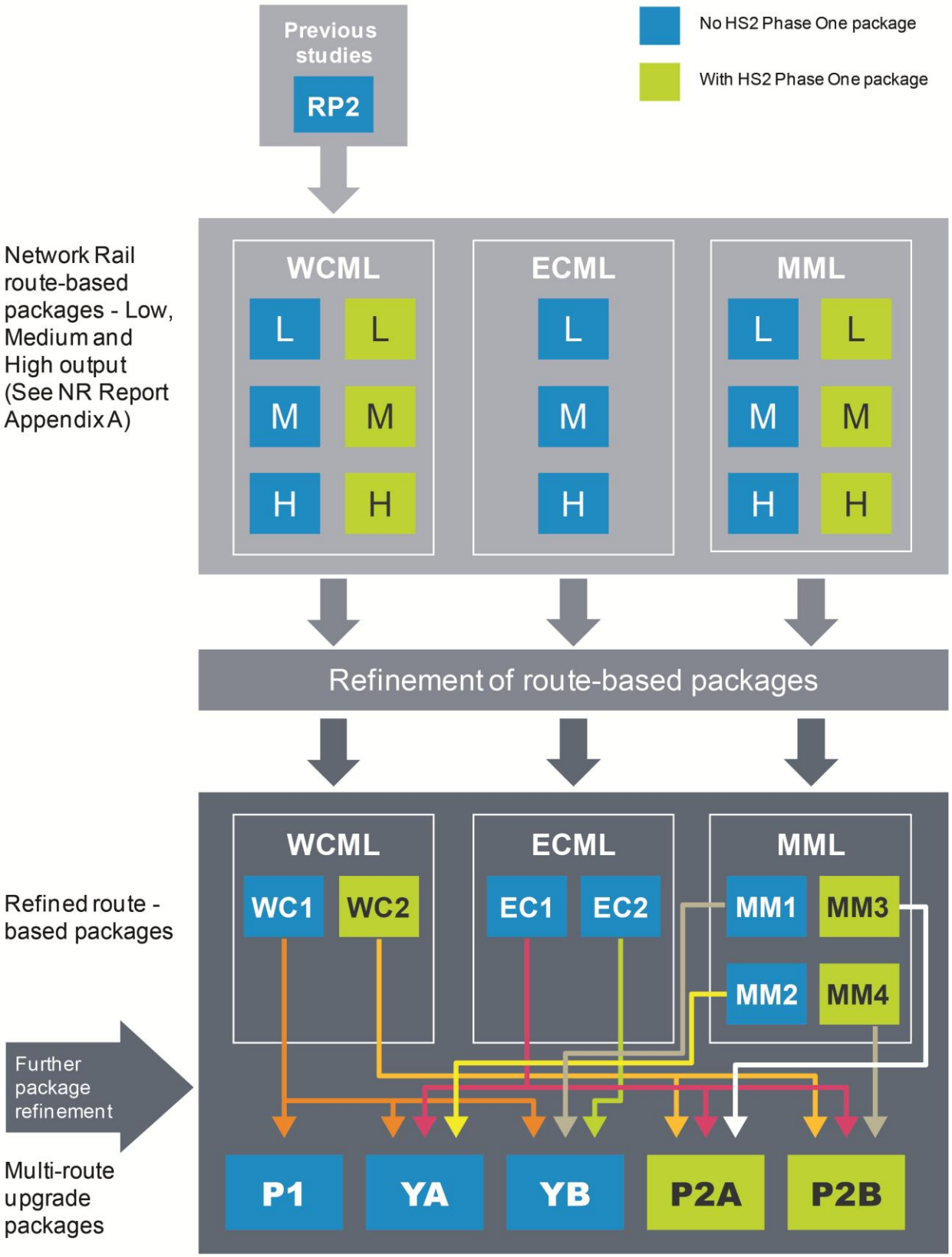
Finally, Section 3.5 describes how the refined route-based packages have been combined to develop the strategic alternative upgrade packages.

Figure 3-1 provides an overall summary for each of the route-based packages developed and described in this chapter. It also summarises how these packages have been used to define the five strategic alternative packages.

This chapter draws extensively on the NR October 2013 report in Appendix A.

[4] Scoping of infrastructure measures has also taken account of potential enhancements to Cross Country services, where these were judged to be in scope for this study (as defined by the scope of the routes considered in Chapter 2). However, Cross Country services share similar geographies (and in some case, lines) with each of ECML, WCML and MML, and, in the interests of avoiding potential duplication, no Cross Country specific package has been defined. Instead interventions designed to benefit Cross Country services have been included within one or other of the three route packages based upon the relevant geography. Broadly this has focussed on: for ECML, routes used for Cross Country services connecting at Doncaster and Leeds; for WCML, routes used for Cross Country services east of Birmingham to Manchester via Wolverhampton and to Nottingham, Sheffield and Leeds via Burton on Trent up to Tamworth; and for MML, routes used for Cross Country service from Birmingham east of Tamworth and via Burton, Derby, Nottingham and Sheffield.

Figure 3-1 Development of route-based and multi-route packages



3.2. The Existing Railway

3.2.1. ECML

The ECML is the electrified high speed route linking London with Yorkshire and Humberside, the North East, and eastern Scotland. It carries commuter flows from London to Hertfordshire, Cambridgeshire and Peterborough, as well as some of the UK's fastest growing intercity flows. Parts of the ECML also handle regional commuter and local passenger services and carry heavy tonnages of freight traffic, particularly over the northern sections.

With the exception of Welwyn and over the fenland south of Peterborough, the ECML is predominately a four track railway between London and just south of Grantham, with two tracks north thereof, with sections of four tracks in the York area. The route is predominately 125mph south of Darlington with some short sections at lower speed. In spite of investments in recent times the route is currently mostly at capacity particularly at the southern end of the route, as train operators have run more frequent train services to match increased demand. Grand Central Railways, Hull Trains and East Coast Main Line have collectively applied for more train paths on the route than considered operable by Network Rail and all parties had to rely on the Office of the Rail Regulator (ORR) to arbitrate and allocate the available remaining capacity.

The current timetable on the ECML provides up to 6 intercity services per off-peak hour. Table 3-1 summarises key statistics relating to the current service levels on the ECML.

Table 3-1 ECML Existing Service Characteristics

Service Characteristics	
Intercity trains per hour (typical off-peak)[1]	
King's Cross – Leeds	2
King's Cross – Edinburgh (note that some services extend to destinations beyond Edinburgh, including Aberdeen, Inverness and Glasgow)	1 or 2
King's Cross – Newcastle (terminating)	0 or 1
Open Access services (includes Grand Central services to Bradford and Sunderland, and Hull Trains to Hull)	1
Indicative journey times[1]	
King's Cross- Leeds	2 hrs 13 mins
King's Cross – Edinburgh	4 hrs 21 mins
King's Cross- Newcastle (passing through/terminating Newcastle)	2 hrs 50 mins / 3 hrs 12 mins

[1] Source: Current ECML timetable (Northbound, Monday to Friday 20 May to 6 December 2013). Information is indicative only and the pattern of services and destinations varies across the day. Some destinations are also served by longer distance trains.

The mixed demand for use drives many of the constraints on the route. Over the last decade, DfT through NR has invested in infrastructure interventions to mitigate a number of the constraints on the route at Allington Chord (near Grantham), at Leeds Station, at Hitchin (grade separation) and at King's Cross (including platform 0).

Operational issues impacting upon current ECML performance include:

- The long two track sections and lack of alternative routes that are electrified means that ECML is vulnerable to trains running out of sequence - i.e. a fast train behind a slow one – and the knock-on impact of delays is consequently greater; and
- Current performance can be severely impacted on by the limits of the existing overhead electrical equipment.

3.2.2. WCML

The WCML is the busiest mixed traffic route in the UK. Intercity services are provided between London Euston, the West Midlands, Stoke, Manchester, Chester and North Wales, Liverpool, Manchester, Lancashire, Cumbria and Scotland. Regional and Interurban services operate between London and Watford, Milton Keynes, Northampton, Trent Valley, Crewe, and the West Midlands. There also are local services between Bletchley and Bedford and between Watford and St. Albans Abbey. Freight services operate over the majority of the WCML serving ports and terminals such as; Channel Tunnel (Dollands Moor) Tilbury, Felixstowe, Southampton, Daventry, Trafford Park and Glasgow.

The current WCML timetable provides 9 intercity services per off-peak hour during the day. Table 3-2 below summarises key statistics relating to the current service levels on the WCML.

Table 3-2 WCML Existing Service Characteristics

Service Characteristics	
Intercity trains per hour (typical off-peak)[1]	
London Euston – Birmingham (1 tph continuing to Wolverhampton)	3
London Euston – Manchester	3
London Euston - Liverpool	1
London Euston – Glasgow	1
London Euston to Chester (some services extend beyond Chester to Bangor and Holyhead)	1
Indicative journey times[1]	
London Euston – Birmingham	1 hr 24 mins
London Euston – Manchester	2 hrs 7 mins
London Euston - Liverpool	2 hrs 8 mins
London Euston – Glasgow	4 hrs 31 mins
London Euston - Chester	2 hrs 2 mins

[1] Source: Current WCML timetable (Northbound, Monday to Friday 20 May to 6 December 2013). Information is indicative only and the pattern of services and destinations varies across the day. Some destinations are also served by longer distance trains. Excludes London Midland services that use the "fast" lines out of Euston until approximately just south of Milton Keynes.

Over the last decade, DfT through NR has invested in the route – mainly through the West Coast Route Modernisation (WCRM). Despite this the line remains close to capacity and particular constraints exist at the southern end of the route.

The difficulties in finding additional paths on the WCML is illustrated by the ORR July 2013 rejection of a request from Virgin Trains to run services to Blackpool North and Shrewsbury, on the grounds that there is insufficient space on the line, and adding further services would cause further deterioration in punctuality by adding traffic to what is already a very busy route[5].

3.2.3. MML – current performance

The MML connects much of the East Midlands with London. The electrified corridor between London and Bedford supports an intensive inner and outer suburban service, in addition to intercity services further north to Derby, Nottingham and Sheffield. The northern part of the route also provides a key element of the north-east – south-west Cross Country route giving access from Scotland, the North East and Yorkshire to Birmingham and places beyond. It allows intercity services to operate at speeds of up to 125mph. It comprises a mixture of two, three and four track railway. There is a significant number of freight terminals located within the East Midlands area. Substantial freight traffic is generated by these terminals whilst the East Midlands route's geographical position means that many flows also traverse the area to and from terminals outside it.

[5] 31st July 2013: ORR Reference: ORR/18/13

The MML has to accommodate a complex mix of freight, suburban, inter-city and regional services. It is constrained by the 2 track sections and by large numbers of routes and services that cross, lying as it does between the ECML and the WCML and serving important centres such as Leicester, Nottingham, Derby and Sheffield.

The current MML timetable provides 5 intercity services per hour during the day. Table 3-3 below summarises key statistics relating to the current service levels on the MML.

Table 3-3 MML Existing Service Characteristics

Service Characteristics	
Intercity trains per hour[1]	
St Pancras – Corby	1
St Pancras – Derby/Sheffield	2
St Pancras – Nottingham	2
Indicative journey times[1]	
St. Pancras – Sheffield	2 hrs 5 mins
St. Pancras – Nottingham	1 hr 44 mins

[1] Source: Current MML timetable (Northbound, Monday to Friday 20 May to 6 December 2013). Information is indicative only and the pattern of services and destinations varies across the day. Some destinations are also served by the same longer distance trains (e.g. Sheffield via Derby) but each train is only shown once.

3.3. The Do-minimum

To address existing capacity constraints, DfT through NR is continuing to invest in upgrading the three routes. This will result in upgrades irrespective of whether HS2 or HS2 strategic alternatives are constructed, and these form the Do-minimum[6]. Some constraints will be removed as a result of these schemes, while others will remain. The nature of these constraints, and the extent to which Do-minimum schemes will remove them is set out in detail, on a route-by-route basis, in the NR October 2013 report in Appendix A.

3.3.1. Impact of the Do-minimum - ECML

An overview of service characteristics in the Do-minimum is given in Table 3-4. The typical service frequency increases from up to 6 tph (currently) to 7 tph, including off-peak open access services.

Table 3-4 Comparison between ECML existing and Do-minimum characteristics

	Present Day	Do Minimum (DM1)
Intercity trains per hour (typical off-peak)[1, 2]		
King's Cross – Leeds	2	3
King's Cross – Edinburgh (note that some services extend to destinations beyond Edinburgh, including Aberdeen, Inverness and Glasgow)	1 or 2	2
King's Cross – Newcastle (terminating)	0 or 1	1
Open Access services (includes Grand Central services to Bradford and Sunderland, and Hull Trains to Hull)	1	1
Indicative journey times[1, 2]		
King's Cross- Leeds	2 hrs 13 mins	2 hrs 6 mins
King's Cross – Edinburgh	4 hrs 21 mins	4 hrs 5 mins
King's Cross- Newcastle (passing through/terminating Newcastle)	2 hrs 50 mins / 3 hrs 12 mins	2 hrs 35 mins / 3 hrs 12 mins

[6] DfT have advised that the majority of the Do-minimum interventions are likely to be complete by 2019 (the end of Network Rail Control Period 5) and the rest in the early 2020's

[1] Indicative only and the pattern of services and destinations varies across the day. Some destinations are also served by longer distance trains (e.g. Newcastle by Scottish trains) but each train is only shown once. [2] Source of ECML DM frequency and journey times: DfT- IEP Phase Two timetable.

Features of note relating to performance of the network in the Do-minimum are:

- The Do-minimum features an enhanced service frequency compared to the present day timetable, with the provision of an additional hourly service to Leeds, and two trains per hour to Edinburgh throughout the day;
- Journey time and capacity improvements arise from the Do-minimum interventions and the introduction of IEP rolling stock on the ECML. Journey times to Leeds are assumed to be reduced by up to 7 mins and to Edinburgh by up to 16 mins; and
- An increase in the number of seats arriving at King's Cross in the morning peak hour.

3.3.2. Impact of the Do-minimum - WCML

The extent of service frequency and journey time enhancements achievable in the Do-minimum compared to current provision in a typical off-peak hour is shown in Table 3-5. The typical service frequency increases from 9 tph (currently) to 10 tph.

Table 3-5 Comparison between WCML existing and Do-minimum characteristics

	Present Day	Do-minimum (DM1)
Long-distance high speed trains per hour (typical off-peak)[1, 2]		
London Euston – Birmingham	3	3
London Euston – Manchester	3	3
London Euston - Liverpool	1	1
London Euston – Glasgow	1	1
London Euston - Chester (some services extend beyond Chester to Bangor and Holyhead)	1	1
London Euston – Preston/Blackpool (terminating)	0	1[3]
Indicative journey times[1, 2]		
London Euston – Birmingham	1 hr 24 mins	1 hr 24 mins
London Euston – Manchester	2 hrs 7 mins	2 hrs 7 mins
London Euston - Liverpool	2 hrs 8 mins	2 hrs 11 mins
London Euston – Glasgow	4 hrs 31 mins	4 hrs 20 mins[5]
London Euston - Chester	2 hrs 2 mins	2 hrs 9 mins[4]

[1] Information is indicative only and the pattern of services and destinations varies across the day. Some destinations are also served by longer distance trains. Excludes London Midland services that use the "fast" lines out of Euston until approximately just south of Milton Keynes (typically near Ledburn Junction and Cheddington/Leighton Buzzard). [2] Source of Do-minimum frequencies and journey times: HS2 Do-minimum model. [3]Terminating services only; Preston is also served by services to Glasgow so the effective frequency for London to Preston is 1tph currently and 2tph in the Do-minimum scenario. [4] Do-minimum journey time to Chester longer than present day due to different stopping pattern assumptions.[5] Journey time savings to Glasgow achieved as a result of modified stopping patterns

Features of note relating to performance of the network in the Do-minimum are:

- The Do-minimum features an only slightly enhanced service frequency compared to the present day timetable, with the provision of an additional hourly service to Preston, with around half of these trains extending to Blackpool;
- Journey time improvements arising from the Do-minimum interventions. Journey times to Glasgow are reduced by approximately 11 mins; and
- An increase in number of seats on services arriving at Euston in the morning peak hour.

3.3.3. Impact of the Do-minimum - MML

An overview of service characteristics in the Do-minimum is given in Table 3-6. The extent of journey time improvements achievable in the Do-minimum compared to current provision in a typical off-peak hour is illustrated below. There are 6 tph – with one additional train per hour (compared to present day) to Corby.

Table 3-6 Comparison between MML existing and Do-minimum characteristics

	Present day	Do-minimum (DM1)
Intercity trains per hour[1, 2]		
St Pancras – Corby	1	2
St Pancras – Derby/Sheffield	2	2
St Pancras – Nottingham	2	2
Indicative journey times[1, 2]		
St. Pancras – Sheffield	2 hr 9 mins	1 hr 55 mins
St. Pancras – Nottingham	1 hr 44 mins	1 hr 33 mins

[1] Indicative only and the pattern of services and destinations varies across the day. Some destinations are also served by the same longer distance trains (e.g. Sheffield via Derby) but each train is only shown once above. [2] Source of Do-minimum frequencies and journey times: HS2 Do-minimum model.

Features of note relating to performance of the network in the Do-minimum are:

- Journey time improvements arising from completion of the electrification of the MML between Bedford and Sheffield. Journey times to Sheffield are reduced by up to 14 mins and to Nottingham by up to 11 mins; and
- An increase in the number of seats on services arriving at St Pancras in the morning peak hour.

3.4. Development and Assessment of the Route Packages

Against the background of network constraints set out in the NR October 2013 report in Appendix A, packages of interventions for each of the three routes were developed by NR. These were categorised, in each case, as ‘Low’, ‘Medium’, and ‘High’ levels of interventions over and above the Do-minimum.

3.4.1. Overview of package development and refinement

While the detailed composition of each of the NR packages (in terms of specific interventions) is given in Appendix B, Table 3-7 below describes (with examples) the key characteristics of each package.

Table 3-7 Key characteristics of NR 'Low', 'Medium', 'High' Output Packages

	Low	Medium	High
All	Train lengthening	Interventions providing increased capacity (relative to the Do-minimum) for intercity, Cross Country and suburban services along with some improvements to connectivity and journey time. Includes all "Low" components plus additional projects to address key capacity constraints. Allows for some line speed improvements, but also, through enhanced train frequency, allows some trains to run faster because they make fewer intermediate stops per train.	Significant additional infrastructure projects to the "Medium" package. Other capacity interventions to segregate flows are proposed so that journey time improvements can be delivered. More line speed improvements than the medium package, and some trains run faster through further enhanced train frequency (in relation to the Medium) because they make fewer intermediate stops per train.
ECML	Small changes above the end of Control Period 5 (CP5) position[7], primarily through train lengthening	Interventions to address capacity constraints and facilitate an increase in intercity services e.g. Welwyn area four-tracking, Doncaster grade separation, Darlington fast-line platforms, and provision of capacity on freight (e.g. electrification on the GN/GE Joint Line and freight avoiding scheme for Doncaster – York) but excludes higher cost capacity projects and line speed upgrades.	Increased train paths for freight, suburban and long distance services and substantially improved inter-city journey times through linespeed upgrades to 140mph running and segregation of mixed-speed services as much as possible south of Newcastle e.g. provision of a new two track alignment from Alexandra Palace to Biggleswade.
WCML – no HS2 Phase One	"RP2" used as starting point[8]. This comprises a range of interventions, providing both increased capacity and improved connectivity, including interventions north of Birmingham	Developed by incrementally adding interventions that could further increase capacity and connectivity, particularly measures north of Birmingham but also including interventions to give increased capacity for commuter services to London	Incremental additions to "Medium" package including interventions to facilitate further capacity improvements for commuter services to London (e.g. from 12 car to 16 car operation), and improved intercity connectivity between London and Liverpool/Glasgow
WCML – with HS2 Phase One	As above with interventions removed south of Birmingham that would not be required with HS2 in place between London and Birmingham.	As above, with increment additions to the interventions to the "Low" output package. The aim of this process was, to explore how much further capacity and connectivity could be enhanced over and above that identified in the earlier RP2 package.	Incremental additions to Medium package including interventions to facilitate improved intercity journey times through linespeed upgrades to 140mph running (e.g. between Handsacre and Weaver Junction).
MML – no HS2 Phase One	Platform additions/enhancements to facilitate train lengthening (St. Pancras/Chesterfield)	Further enhancements to allow increased commuter frequency (e.g. Hendon lines), freight capacity and line speed enhancements (e.g. Erewash Valley line)	Further line speed improvements delivered through interventions including new by-passes at Wellingborough & Market Harborough
MML – with HS2 Phase One	As above	As above, adapted for HS2. Includes upgraded Lichfield Freight Line and connection (chord) from HS2 Phase One to facilitate services to Sheffield via HS2 Phase One.	As above, adapted for HS2, but also includes higher specification upgrades on Lichfield Freight Line and chord to facilitate improved journey times through 140mph running

[7] Control Period 5 (CP5) covers NR's plans for 2014-1019

[8] RP2 was developed as part of previous phases of work examining strategic alternatives for HS2 - further detail is given in 3.4.3. in the context of discussion on development of WCML options

As a result of further development work, and a process of review and refinement by NR and DfT, with support from Atkins, a number of refined packages were identified (see also figure 3-1). This involved two activities:

- The individual components (specific interventions) within the Low/Medium/High, were sifted such that those interventions which performed unsatisfactorily against strategic objectives were excluded, and – in some cases – alternative interventions added (as set out in detail in Appendix B); and
- The Low/Medium/High packages themselves were refined to remove those performing unsatisfactorily against strategic objectives. The reasons for intervention inclusion/exclusion are described further in the following route-specific sections.

3.4.2. ECML package assessment and refinement

The impact of the ECML packages on capacity and connectivity metrics are summarised in Table 3-8.

This shows the likely level of improvement in intercity trains per hour between key centres and journey times. It is noted that the frequency and journey time estimates for the Service Packages have been made by NR and provided in their October 2013 report in Appendix A. Estimates of journey times for the refined packages (both here and for the other route packages set out below in this section) have been made by DfT with support from Atkins[9].

Table 3-8 ECML Route-Based Packages: Summary of Impact on Typical Frequency and Journey Times (assumes no HS2)

Indicator	Existing	Do-minimum DM1	NR Service Package A – High Output	NR Service Package B – Medium Output	NR Service Package C – Low Output	Refined Package – EC1	Refined Package – EC2
Intercity trains per hour[1]							
King's Cross – Leeds	2	3	4	4	3	4	4
King's Cross – Edinburgh[2]	1 or 2	2	2	2	2	3	3
King's Cross – Newcastle (terminating)	0 or 1	1	2	2	1	1	1
King's Cross – Nottingham	n/a	n/a	2	n/a	n/a	2	n/a
Open access	1	1	1	1	1	1	1
Indicative journey times[1]							
King's Cross- Leeds	2 hrs 13 mins	2 hrs 6 mins	1 hr 40 mins	1 hr 55 mins	2 hrs 6 mins	1 hr 36 mins	1 hr 39 mins
King's Cross – Edinburgh	4 hrs 21 mins	4 hrs 5 mins	3 hrs 30 mins	4 hrs 00 mins	4 hrs 5 mins	3 hrs 40 mins	3 hrs 43 mins
King's Cross- Newcastle	2 hrs 50 mins	2 hrs 35 mins	Not provided by NR			2 hrs 21 mins	2 hrs 24 mins
King's Cross – Nottingham	n/a	n/a	1 hr 10 mins	n/a	n/a	1 hr 10 mins	n/a

[1] Existing times and frequencies derived from current timetables; Service Package information derived from NR October 2013 report in Appendix A and are indicative only and not based on detailed timetable. Refined Package times and frequencies estimated by DfT/Atkins, and reviewed by NR, employed in high-level modelling of service patterns for upgrade packages. Note because journey times vary by service stopping patterns, typical fastest times are quoted. [2] All Edinburgh services call at Newcastle so effective hourly frequency to Newcastle in NR medium/high service packages and both refined packages is 4tph.

[9] Whilst performance modelling and timetabling work would be necessary to confirm the journey times, and in the absence of this some of the journey times might be subject to small changes following further work, the journey times have been reviewed and confirmed as plausible by NR.

Low package assessment

Table 3-8 above shows that no increases in train frequency or journey time (and hence connectivity) were achieved with the Low package of interventions (relative to the Do-minimum). In terms of passenger capacity, the package provides some increase in seat availability arising from lengthening of all ECML intercity trains to 10 car IEP.

In terms of freight capacity, NR have stated that the Low option provides no significant enhancements.

On the basis of the inability of the Low Output (Route) Package to improve journey times, or to provide for any significantly increased suburban peak capacity[10] the 'Low' was excluded from further consideration by DfT in consultation with NR.

Medium and High package assessment

The main difference between the Medium and the High package is the way that the bottleneck at Welwyn is addressed. In the Medium package, works at Welwyn north are proposed which avoid doubling the viaduct but still generate additional train service paths. In the High Package a new by-pass route is constructed.[11]

Both packages offer frequency, journey time and capacity enhancements relative to the Do-minimum. They also both provide for long-term growth in freight. The growth anticipated in the 2030 Strategic Freight Network (SFN) forecasts. Both were therefore taken forward for further analysis.

3.4.3. WCML package assessment and refinement

The impact of the route-based packages on capacity and connectivity metrics are summarised in Table 3-9 (no HS2) and Table 3-10 (with HS2). For comparative purposes, Table 3-9 also sets out the metrics associated with RP2, which is the package of WCML measures which was developed by earlier studies. The table shows the likely level of improvement in intercity trains per hour between key centres and journey times. It is worth noting that where classic journey times have increased in Table 3-10 that is typically because High Speed Rail now provides an express service leaving classic rail to be to able to add more stops and to provide more intermediate locations with a direct service.

[10] The most significant constraint on reducing peak crowding on suburban services is the Welwyn viaduct where the ECML is reduced to a two track section with a station, and a scheme at this location was not included in the 'Low' package
[11] See NR October 2013 report in Appendix A

Table 3-9 No HS2 Phase One - WCML Route-Based Packages: Summary of Impact on Typical Frequency and Journey Times

Indicator	Existing	Do-minimum DM1	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Refined package – WC1 - Augmented RP2[5]	Original RP2 (2012)[5]
Intercity trains per hour[1]							
London Euston – Birmingham	3	3	4	4	4	4	4
London Euston – Manchester	3	3	4	4	4	4[2]	4
London Euston - Liverpool	1	1	2	1	1	2[4]	1.5
London Euston – Glasgow	1	1	2	1	1	2[4]	1.5
London Euston to Chester	1	1	1	1	1	1	1
London Euston – Preston (terminating)[3]	-	1	-	-	-	-	-
Indicative journey times[1]							
London Euston – Birmingham	1 hr 24 mins	1 hr 24 mins	1 hr 13 mins	1 hr 13 mins	1 hr 13 mins	1 hr 13 mins	1 hr 13 mins
London Euston – Manchester	2 hrs 7 mins	2 hrs 7 mins	2 hrs 2 mins	2 hrs 2 mins	2 hrs 2 mins	2 hrs 1 mins	2 hrs 3 mins
London Euston - Liverpool	2 hrs 8 mins	2 hrs 11 mins	2 hrs 6 mins	2 hrs 6 mins	2 hrs 6 mins	2 hrs 6 mins	2 hrs 2 mins
London Euston – Glasgow	4 hrs 31 mins	4 hrs 20 mins	4 hrs 13 mins	4 hrs 13 mins	4 hrs 13 mins	4 hrs 5 mins	4 hrs 13 mins
London Euston to Chester	2 hrs 2 mins	2 hrs 9 mins	2 hrs 12 mins	2hrs 12 mins	2 hrs 12 mins	2 hrs 8 mins	2 hrs 12 mins

[1] Existing times and frequencies derived from current timetables; Service Package information derived from the NR October 2013 report in Appendix A and are indicative only and not based on detailed timetable, Refined Package times and frequencies estimated by DfT/Atkins, and reviewed by NR, employed in high-level modelling of service patterns for upgrade packages. Because journey times vary by service stopping patterns, typical fastest times are quoted. [2]In addition to what is shown in the table, 2 services are assumed from Euston to Manchester via Birmingham. [3]Terminating services only; Preston is served by services to Glasgow so the effective frequency for London to Preston is 1tph currently, 2tph in the Do-minimum scenario, 2tph in refined package WC2 and 1.5 tph in the original RP2 package. [4]The intercity fast line frequency is 12 tph, but services sum to 13 in table because 1 tph to Liverpool and Glasgow operates as a combined service as far as Warrington, where it splits 5Figures apply to both peak and off peak (elsewhere in table figures are off peak)

Table 3-10 With HS2 Phase One - WCML Route-Based Packages: Summary of Impact on Typical Frequency and Journey Times

Indicator	Existing	Do-minimum DM2 (HS/Classic)[2]	Service Package D – High Output (HS/Classic)	Service Package E – Medium Output (HS/Classic)	Service Package F – Low Output (HS/Classic)	Refined Package WC2 (HS/Classic)
Intercity trains per hour[1]						
London Euston – Birmingham	3	3 / 2	3 / 2	3 / 2	3 / 2	4 / 2
London Euston – Manchester	3	3 / 1	3 / 1	3 / 1	3 / 1	4 / 2
London Euston - Liverpool	1	2 / 0	2 / 0	2 / 0	2 / 0	2 / 0
London Euston – Glasgow	1	1 / 0.5	2 / 0	2 / 0	2 / 0	1 / 0.5
London Euston – Chester	1	0 / 1	0 / 1	0 / 1	0 / 1	0 / 1
London Euston – Preston	0	2 / 1	3 / 0	3 / 0	3 / 0	2 / 2
Indicative journey times[1]						
London Euston – Birmingham	1 hr 24 mins	49 mins / 1hr 34 mins	Not given	Not given	Not given	49 mins / 1hr 32 mins
London Euston – Manchester	2 hrs 7 mins	1 hr 40 mins / 2 hrs 10 mins	1 hr 35 mins (HS)	1 hr 37 mins	1 hr 39 mins	1 hr 43 mins / 2 hrs 9 mins
London Euston - Liverpool	2 hrs 8 mins	1 hr 46 mins / N/A	1 hr 45 mins (HS)	1 hr 47 mins	1 hr 49 mins	1 hr 46 mins / N/A
London Euston – Glasgow	4 hrs 31 mins	3 hrs 54 mins / 5 hrs 29 mins	3 hrs 54 min (HS)	3 hrs 56 mins	3 hrs 58 mins	3 hrs 54 mins / 5 hrs 4 mins
London Euston – Chester	2 hrs 2 mins	N/A / 2 hrs 22 mins	Not given	Not given	Not given	N/A / 2 hrs 1 min

[1] Existing times and frequencies derived from current timetables; Service Package information derived from NR October 2013 report in Appendix A and are indicative only and not based on detailed timetable, Refined Package times and frequencies estimated by DfT/Atkins, and reviewed by NR, employed in high-level modelling of service patterns for upgrade packages. Note because journey times vary by service stopping patterns, typical fastest times are quoted. Note that where a train runs through a City to another destination it is included. [2] The Do Minimum assumes that HS2 Phase One is in place. (Birmingham journey times and frequencies are based on trains to New Street and Curzon Street).

Package Assessment and Refinement

Development of a refined package for WCML was undertaken with reference to each of the three packages developed for this study (Low, Medium, and High) and to the RP2 package which emerged from the earlier 2010 study of strategic alternatives. In practice, both Low and Medium packages draw heavily upon the schemes which formed part of RP2.

The High package represents a level of investment which exceeds what was included in any of the WCML Low, Medium or RP2 packages, with the objective of testing whether or not greater investment could achieve improved package value for money by delivering greater levels of capacity and connectivity enhancement. It included 140 mph running and further capacity improvements north of Birmingham.

The High packages also included, for example, 16 car running on suburban services and extensive line speed enhancements. It would add significant additional cost for little additional benefit against objectives. Following this further testing and subsequent discussions with DfT, the High package option was therefore excluded from further analysis.

This provided a re-affirmation of the merits of a package of the broad scale of RP2 as an appropriate strategic alternative for WCML. Work therefore focused on drawing together and refining schemes from across the Low, Medium and RP2 packages, taking account of the following impacts:

- The increases in train frequency and journey time (and hence connectivity) achieved with Low, Medium and RP2 packages of interventions (relative to the Do-minimum);
- The increase in seat availability, arising from
    - all West Coast Trains running at the maximum length permitted for each destination on the West Coast Main Line, and with the RP2 service pattern;
    - London suburban trains being lengthened to the maximum length the infrastructure could support; and
    - Conversion of one coach from first to standard, as proposed by 51M.
- In terms of freight capacity, NR have stated that the Low option provides no significant enhancements, while the Medium and High provide for long-term growth in freight.

A hybrid of Low/Medium/RP2 package interventions emerged as the refined package. This was effectively an augmented version of RP2, and was taken forward for further assessment, as it provided greater frequency and journey time impacts than the Low and Medium options as originally specified. Low and Medium, as originally specified, were excluded from further analysis.

3.4.4. MML package assessment and refinement

The impact of the MML route-based packages on capacity and connectivity metrics are summarised in Tables 3-11 and 3-12. These show the likely level of improvement in intercity trains per hour between key centres and journey times.

Table 3-11 No HS2 Phase One - MML Route-Based Packages: Summary of Impact on Typical Frequency and Journey Times

Indicator	Existing	Do-minimum DM1	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Refined Package MM1	Refined Package MM2
Intercity trains per hour[1]							
St Pancras – Corby	1	2	2[2]	2	2	2	2
St Pancras – Derby (terminating)	0	0	1	0	0	1	1
St Pancras – Derby/Sheffield	2	2	3	2	2	2	2
St Pancras - Nottingham	2	2	3	2	2	3	1
Indicative journey times[1]							
St Pancras – Sheffield	2 hr 9 mins	1 hr 55 mins	1 hr 39 mins	1 hr 46 mins	1 hr 49 mins	1 hr 55 mins	1 hr 55 mins
St Pancras - Nottingham	1 hr 44 mins	1 hr 33 mins	1 hr 23 mins	1 hr 33 mins	1 hr 33 mins	1 hr 52 mins	1 hr 52 mins

[1] Existing times and frequencies derived from current timetables; Service Package information derived from NR October 2013 report in Appendix A and are indicative only and not based on detailed timetable, Refined Package times and frequencies estimated by DfT/Atkins, and reviewed by NR, employed in high-level modelling of service patterns for upgrade packages. Because journey times vary by service stopping patterns, typical fastest times are quoted. Frequency to Nottingham in MM2 is reduced compared to MM1 as fast services to Nottingham operated via ECML in this scenario. [2] Corby served by Nottingham services.

Table 3-12 With HS2 Phase One - MML Route-Based Packages: Summary of Impact on Typical Frequency and Journey Times

Indicator	Existing	Do-minimum DM2	Service Package D – High Output (HS/Classic)	Service Package E – Medium Output (HS/Classic)	Service Package F – Low Output (HS/Classic)	Refined Package MM3 (HS/Classic)	Refined Package MM4 (HS/Classic)
Intercity trains per hour[1]							
St Pancras – Corby	1	2	0 / 2	0 / 2	0 / 2	0 / 2	0 / 2
St Pancras – Derby (terminating)	0	0	0 / 1	0 / 1	0 / 0	0 / 1	0 / 1
St Pancras – Derby/Sheffield	2	2	2 / 1	2 / 1	0 / 2	2 / 2	2 / 2
St Pancras - Nottingham	2	2	0 / 3	0 / 3	0 / 2	2 / 1	0 / 2
Indicative journey times[1]							
St Pancras – Sheffield	2 hrs 9 mins	1 hr 55 mins	1 hr 39 mins	1 hr 46 mins	1 hr 49 mins	1 hr 26 mins	1 hr 26 mins
St Pancras - Nottingham	1 hr 44 mins	1 hr 33 mins	1 hr 23 mins	1 hr 33 mins	1 hr 33 mins	1 hr 7 mins	1 hr 52 mins

[1] Existing times and frequencies derived from current timetables; Service Package information derived from NR October 2013 report in Appendix A and are indicative only and not based on detailed timetable, Refined Package times and frequencies estimated by DfT/Atkins, and reviewed by NR, employed in high-level modelling of service patterns for upgrade packages. Because journey times vary by service stopping patterns, typical fastest times are quoted. Frequency to Nottingham in MM4 is reduced compared to MM3 as fast services to Nottingham operated via ECML in this scenario.

Low package assessment

Table 3-11 and 3-12 above show some decreases in journey time (for instance, a 6 minute journey time saving between London and Sheffield) with the Low package of interventions (relative to the Do-minimum). In terms of passenger capacity, the package achieves some increase in seat availability, arising from lengthening of Midland Main Line intercity trains to 11 x 23 metre vehicles (or 12 x 20 metre) and Cross Country services to 10 x 23 metre vehicles. There are no interventions targeted at suburban crowding, but some capacity relief for commuters will be provided from lengthening of the intercity trains.

In terms of freight capacity, NR has stated that the Low option provides for some growth in freight.

On the basis of the inability of the Low Output (Route) Package to improve journey times, or to provide for any significant increased suburban capacity the ‘Low’ was excluded from further consideration by DfT in consultation with NR.

Medium and high package assessment

Both packages offer frequency, journey time and capacity enhancements relative to the Do-minimum. NR state that they both also provide for growth in freight. Both were therefore taken forward for further analysis and refinement.

3.4.5. Route package development - scheme details

A series of tables given in Appendix B present each of the route-based packages described above defining the individual interventions making up each package. The tables also show how interventions have been included, excluded or modified as part of the package refinement process.

3.5. Assembling Strategic Alternative Upgrade Packages

The route-based packages described in the previous sections are useful indicators of what might be required on a route-by-route basis but (excepting HS2 Phase One only) are not of themselves individually alternatives to HS2: either to the "Full network" or to Phase Two. HS2 serves all the key destinations on all of the WCML, the ECML and the MML, and also many of the destinations served by the Cross Country network (excepting South and South-West of Birmingham). As a result, single route-based packages are not of themselves alternatives to HS2 (except to Phase One of HS2 only), and were therefore combined into composite multi-route packages.

The process of combining single route packages into multi-route packages provided another opportunity for review of the individual package interventions (as described below), with a view to further refinement of the combined packages before taking them forward for further testing.

It was recognised that simple combination of route packages by Medium or High intervention (with Low packages having been rejected during earlier work as described earlier in this chapter) would lead to duplication, as the routes interact. For instance, upgrading both the ECML and the MML would lead to potential duplication where they serve the same destination. Such duplication becomes even more of a risk when the impacts of HS2 Phase One are taken into account. Nottingham might be served via the ECML, the MML and via HS2 and an upgraded Cross Country link from Birmingham via Burton (part of the WCML route packages).

Assembling multi-route packages from single route-based packages therefore followed a process which was designed to:

- Avoid duplication (as illustrated above); but also
- Assess and refine how the components of individual packages would work in combination with each other. This was more than a case of avoiding duplication, and involved also consideration of where schemes in different packages might be complementary to each other (or indeed conflict);
- Avoid over-complexity. Combining packages can lead to multiple permutations; the challenge was to identify a range of packages which - by including the critical interventions - were representative of the full scale and nature of potential impacts (given multiple variants and sub-options) while ensuring that the process remained manageable;
- Identify multi-route packages to identify whether or not further detailed work was likely to be required, rather than a large number of extensively developed options (which was not feasible within the timescale of the study); and
- Take into consideration the levels of crowding that could occur and where the greatest benefits from speeding up trains and increasing frequency could be found.

In total five multi-route composite packages were developed based on the single route Medium and High packages which were carried through from the previous stage of work as meriting further consideration (see also Figure 3-1):

*Alternatives to the HS2 Phase One (**P1** package):*

- **Package P1**

*Alternatives to the HS2 Phase One and Phase Two (the "Y" network) (**Y** packages):*

- **Package YA**
- **Package YB**

*Alternatives to the HS2 Phase Two (**P2** packages):*

- **Package P2A**
- **Package P2B**

The combination of route-based packages agreed between DfT and the study team, and used to form the strategic alternative multi-route packages, are shown in Table 3.13.

During the final modelling phase by Atkins some further refinement took place – in particular NR took the opportunity to refine which interventions were in each multi-route package and confirm that the proposed service pattern could be delivered with the proposed infrastructure. This led to infrastructure being added to improve resilience, for example on re-considering the service specification for Package YA an extra intervention was thought necessary at Newcastle on the ECML.

Table 3-13 Composition of Strategic Alternative Packages from Route Based Strategies

Upgrade Package	ECML	WCML	MML
P1	n/a	WC1	n/a
YA	EC1	WC1	MM2
YB	EC2	WC1	MM1
P2A	EC1	WC2	MM3
P2B	EC1	WC2	MM4

4. Overview of Upgrade Packages

4.1. Introduction

Five conventional rail upgrade packages have been developed to represent strategic alternatives to three different HS2 construction scenarios, as follows:

- **Package P1** – as a strategic alternative to providing the HS2 Phase One London-Birmingham route;
- **Package YA and YB** – as strategic alternatives to providing the full Phase 1 and Phase 2 HS2 "Y-network", and
- **Packages P2A and P2B** – as strategic alternatives to providing the HS2 Phase Two extension to Leeds and Manchester but with HS2 Phase One London-Birmingham in place.

4.2. Upgrade Package P1

Package P1 is a strategic alternative to HS2 Phase One, comprising only the refined West Coast package previously described. It assumes that the train service frequency on the WCML 'fast' lines is increased to 16 tph (an incremental increase of 3tph on the 'fast' lines frequency of 13tph in the Do Minimum) over the section of the WCML between Euston and Ledburn Junction (between Cheddington and Leighton Buzzard). The package assumes a standard hour timetable based on the service specification shown below and displayed graphically in Figure 4-1. Note that the number of services listed below totals 17 services. However, the number of services departing London Euston would be 16tph, as one train per hour would split at Warrington with the two portions travelling on to Glasgow and Liverpool respectively (more details are provided on this below).

- Euston – Birmingham: 2 trains per hour (tph)
- Euston – Wolverhampton via Birmingham: 2tph
- Euston – Manchester: 4tph
- Euston – Liverpool: 2tph
- Euston – Carlisle/Glasgow via Preston: 2tph
- Euston – Chester/North Wales 1tph calling stations on the Trent Valley;
- Euston – Milton Keynes - Northampton – Rugby: 4tph commuter "fasts":
  - 2 tph extended to Birmingham New Street;
  - 1 tph terminating at Rugby; and
  - 1 tph extended to Crewe to serve stations along the Trent Valley route.

This service pattern was based on work undertaken to support the earlier strategic alternatives studies which included 3 "fast" trains every 2 hours to Liverpool and Glasgow. The frequency of 2tph to Liverpool and Glasgow in P1 is achieved by operating a double 6 car Class 390 as far as Warrington, whereupon the train is assumed to split with one 6 car set continuing to Liverpool and the other half continuing to Glasgow. It should be noted that no specific revenue assessment has been made of this service option to compare with the provision of an alternating service to Liverpool and Glasgow (as per RP2).

All Class 390 Pendolinos are assumed to be extended to 11 car operation, though with the conversion of one first class carriage to standard class, an increase in capacity of 30 seats per train. The outer suburban fast line services are assumed to be operated by 11 car Pendolinos with 2 first class carriages converted to standard class. This assumption is consistent with the previous RP2 specification; however, it is worth noting that they could be operated by 110 mph 12 car class 350s.

The slow line service specification under earlier work was the same as in the Do-minimum; in P1 all slow-line services to/from London Euston have been extended to 12 car operation all-day.

Table 4-1 and Figures 4-2 and 4-3 present a summary of the upgrade projects that have been included in Package P1.

Table 4-1 Package P1 Intervention Components

Route	Components
West Coast Main Line	• 4-tracking Attleborough to Brinklow (RP2 scheme) • 4-tracking Beechwood Tunnel (Berkswell) to Stechford, including stations (RP2 scheme) • 4-tracking Chat Moss Line, approx 3 miles • Dynamic passing loops at Shap and Beattock for freight • Extend Warrington slow line platforms to enable splitting / joining • Grade separated Colwich Junction (RP2 scheme) • Grade separated junction between Cheddington and Leighton Buzzard (RP2 scheme) • North of Preston, Dynamic passing loops & 75mph turnouts between Preston and Lancaster (and up-speed existing Garstang crossovers to 75mph) • Power supply upgrade • Northampton area speed improvements (RP2 scheme)

Table 4-2 shows the main variances in schemes between RP2, 51M and P1[12].

Table 4-2 Comparison of Package P1 Interventions with RP2 and 51M

	RP2[1]	51M	P1
Additional Platforms at Euston	•		
Grade separated junction between Cheddington and Leighton Buzzard	•	•	•
4 tracking Attleborough – Brinklow	•	•	•
Stafford By-pass		•	
Grade separated Colwich Junction	•		•
4 Tracking Beechwood Tunnel to Stechford	•		•
Northampton area speed improvements	•	•	•
Dynamic passing loops between Preston and Lancaster			•
4-tracking Chat Moss Line			•
Dynamic passing loops at Shap and Beattock			•
Extend Warrington slow line platforms to enable splitting / joining			•

[1] This is RP2 as assessed in the January 2012 Update Following Consultation

The P1 package is a development of RP2 which takes account of a number of changes since RP2 was first developed. Since 2010 the number of trains operated and the infrastructure on the West Coast Route has been enhanced. Virgin operates a service to Glasgow on an hourly basis and at faster average journey times. Norton Bridge (the key component of "Stafford by-pass") will be built as part of the Do-Minimum. Timetable work by Network Rail in 2011 and 2013 also indicated that some of the infrastructure schemes proposed for the Greater Manchester area are not required, in large part because of the Northern Hub Project. NR has also suggested that for 16 trains per hour that Euston would not need extra platforms if the turnaround times could be reduced. However, work by NR has suggested that a small number of smaller scale infrastructure schemes are required to ensure P1 fits with the route demand for freight, in particular three sets of additional loops between Preston and Scotland.

[12] Network Rail: review of Strategic Alternatives to High Speed Two; November 2011;

Figure 4-1 Package P1 Modelled Service Specification

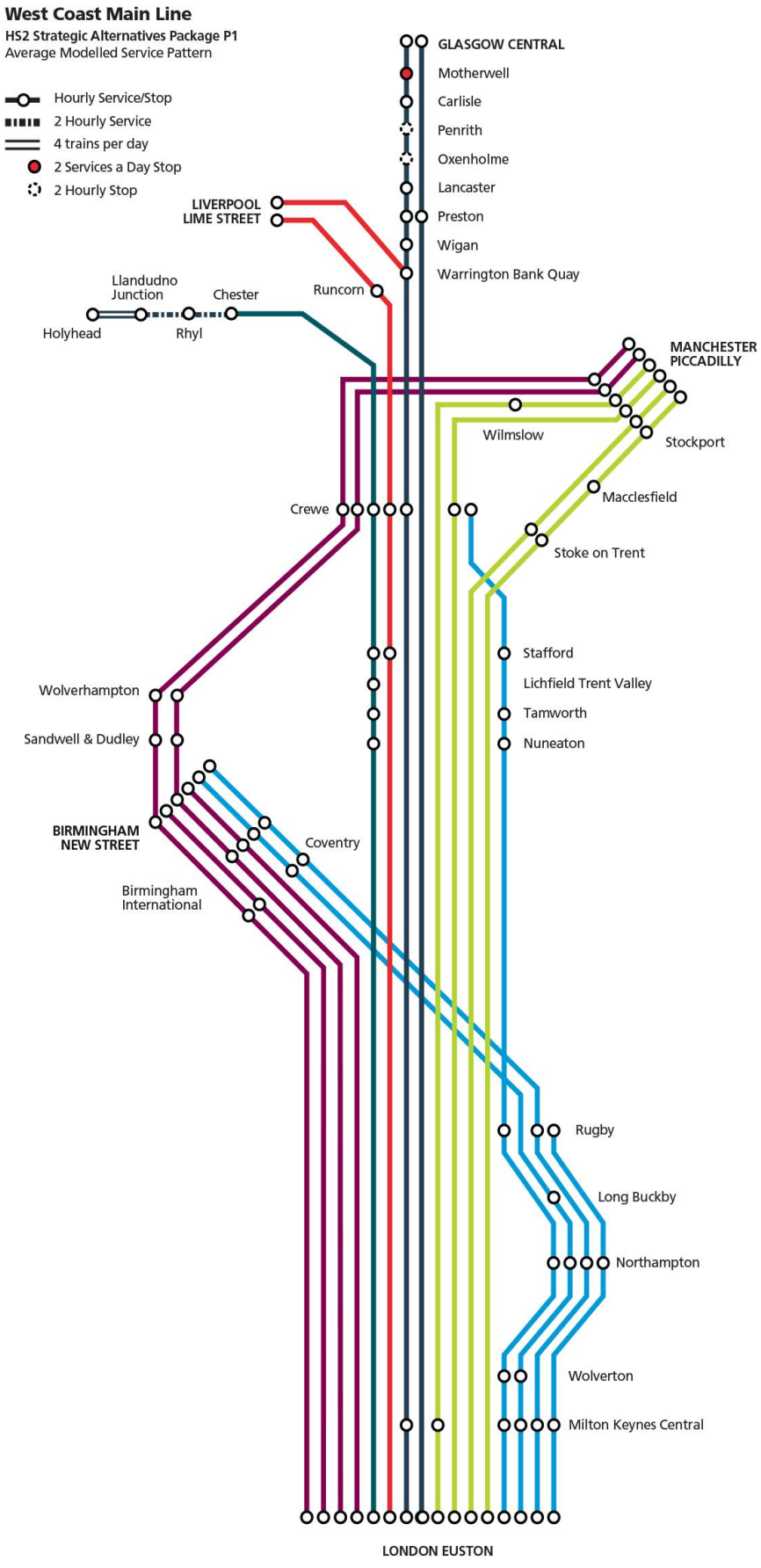


Figure 4-2 Summary of Package P1 Upgrade Projects – North

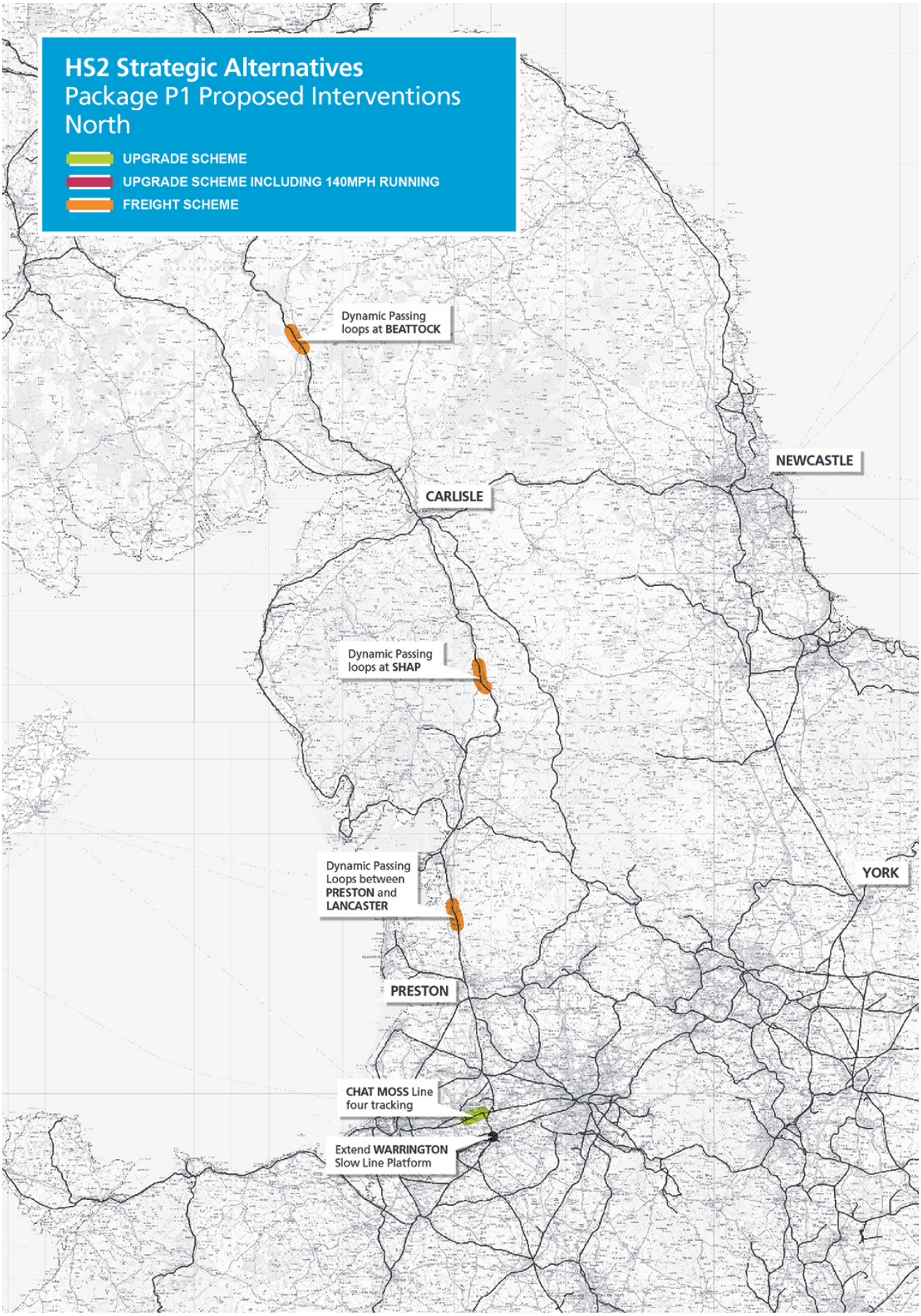


Figure 4-3 Summary of Package P1 Upgrade Projects - South

4.3. Upgrade Package YA

Package YA is designed as a strategic alternative upgrade package to both Phase One and Phase Two on HS2. It assumes HS2 is not constructed. An outline description of what Package YA is intended to deliver is provided below.

East Coast Main Line

An 11 tph timetable is provided for intercity ECML services, all assumed to be operated by 140mph IEP sets segregated from commuter, freight and other services for much of the route between London and Newcastle. This is an incremental increase of 4tph over the intercity frequency of 7tph in the Do Minimum. Services to Sheffield and Leeds are assumed to be operated by 7 car IEP sets, while services to Bradford are assumed to be operated by 5 car IEP sets (extended to 10 car sets in the peak). Services to Newcastle and Scotland are assumed to be operated by 9 car IEP sets. The assumed service specification is:

- London – Nottingham and Sheffield: (via Grantham and Erewash Valley) 2 tph;
- London – Leeds: 4tph (2tph express services stopping Wakefield Westgate only, 2tph via Hambleton extending to Bradford);
- London – Newcastle: 4tph, all stopping York and 3tph extend to Edinburgh; and
- 1tph open access service assumed to continue as per Do-minimum (rolling stock upgraded to IEP to benefit from journey time improvements on ECML).
- An additional 2tph shuttle service between Doncaster and Leeds is also proposed to compensate for the loss of connectivity between Leeds and Doncaster by operating the direct Leeds services non-stop to Wakefield.

Suburban services operating on the ECML are modified to provide the following:

- London – Cambridge: 4tph ‘fast’, with 1tph extended to Kings Lynn (replacing the current 1 tph to Cambridge and 1tph to Kings Lynn); and
- London – Royston: additional 2tph all-day stopping service.

The fast services to Cambridge are assumed to be operated 5 car IEP sets (extended to 10 car sets in the peak), while Royston services are operated by 4 car Class 350 sets.

The above service specification is shown in Figure 4-4.

Midland Mainline

A 6tph intercity service pattern is provided, with the following service specification assumed (shown in Figure 4-5):

- London St Pancras – Sheffield: 2tph (fast between London and Leicester)
- London St Pancras – Nottingham: 1tph (calling at intermediate stations)
- London St Pancras – Derby: 1tph (calling at intermediate stations)
- London St Pancras – Corby: 2tph

The above service frequency is the same as the Do-Minimum MML intercity frequency of 6tph, though with a slight change in destinations served (1tph to Nottingham compared with 2tph in the Do Minimum as ‘fast’ services to Nottingham are served via the ECML in this package, and 1tph terminating at Derby which is typically served by trains to Sheffield).

These services are assumed to be operated by modern electric loco-hauled 7 car trains as per the Do-minimum, with the exception of the Corby services which are assumed to be operated by 4 car Class 377 sets (extended to 12 car in the peak).

- In addition, an hourly shuttle service between Leicester and Nottingham is proposed to compensate for the loss of connectivity between Leicester and Nottingham by rerouting the London to Nottingham services via the ECML in this scenario.

Suburban capacity on the MML is increased in this scenario through the provision of an additional 2tph all-day between London St Pancras and Luton.

West Coast Main Line

The deliverables for the WCML in Package YA are the same as for Package P1 described above, with the exception that services between Euston and Wolverhampton are extended to Manchester to improve connectivity and reduce journey times between Birmingham and Manchester. The service specification is shown diagrammatically in Figure 4-6.

Cross Country

Package YA assumes a higher frequency timetable along the Cross Country corridor between Birmingham and the East Midlands. The overall Cross Country train service specification is listed below and shown in Figure 4-7:

- Bristol – Manchester: 1tph
- South coast – Manchester: 1tph (via Birmingham)
- Cardiff – Newcastle: 2tph (existing Cardiff - Nottingham service extended to Newcastle, running non-stop between Birmingham and Nottingham. Also re-routed via Bristol Parkway to ensure the whole route is electrified)
- Birmingham – Nottingham: 2tph (local stopping services, 1tph from Birmingham Moor Street to compensate for the loss of connectivity by running the Cardiff services non-stop to Nottingham and 1tph existing service from Birmingham New Street)
- Newport – Cheltenham: 1tph (local stopping service to compensate for the loss of connectivity by rerouting the Cardiff – Nottingham - Newcastle service via Bristol)
- Birmingham Moor Street – Leeds: 2tph
- Birmingham – Leicester: 1tph
- South Coast - Scotland: 1tph (stopping pattern modified to run non-stop between Birmingham and Derby)
- Southampton/Reading – Newcastle: 1tph

This provides a total of 8 Cross Country services an hour east of Birmingham: the two existing services to Scotland and Newcastle, two new services to Leeds via Sheffield, two new services via Nottingham to the ECML and then on with stops to Newcastle, and two stopping services to Nottingham. The new services from Cardiff to Newcastle and Birmingham Moor Street to Leeds are assumed to be operated by 5 car IEP sets. The services between Scotland and the South Coast and Southampton/Reading and Newcastle are also assumed to be operated by 5 car IEP sets, thereby benefitting from journey time improvements delivered by the infrastructure upgrades on both the Cross Country route north-east of Birmingham and also along the ECML.

The above specification includes 2 tph between Birmingham and Manchester which are present in the Do-minimum service specification. When combined with the 2 services extended from Wolverhampton to Manchester (described in the WCML section above), Package YA effectively provides 4tph between Birmingham and Manchester, and hence improved connectivity between the two cities.

Table 4-3 and Figures 4-8 to 4-10 present a summary of the upgrade projects that have been included in Package YA.

Table 4-3 Package YA Intervention Components

Route	Components

East Coast Main Line	• King's Cross throat works, including lengthening all platforms to at least 12-car suburban length, reducing the total number of platforms by 1, and reopening the disused tunnels.
	• Additional 2 tracks between Alexandra Palace and Biggleswade via a combination of tunnel to the M25 and then new alignment broadly following the A1
	• Huntingdon – Peterborough area - 4 tracking
	• Electrification of Grantham to Nottingham, and line speed improvements to 125mph
	• Grantham - 2 additional platforms at Grantham on the Down side of the layout with the single line doubled from Nottingham Branch Junction to Grantham Station
	• Line speed improvements on the fast lines north of Biggleswade on sections as far as Darlington, and on a section south of Berwick through replacing the OLE equipment, and works on the track, structures and formation
	• Level crossings - closure of all level crossings south of Darlington
	• Electrification of the Joint Line through Lincolnshire for freight and diversionary purposes
	• Grade separation at Doncaster to allow for east-west crossings without interfering with the operations of the main line
	• Grade separation at Doncaster to allow for east-west crossings without interfering with the operations of the main line
	• Freight avoiding scheme for Doncaster – York via Barnby Dun and Knottingley
	• Darlington - provision of fast line platform at Darlington Station
	• Northallerton to Newcastle:
	  ○ Upgrade the Stillington Line – 60 or 75mph with 4 or 5 minute headways
	  ○ Re-open southern end of Leamside Line for passenger between Tursdale and, via a largely tunnelled new alignment, Chester-le-street (140mph where possible)
	  ○ Upgrade gauge of Northallerton tunnel and platforms
	• New platforms at Haringey and Hornsey to enable more intensive use of second slow lines for short distance services, leaving slow line 1 clear for longer distance Thameslink services until north of Alexandra Palace
	• Changes to S&C in Alexandra Palace area to help access to and from the fast lines for Thameslink services north of the new tunnel entrance at Alexandra Palace
	• Doncaster - Leeds improvements (4-tracking between Doncaster and Wakefield, a new tunnelled approach to Leeds and extra platforms at Leeds).
	• Newcastle - Edinburgh power supply upgrade – to allow 3tph London – Edinburgh
	• Cambridge chord – cut-off route from new Alexandra Palace to Biggleswade line south of Baldock to join line to Cambridge.
	• 775m Freight loops between Newcastle and Edinburgh
	• Skelton Bridge Flyover north of York
	• Additional trackwork at Newcastle station to improve access to the terminating bay platforms
	• Newark flyover and chord connecting to the ECML

Midland Mainline	• Additional platform at St Pancras • Turn-back in the Luton area - centre turn-back at Linbury • Erewash linespeed work to increase speeds to 110mph • Chesterfield station works • Nottingham station extra capacity (Part A), additional platform provided • Nottingham station extra capacity (Part B): Over and above that proposed in part A, provide capacity for additional 2tph through services • North of Sheffield capacity enhancements, including a tunnel immediately

Route	Components

	north of the station to segregate long distance from many short distance services, and diverted local services to serve new Meadowhall station.
	• South of Sheffield capacity enhancements including 4-tracked approach to Sheffield and a new tunnel avoiding Dore.
	• Sheffield - Leeds improvements:
	  ○ 4-track between Swinton and Moorthorpe / South Kirby Junction, grade separate South Kirby junction
	  ○ Upgrade linespeed from Sheffield to Moorthorpe to 125mph
	• 4-track Tamworth to Stenson Junction at 140mph
	• Rebuild Burton-on-Trent station with platforms on the slow lines
	• Nottingham to Newark upgrade, electrification and line-speed increased to 125mph
	• High speed connection Stenson Junction – Trent Junction – Nottingham

West Coast Main Line	• 4-tracking Attleborough to Brinklow • 4-tracking Beechwood Tunnel to Stechford, including stations • 4-tracking Chat Moss Line, approx 3 miles • Dynamic passing loops at Shap and Beattock • Extend Warrington slow line platforms to enable splitting / joining • Grade separated Colwich Junction • Grade separated junction between Cheddington and Leighton Buzzard • North of Preston, Dynamic passing loops & 75mph turnouts between Preston and Lancaster (and up-speed existing Garstang crossovers to 75mph) • Northampton area speed improvements. • Re-instate the Camp Hill chords to be able to use Moor Street station, and additional platforms at Moor Street. • 4-tracking Kingsbury Junction to Tamworth (approx 6 miles) • 4-tracking Water Orton corridor (approx 8 miles) to Water Orton Junction • 140mph linespeed improvements Birmingham to Derby (Cross Country via Tamworth and Burton) • Dynamic passing loops between Congleton and Macclesfield station • Extend passing loops at Chelford, • 1 x Extra Platform at Manchester Piccadilly

Figure 4-4 Package YA: ECML Modelled Service Specification

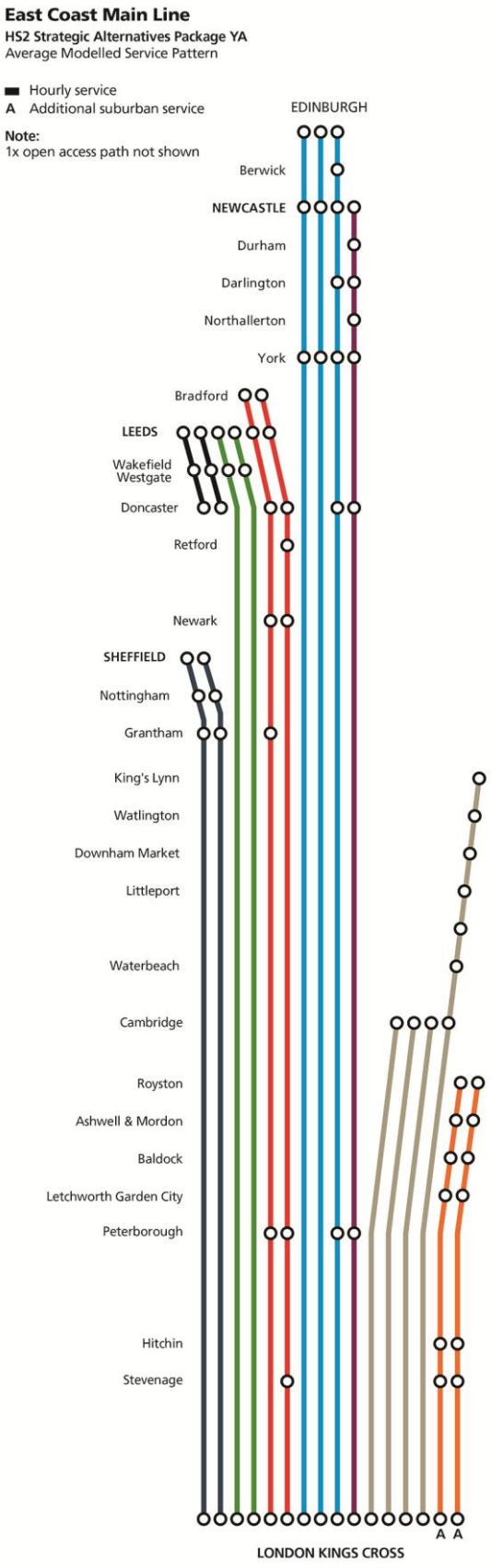


Figure 4-5 Package YA: MML Modelled Service Specification

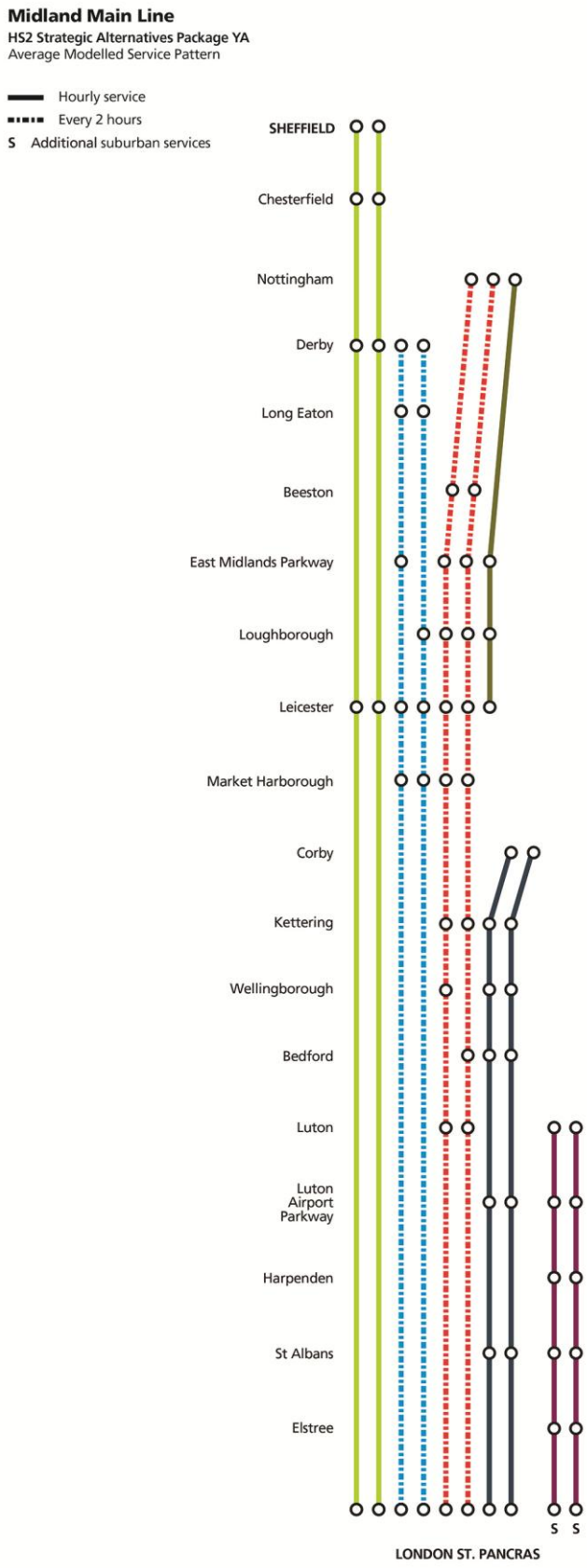


Figure 4-6 Package YA: WCML Modelled Service Specification

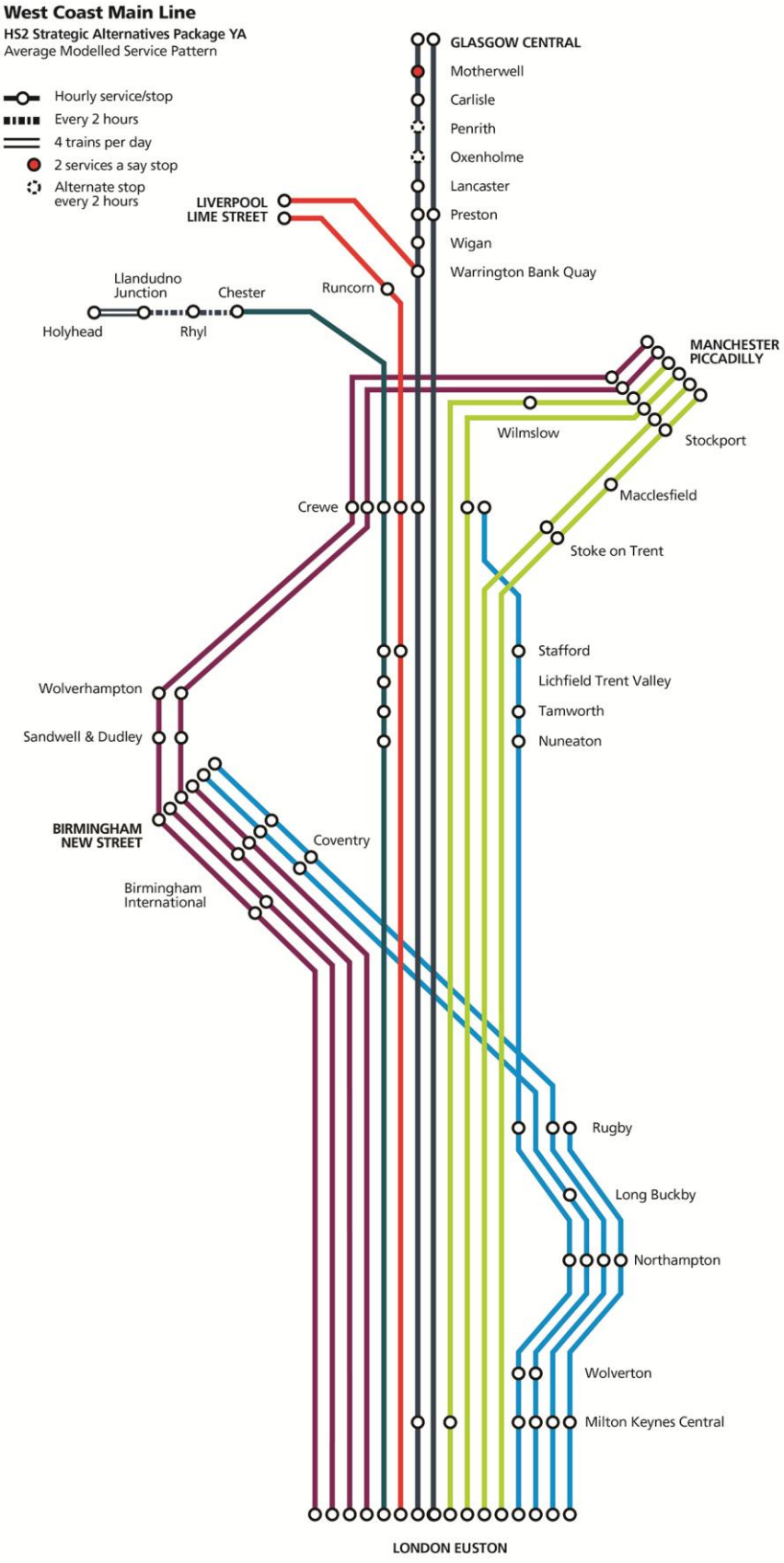


Figure 4-7 Package YA: Cross Country Modelled Service Specification

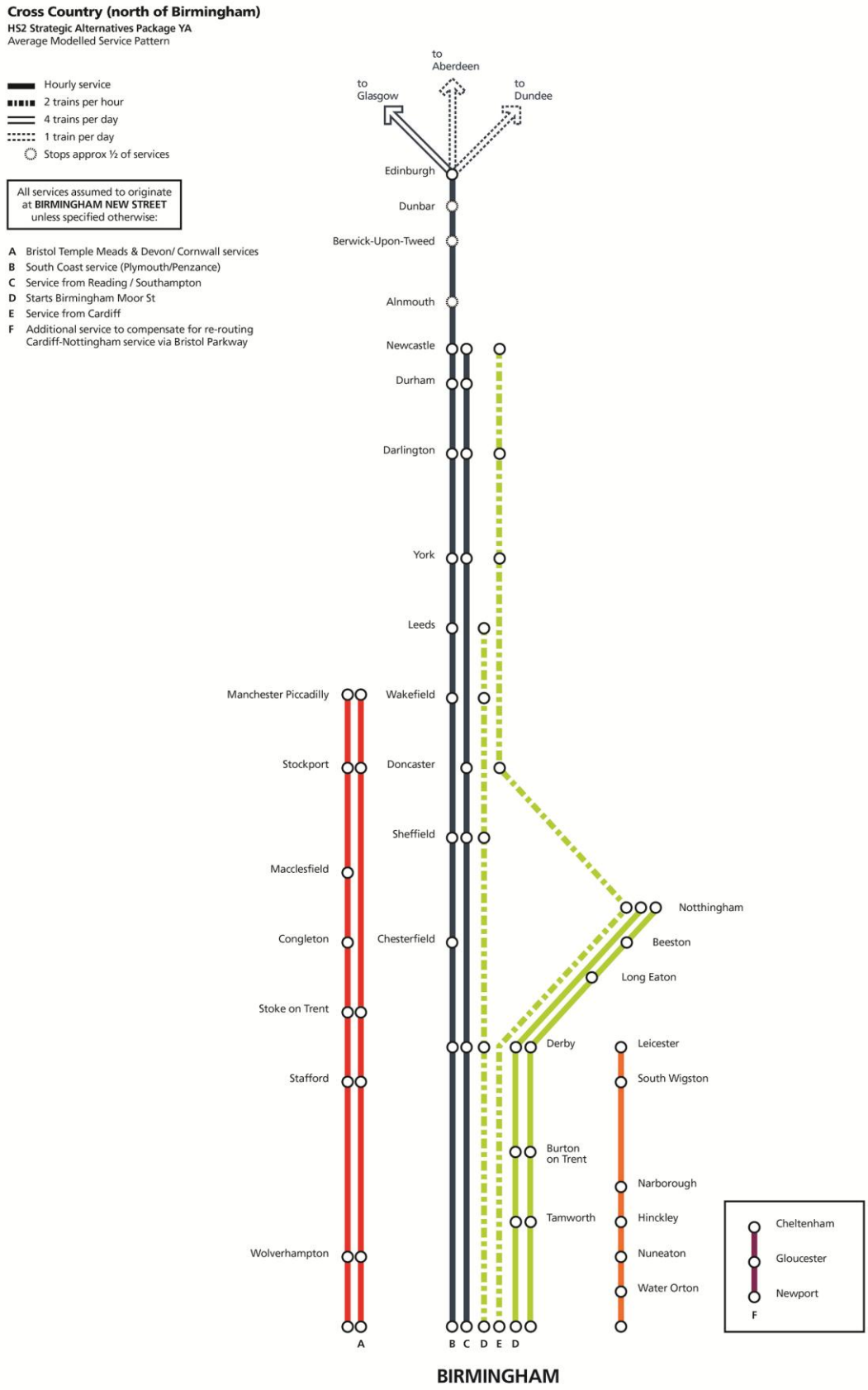


Figure 4-8 Summary of Package YA Upgrade Projects: North

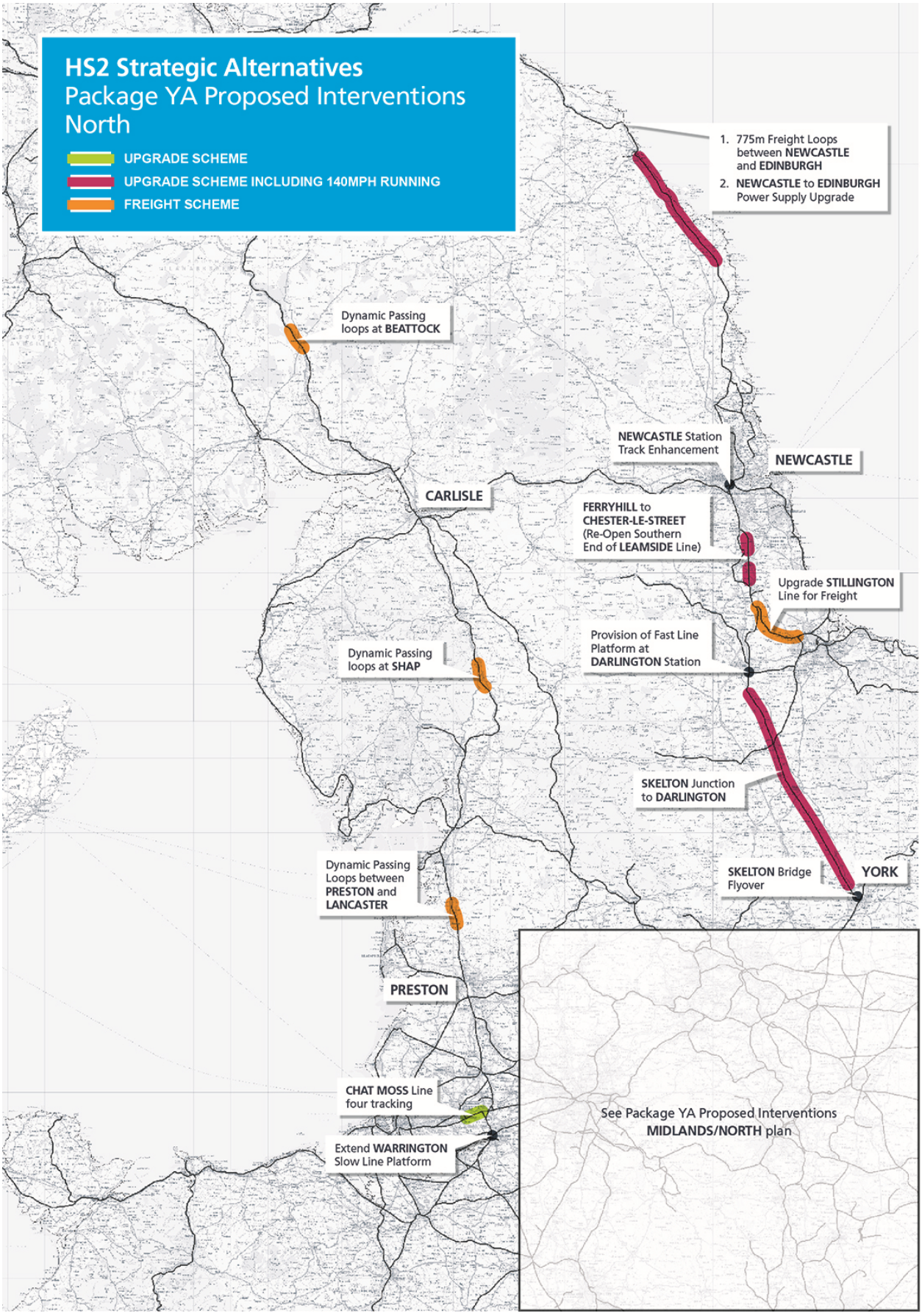


Figure 4-9 Summary of Package YA Upgrade Projects: Midlands/North

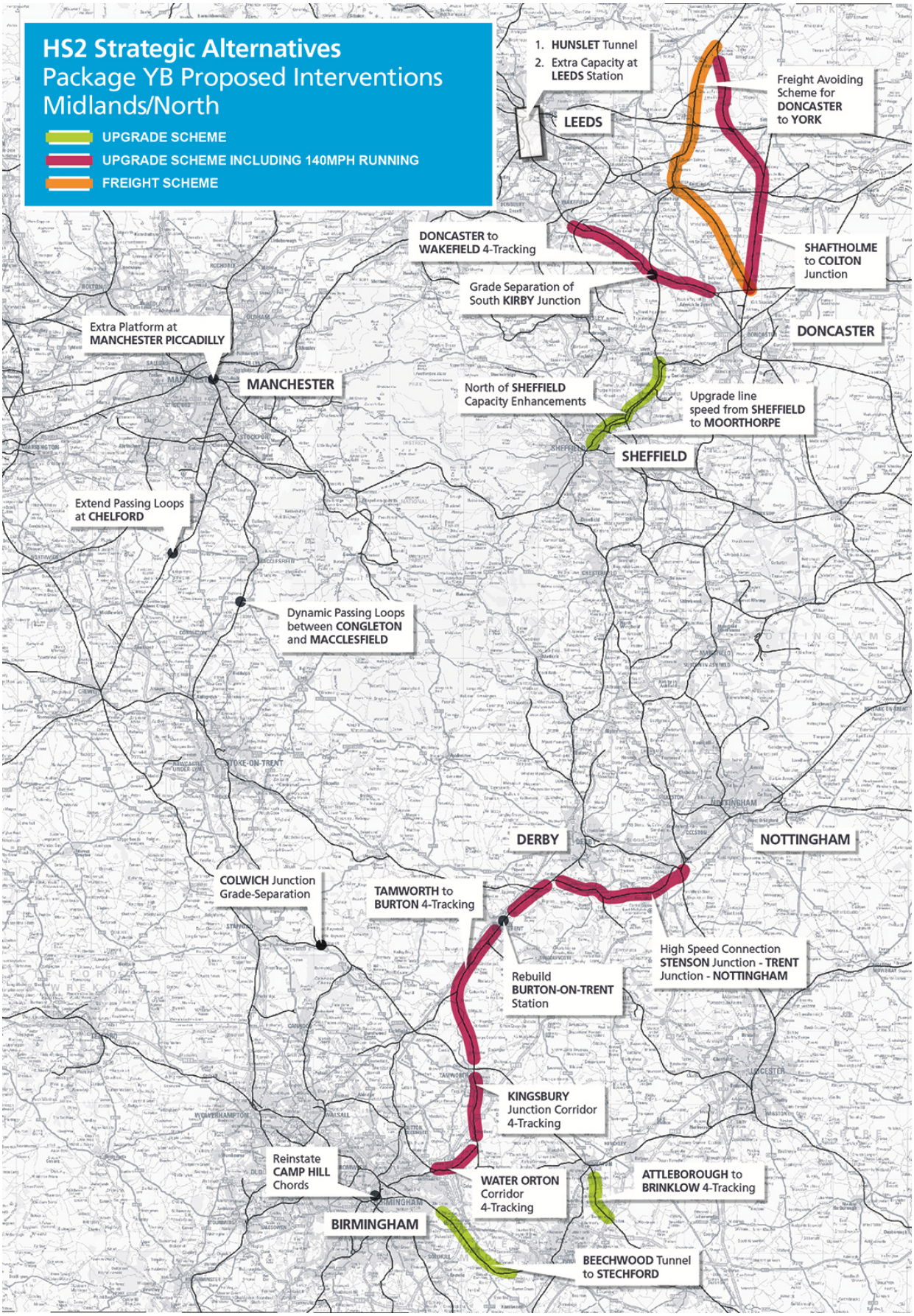
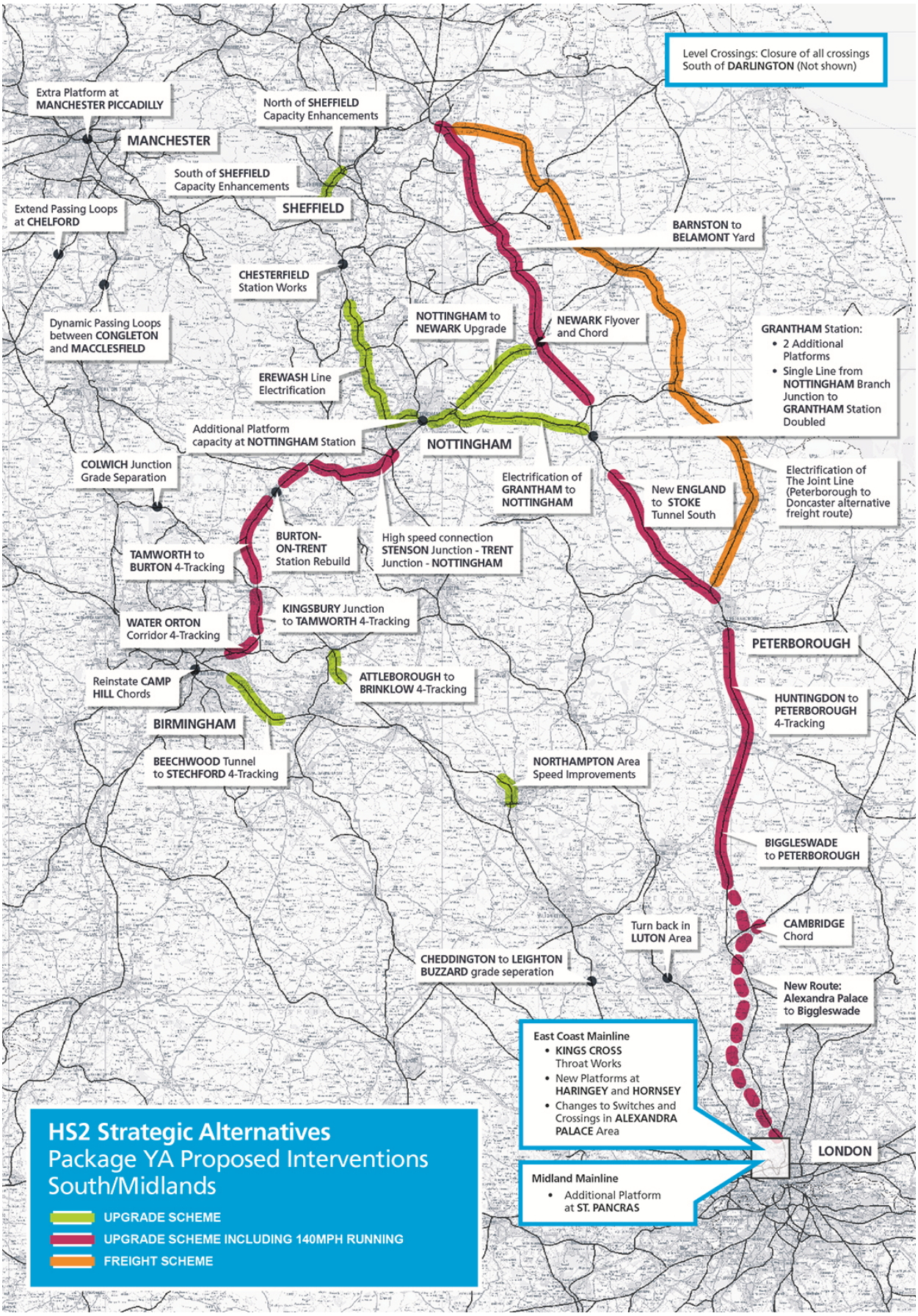


Figure 4-10 Summary of Package YA Upgrade Projects – South/Midlands



4.4. Upgrade Package YB

Package YB is designed as a second strategic alternative upgrade package for both Phase One and Phase Two of HS2. It assumes HS2 is not constructed. An outline description of what Package YB is intended to deliver is provided below.

East Coast Main Line

A 10 tph timetable is provided for intercity ECML services, with all rolling stock assumed to be operated by 140mph IEP sets, with improved segregation of fast services north of Hitchin. This is an incremental increase of 3tph over the intercity frequency of 7tph in the Do Minimum. Services to Leeds are assumed to be operated by 7 car IEP sets, while services to Bradford are assumed to be operated by 5 car IEP sets (extended to 10 car sets in the peak). Services to Newcastle and Scotland are assumed to be operated by 9 car IEP sets. The assumed service specification is:

- London – Leeds: 4tph (2tph express services stopping Wakefield Westgate only, 2tph via Hambleton extending to Bradford);
- London – Newcastle: 4tph, all stopping York and 3 extend to Edinburgh;
- London – Lincoln: 1tph; and
- 1tph open access service assumed to continue as per Do-minimum (rolling stock upgraded to 5 car IEP to benefit from journey time improvements on ECML).
- An additional 2tph shuttle service between Doncaster and Leeds (suburban 4 car unit) is also proposed to compensate for the loss of connectivity between Leeds and Doncaster by operating the direct Leeds services non-stop to Wakefield.

Suburban services operating on the ECML are modified to provide the following:

- London – Royston: additional 2tph all-day stopping service.

The above service specification is shown in Figure 4-11.

Midland Main Line

An 8 tph intercity service pattern (6tph off-peak) is provided, with the following service specification assumed (shown in Figure 4-12):

- London St Pancras – Sheffield extended to Leeds: 2tph (fast between London and Leicester)
- London St Pancras – Nottingham: 2tph (fast calling Leicester only)
- London St Pancras – Nottingham: 1tph (calling at intermediate stations)
- London St Pancras – Derby: 1tph (calling at intermediate stations)
- London St Pancras – Corby: 2tph in the peak only
- Bedford – Corby: 2tph

The above off-peak service frequency is the same as the Do-minimum MML intercity frequency of 6tph, while the peak service frequency is an incremental increase of 2tph. This package provides 3tph to Nottingham compared with 2tph in the Do-minimum, and a service terminating at Derby which is served by Sheffield trains in the Do-minimum. Services to Corby are operated from St Pancras in the peak, while in the off-peak, it is proposed to extend existing Thameslink services from Bedford to Corby.

The Sheffield/Leeds and Nottingham (fast) services are assumed to be operated by 7 car IEP sets, while the Derby and Nottingham hourly stopping services are operated by 5 car IEP sets. The Corby services are assumed to be operated by 12 car Class 377 sets in the peak, and 8 car Thameslink rolling stock in the off-peak.

Suburban capacity on the MML is increased in this scenario through the provision of an additional 2tph all-day between London St Pancras and Luton.

West Coast Main Line

The deliverables for the West Coast Mainline in Package YB are the same as for Package YA as described in the previous section.

Cross Country

Package YB assumes a higher frequency timetable along the Cross Country corridor between Birmingham and the East Midlands. The overall train service specification is shown below and represented diagrammatically in Figure 4-13:

- Birmingham – Manchester: 1tph
- South coast – Manchester: 1tph (via Birmingham)
- Cardiff – Newcastle: 2tph (existing Cardiff - Nottingham service extended to Newcastle, running non-stop between Birmingham and Nottingham. Also re-routed via Bristol Parkway to ensure the whole route is electrified)
- Birmingham – Nottingham: 2tph (local stopping services, 1tph from Birmingham Moor Street to compensate for the loss of connectivity by running the Cardiff services non-stop to Nottingham and 1tph existing service from Birmingham New Street)
- Newport – Cheltenham: 1tph (local stopping service to compensate for the loss of connectivity by rerouting the Cardiff – Nottingham - Newcastle service via Bristol)
- Birmingham – Leicester: 1tph
- South Coast – Scotland: 1tph (stopping pattern modified to run non-stop between Birmingham and Derby)
- Southampton/Reading – Newcastle: 1tph (re-routed via Leeds instead of via Doncaster)
- Doncaster – Sheffield shuttle: 1tph (to compensate for loss of connectivity from re-routeing the Reading – Newcastle services via Leeds instead of Doncaster)

This gives a total of 6 Cross Country services east of Birmingham: 2 via Sheffield and Leeds to Newcastle/Scotland, 2 new services via Nottingham to the ECML and then on with stops to Newcastle, and 2 stopping services to Nottingham. The new services from Cardiff to Newcastle and Birmingham Moor Street to Leeds are assumed to be operated by 5 car IEP sets. The services between Scotland and the south coast and Southampton/Reading and Newcastle are also assumed to be operated by 5 car IEP sets to benefit from journey time improvements delivered by the infrastructure upgrades on the Cross Country route north-east of Birmingham, between Sheffield and Leeds and also along the ECML. The local stopping services between Birmingham and Nottingham are assumed to be operated by Class 170 rolling stock.

The above specification includes 2 tph between Birmingham and Manchester which are present in the Do Minimum service specification. When combined with the 2 services extended from Wolverhampton to Manchester (described in the WCML section above), Package YA effectively provides 4tph between Birmingham and Manchester, and hence improved connectivity between the two cities.

Table 4-4 and Figures 4-14, 4-15 and 4-16 present a summary of the upgrade projects that have been included in Package YB.

Table 4-4 Package YB Intervention Components

Route	Components

East Coast Main Line	• King's Cross throat works, including lengthening all platforms to at least 12-car suburban length, reducing the total number of platforms by 1, and reopening the disused tunnels.
	• Huntingdon – Peterborough area -4 tracking
	• Line speed improvements on the fast lines north of Biggleswade on sections as far as Darlington, and on a section south of Berwick through replacing the OLE equipment, and works on the track, structures and formation
	• Level crossings - closure of all level crossings south of Darlington
	• Electrification of the Joint Line through Lincolnshire for freight and diversionary purposes
	• Grade separation at Doncaster to allow for east-west crossings without interfering with the operations of the main line
	• Freight avoiding scheme for Doncaster – York via Barnby Dun and Knottingley Darlington - provision of fast line platform at Darlington Station
	• New platforms at Haringey and Hornsey to enable more intensive use of second slow lines for short distance services, leaving slow line 1 clear for longer distance Thameslink services until north of Alexandra Palace
	• Welwyn - 4 tracking from Woolmer Green – Welwyn North, with platforms at Welwyn North on the slow lines
	• Darlington - provision of fast line platform at Darlington Station
	• Northallerton to Newcastle:
	  • Upgrade the Stillington Line – 60 or 75mph with 4 or 5 minute headways
	  • Re-open southern end of Leamside Line for passenger between Tursdale and, via a largely tunnelled new alignment, Chester-le-street (140mph where possible)
	  • Upgrade gauge of Northallerton tunnel and platforms
	• Doncaster - Leeds improvements (4-tracking between Doncaster and Wakefield, a new tunnelled approach to Leeds and extra platforms at Leeds).
	• Newcastle - Edinburgh power supply upgrade - to allow 3tph London – Edinburgh
	• 775m Freight loops between Newcastle and Edinburgh
	• Skelton Bridge Flyover north of York
	• Additional trackwork at Newcastle station to improve access to the terminating bay platforms
	• Newark flyover and chord connecting to the ECML

Midland Main Line	• Additional platform at St Pancras
	• Selective line speed improvements between Bedford and Leicester & Hendon Lines electrification
	• Turn-back in the Luton area - centre turn-back at Linbury
	• Wellingborough by-pass
	• Market Harborough by-pass
	• Sileby - Loughborough line-speed improvements
	• Upgrade southern end of route – new tunnel from Canal Tunnel Junction to Kentish Town and grade separation south of St Albans
	• Sheffield - Leeds improvements (minor)
	  • Upgrade linespeed from Sheffield to Moorthorpe to 125mph
	  • Grade separated junction at South Kirby
	• 4-track Tamworth to Stenson Junction at 140mph
	• Rebuild Burton-on-Trent station
	• High speed connection Stenson Junction – Trent Junction – Nottingham
	• North of Sheffield capacity enhancements, including a tunnel immediately north of the station to segregate long distance from many short distance

Route	Components
	services, and diverted local services to serve new Meadowhall station.
West Coast Main Line	• 4-tracking Attleborough to Brinklow • 4-tracking Beechwood Tunnel to Stechford, including stations • 4-tracking Chat Moss Line, approx 3 miles • Dynamic passing loops at Shap and Beattock • Extend Warrington slow line platforms to enable splitting / joining • Grade separated Colwich Junction • Grade separated junction between Cheddington and Leighton Buzzard • North of Preston, Dynamic passing loops, & 75mph turnouts between Preston & Lancaster • Northampton area speed improvements. • Re-instate the Camp Hill chords to be able to use Moor Street station, and additional platforms. • 4-tracking Kingsbury Junction to Tamworth (approx 6 miles) • 4-tracking Water Orton corridor (approx 8 miles) to Water Orton Junction • 140mph linespeed improvements Birmingham to Derby (Cross Country via Tamworth and Burton) • Dynamic passing loops between Congleton and Macclesfield station • Extend passing loops at Chelford • 1 x Extra Platform at Manchester Piccadilly

Figure 4-11 Package YB: ECML Modelled Service Specification

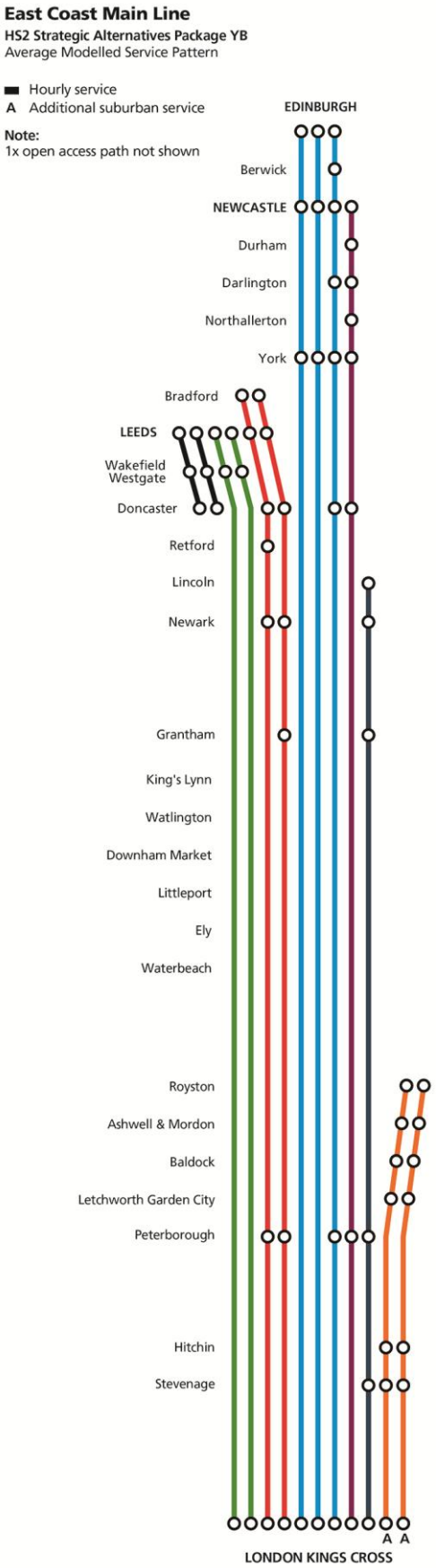


Figure 4-12 Package YB: MML Modelled Service Specification

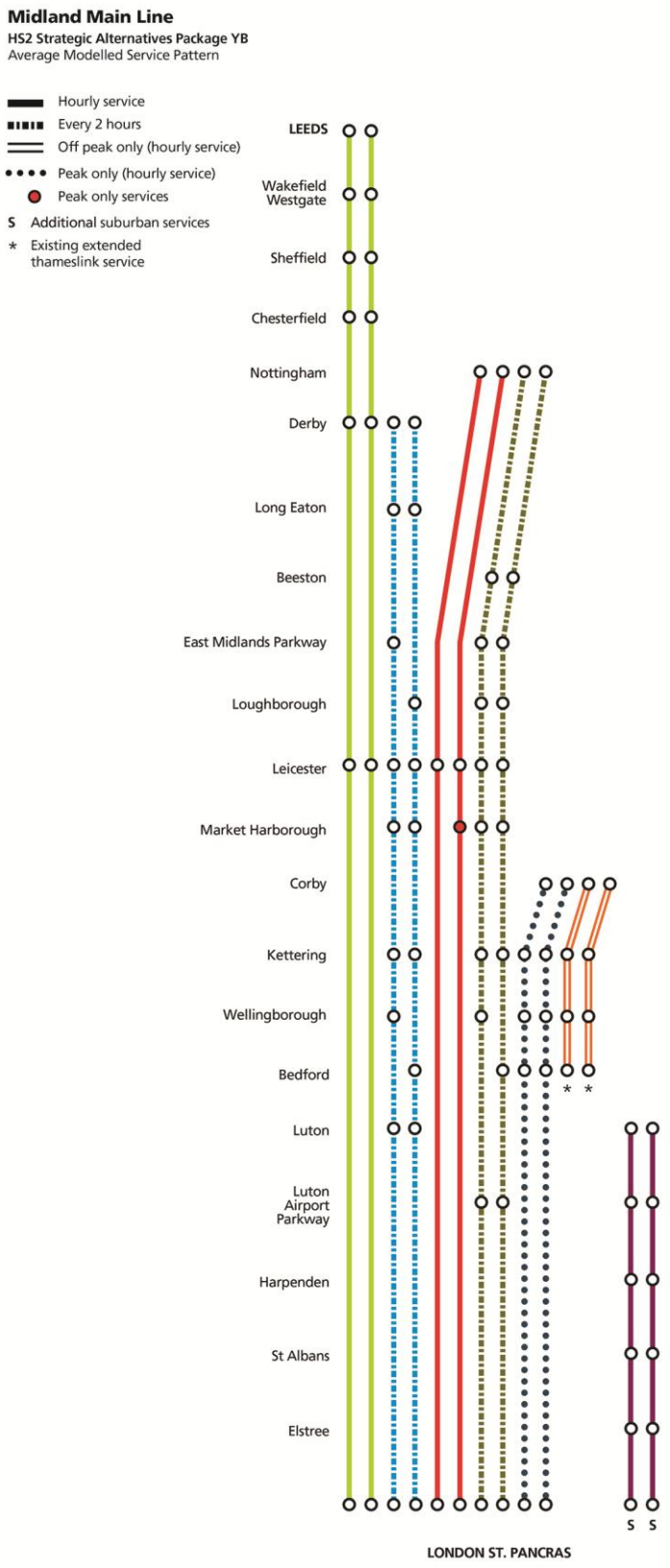


Figure 4-13 Package YB: Cross Country Modelled Service Specification

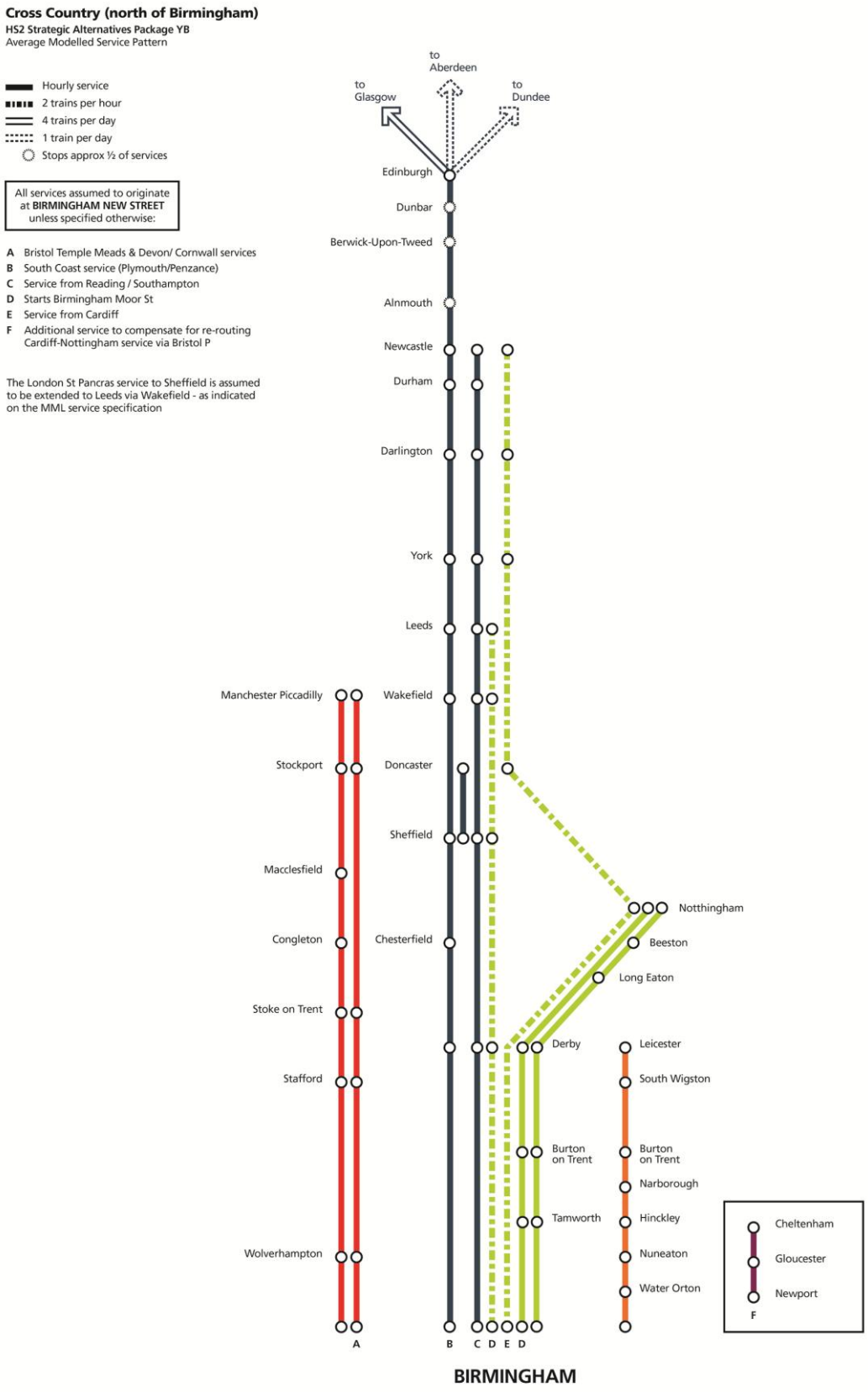


Figure 4-14 Summary of Package YB Upgrade Projects: North

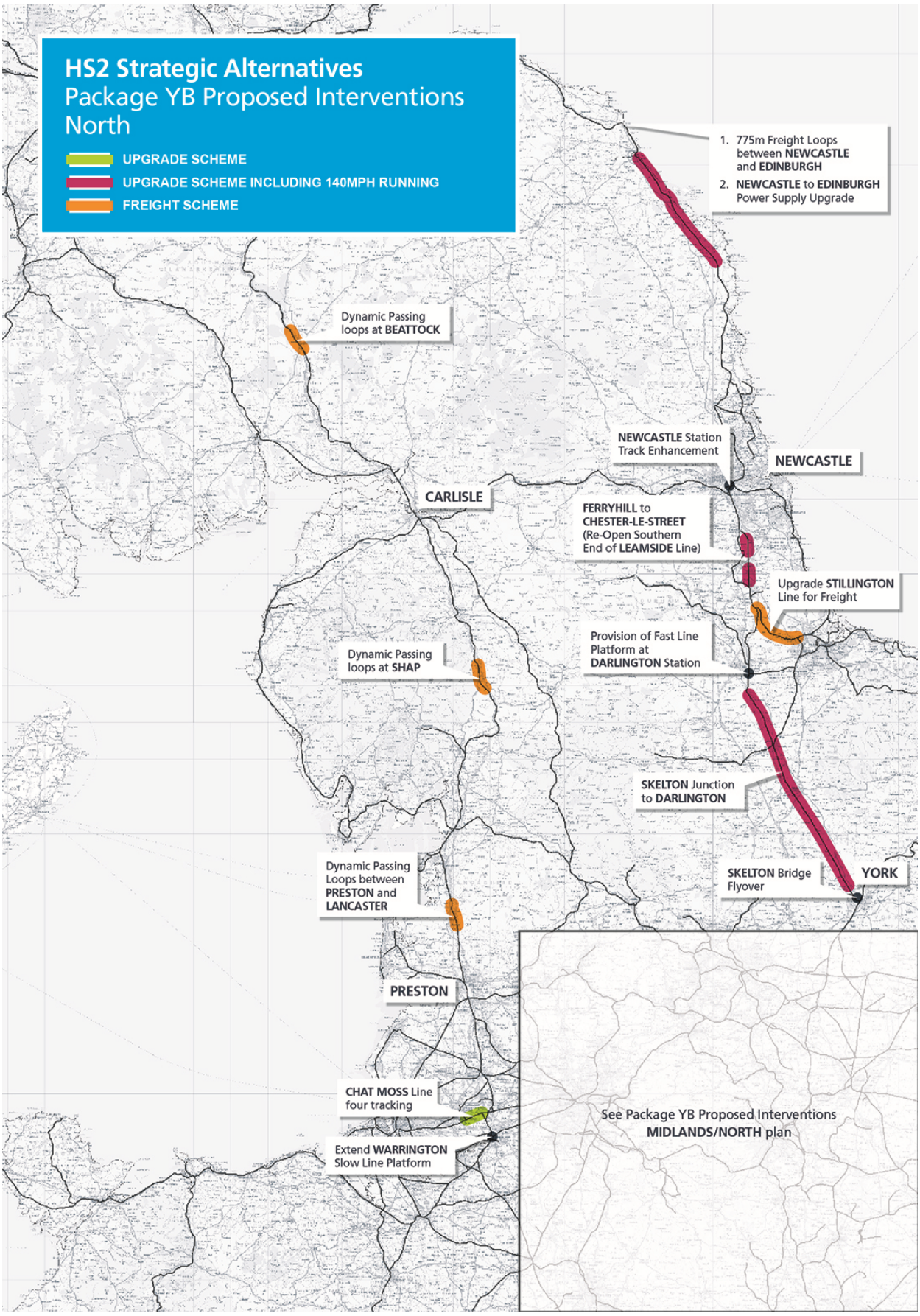


Figure 4-15 Summary of Package YB Upgrade Projects: Midlands/North

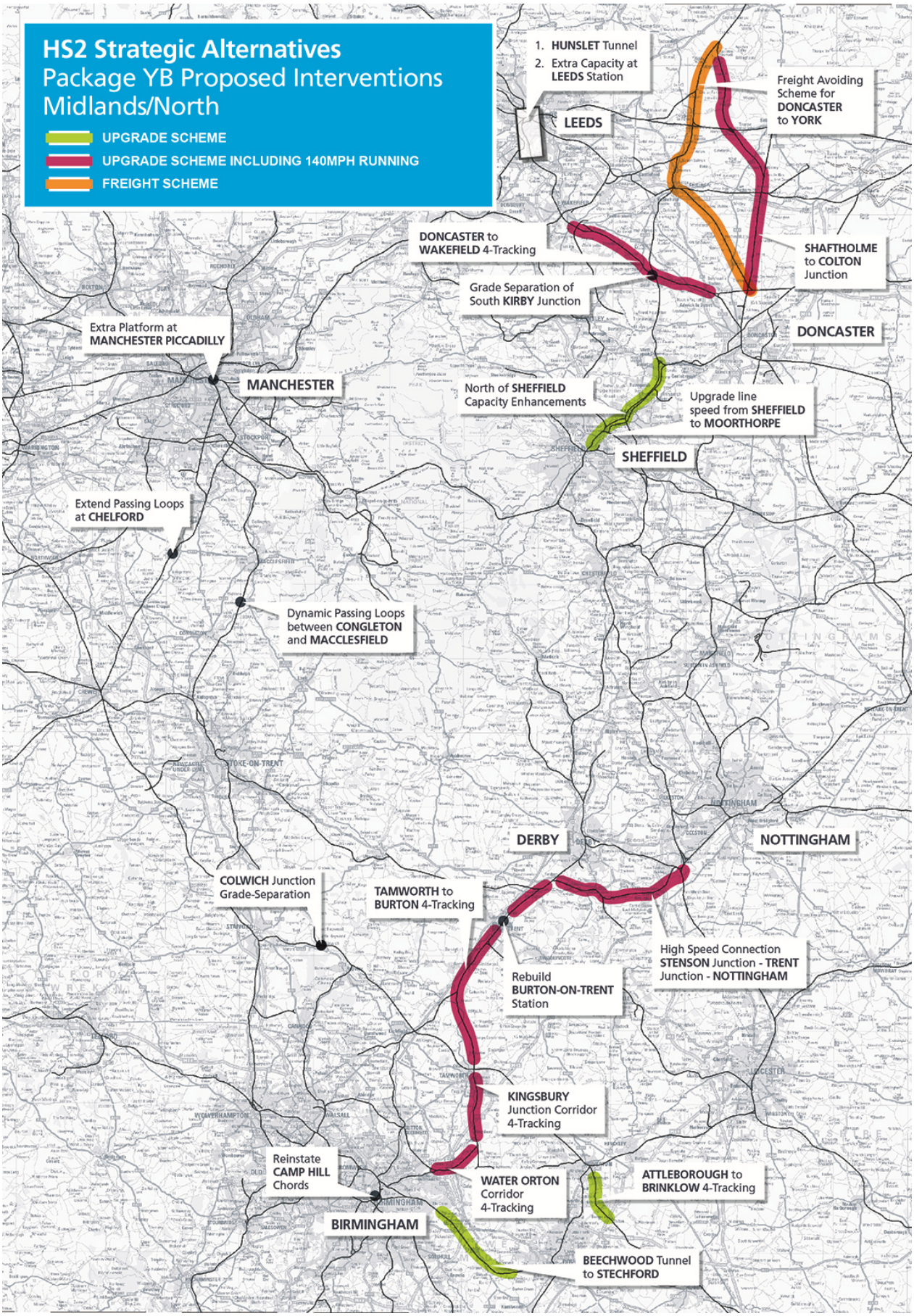
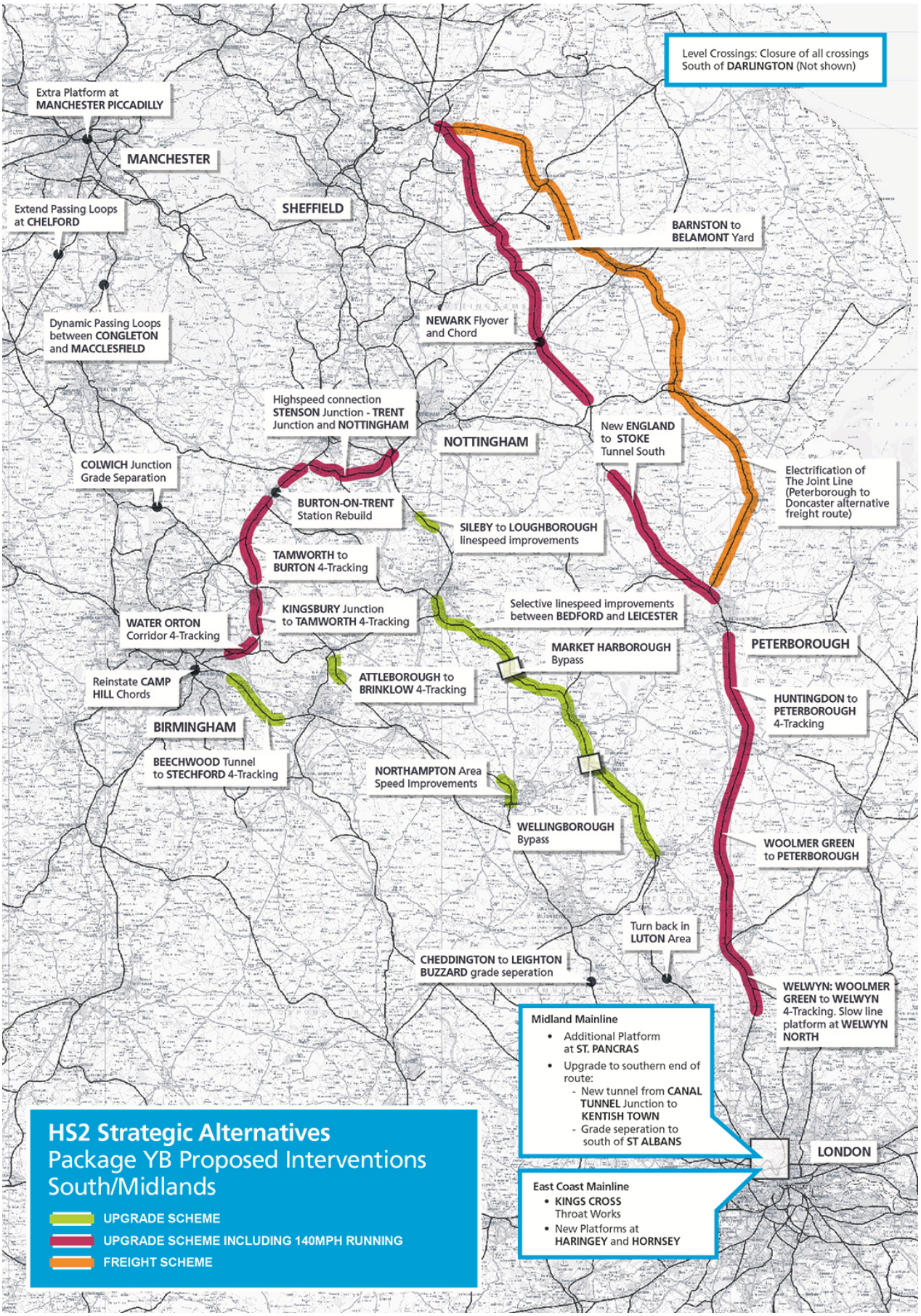


Figure 4-16 Summary of Package YB Upgrade Projects – South/Midlands



4.5. Upgrade Package P2A

Package P2A is a strategic alternative to HS2 Phase Two only, and assumes that HS2 Phase One has already been delivered. An outline description of what Package P2A is intended to deliver is provided below. . Indicative train service patterns assumed for the modelling of this package are represented diagrammatically in Figures 4-17 to 4-20.

East Coast Main Line

A 9 tph timetable is provided for intercity ECML services, with all rolling stock assumed to be operated by 140mph IEP sets, segregated from commuter, freight and other services for much of the route between London and Newcastle. This is an incremental increase of 2tph over the inter-city frequency of 7tph in the Do Minimum. Services to Leeds are assumed to be operated by 7 car IEP sets, while services to Bradford are assumed to be operated by 5 car IEP sets (extended to 10 car sets in the peak). Services to Newcastle and Scotland are assumed to be operated by 9 car IEP sets. The assumed service specification is summarised below and shown in Figure 4-17:

- London – Leeds: 4tph (2tph express services stopping Wakefield Westgate only and 2tph via Hambleton extending to Bradford);
- London – Newcastle: 4tph, all stopping York and 3 extending to Edinburgh; and
- 1tph open access service assumed to continue as per Do-minimum (rolling stock upgraded to 5 car IEP to benefit from journey time improvements on ECML).
- An additional 2tph shuttle service between Doncaster and Leeds is also proposed to compensate for the loss of connectivity between Leeds and Doncaster by operating the direct Leeds services non-stop to Wakefield.

Suburban services operating on the ECML are modified to provide the following:

- London – Cambridge: 4tph speeded up ‘fast’ services, with 1tph extended to Kings Lynn (replacing the current 1 tph to Cambridge and 1tph to Kings Lynn); and
- London – Royston: additional 2tph all-day stopping service.

The fast services to Cambridge are assumed to be operated 5 car IEP sets (extended to 10 car sets in the peak), while Royston services are operated by 4 car Class 350 sets.

Midland Main Line

A 10 tph long distance timetable is provided, with 4tph operated via the HS2 Phase One network. The following service specification is assumed (shown in Figure 4-18):

- London Euston – Derby and Sheffield **via HS2 Phase One**: 2tph
- London Euston – Nottingham **via HS2 Phase One**: 2tph
- London St Pancras – Sheffield: 2tph (fast to Leicester then calling at intermediate stations between Leicester and Sheffield)
- London St Pancras – Nottingham: 1tph (calling at intermediate stations)
- London St Pancras – Derby: 1tph (calling at intermediate stations)
- London St Pancras – Corby: 2tph

The service frequency shown above is the same as the Do-Minimum intercity service frequency of 6tph in terms of departures from London St Pancras. Four additional services are provided to Derby/Sheffield and Nottingham via HS2 from London Euston.

The services to Sheffield and Nottingham via HS2 Phase One are assumed to be operated by 200m HS2 classic compatible sets. The remaining services are assumed to be operated by modern electric loco-hauled 7 car sets as per the Do-minimum, with the exception of the Corby services which are assumed to be operated by 4 car Class 377 sets (extended to 12 car in the peak).

Suburban capacity on the MML is increased in this scenario through the provision of an additional 2tph all-day between London St Pancras and Luton.

West Coast Main Line

A modified version of HS2's Phase 1 timetable is proposed for WCML in this scenario, with additional services provided to utilise the spare paths on the Phase 1 network (assuming that Phase 2 is not built then 6 train paths are available). Extra services are provided to Manchester and Birmingham, and connectivity is increased through the extension of the HS service to Preston north to Carlisle. The assumed High Speed service specification is as follows:

- Euston – Birmingham Curzon Street: 4tph (1 tph additional over the HS2 Phase One timetable)
- Euston – Manchester: 4tph (additional 1tph over the HS2 Phase One timetable)
- Euston – Carlisle: 1tph (achieved by extending the HS2 Preston service to Carlisle, with stops at Lancaster, and Penrith/Oxenholme served alternately every two hours)
- Euston – Liverpool: 2tph, as per the HS2 Phase One service specification
- Euston – Glasgow: 1tph, as per the HS2 Phase One service specification

The additional Manchester service provides improved connectivity by routeing via Stoke. Additional stops are added into the other Manchester services at either Crewe or Wilmslow. In providing a fourth service per hour to Birmingham, the service specification assumes that the capacity of the existing HS2 trains to Birmingham will be halved (i.e. the 400m trains, which operate as 2x200m captive HS sets, will be reduced to single 200m sets), with the sets freed up by this proposal being used to provide the additional service. This enables the operation of 4tph to Birmingham without requiring the procurement of additional rolling stock to provide the additional service.

HS2's classic line service specification has been modified to provide improved connectivity and reduced journey times to stations north of Stafford. The following service specification (in addition to the Do-minimum) has been assumed:

- Euston – Birmingham – Wolverhampton – Manchester: 2tph
- Euston – Crewe via Stoke and Alsager: 1tph
- Euston – Blackpool: 1tph
- Euston – Glasgow via Manchester: 8tpd
- Euston – Edinburgh via Manchester: 8tpd
- Euston – Chester: 1tph with 3 tpd extending to Llandudno and 5tpd extending to Holyhead
- Euston – Northampton:1tph

The three peak trains to Manchester and Crewe respectively in HS2's classic line timetable have been removed. These services were no longer required given the improved connectivity provided by the fourth HS service to Manchester and the introduction of a Crewe stop into one of the HS2 services to Manchester. The existing London Midland service from Euston to Crewe was removed and replaced with the faster Pendolino service to Crewe via Stoke and Alsager shown above. Some small journey time savings have also been achieved by removing all stops from the Chester/North Wales services south of Stafford (stops at stations south of Stafford have been included in the Crewe and Blackpool services to compensate), and by varying the stopping pattern on the Glasgow/Edinburgh services north of Lancaster (stops at Carlisle and Lockerbie removed, and Penrith/Oxenholme served every two hours).

The above service specifications are shown in Figure 4-19.

Cross Country

Package P2A assumes a higher frequency timetable along the Cross Country corridor between Birmingham and the East Midlands. The overall service specification is summarised below and shown in figure 4-20:

- Birmingham – Manchester: 1tph
- South coast – Manchester: 1tph (via Birmingham)
- Birmingham Curzon Street – Nottingham - Newcastle: 2tph
- Birmingham Curzon Street – Leeds: 2tph.
- Birmingham – Nottingham: 1tph
- Cardiff – Nottingham: 1tph (via Birmingham New Street)
- Birmingham – Leicester: 1tph
- South Coast – Scotland: 1tph

- Southampton/Reading – Newcastle: 1tph

The services between Curzon Street and Newcastle/Leeds are additional services proposed by Package 2A, and are assumed to be operated by 5 car IEP sets, making use of a short section of HS2 to get to Lichfield and chord to the Derby line. The services between Scotland and the south coast and Southampton/Reading and Newcastle are also assumed to be upgraded to 5 car IEP operation to benefit from the journey time improvements delivered by the infrastructure upgrades on both the Cross Country route north-east of Birmingham and also along the ECML.

Table 4-5 and Figures 4-21 to 4-23 present a summary of the upgrade projects that have been included in Package P2A.

Table 4-5 Package P2A Intervention Components

Route	Components

East Coast Main Line	• King's Cross throat works, including lengthening all platforms to at least 12-car suburban length, reducing the total number of platforms by 1, and reopening the disused tunnels.
	• Additional 2 tracks between Alexandra Palace and Biggleswade via a combination of tunnel to the M25 and then new alignment broadly following the A1
	• Huntingdon – Peterborough 4 tracking
	• Line speed improvements on the fast lines north of Biggleswade on sections as far as Darlington, and on a section south of Berwick through replacing the OLE equipment, and works on the track, structures and formation
	• Level crossings - closure of all level crossings south of Darlington
	• Electrification of the Joint Line through Lincolnshire for freight and diversionary purposes
	• Grade separation at Doncaster to allow for east-west crossings without interfering with the operations of the main line
	• Freight avoiding scheme for Doncaster – York via Barnby Dun and Knottingley
	• Darlington - provision of fast line platform at Darlington Station
	• Northallerton to Newcastle:
	  • Upgrade the Stillington Line – 60 or 75mph with 4 or 5 minute headways
	  • Re-open southern end of Leamside Line for passenger between Tursdale and, via a largely tunnelled new alignment, Chester-le-street (140mph where possible)
	  • Upgrade gauge of Northallerton tunnel and platforms
	• New platforms at Haringey and Hornsey to enable more intensive use of second slow lines for short distance services, leaving slow line 1 clear for longer distance Thameslink services until north of Alexandra Palace
	• Changes to S&C in Alexandra Palace area to help access to and from the fast lines for Thameslink services north of the new tunnel entrance at Alexandra Palace
	• Doncaster - Leeds improvements (4 -tracking between Doncaster and Wakefield, a new tunnelled approach to Leeds and extra platforms at Leeds).
	• Newcastle - Edinburgh power supply upgrade - to allow 3tph London - Edinburgh
	• Cambridge chord – cut-off route from new Alexandra Palace to Biggleswade line south of Baldock to join line to Cambridge.
	• 775m Freight loops between Newcastle and Edinburgh
	• Skelton Bridge Flyover north of York
	• Additional trackwork at Newcastle station to improve access to the terminating bay platforms

Route	Components
	• Newark flyover and chord connecting to the ECML

Midland Main Line	• Turn-back in the Luton area - centre turn-back at Linbury
	• 4-track Tamworth to Stenson Junction at 140mph (for HS2 services)
	• Rebuild Burton-on-Trent station (for HS2 services) with platforms on the slow lines
	• Wichnor Junction grade separation (for HS2 services)
	• Lichfield freight line - severe upgrade of the line to 140mph (for HS2 services)
	• New chord (approx. 1 mile) from HS2 to Lichfield freight line
	• High speed connection Stenson Junction – Trent Junction – Nottingham
	• Nottingham station extra capacity (Part A) - additional platform provided
	• Nottingham station extra capacity (Part B): Over and above that proposed in part A, provide capacity for additional 2tph through services
	• South of Sheffield capacity enhancements, including 4-tracked approach to Sheffield and a new tunnel avoiding Dore.
	• Sheffield - Leeds improvements:
	  • 4-track between Swinton and Moorthorpe / South Kirby Junction, grade separate South Kirby junction
	  • Upgrade line speed from Sheffield to Moorthorpe to 125mph
	• Nottingham to Newark upgrade with electrification and line speed increase to 125mph
	• North of Sheffield capacity enhancements including a tunnel immediately north of the station to segregate long distance from many short distance services, and diverted local services to serve new Meadowhall station.

West Coast Main Line	• Dynamic passing loops at Shap and Beattock • Grade separated Colwich Junction • North of Preston, Dynamic passing loops, & 75mph turnouts between Preston and Lancaster. • Dynamic passing loops between Congleton and Macclesfield station • Extend passing loops at Chelford • 1 x Extra Platform at Manchester Piccadilly on east side • Grade separation at Whitehouse Junction (near Shugborough)

Figure 4-17 Package P2A: ECML Modelled Service Specification

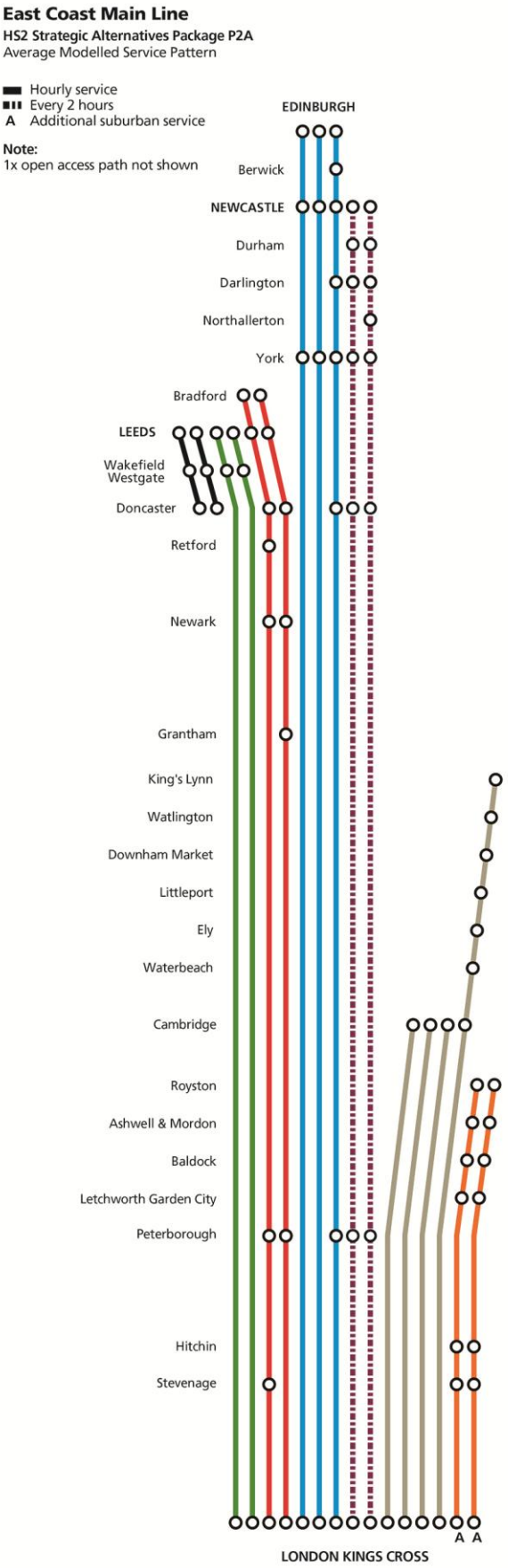


Figure 4-18 Package P2A: MML Modelled Service Specification

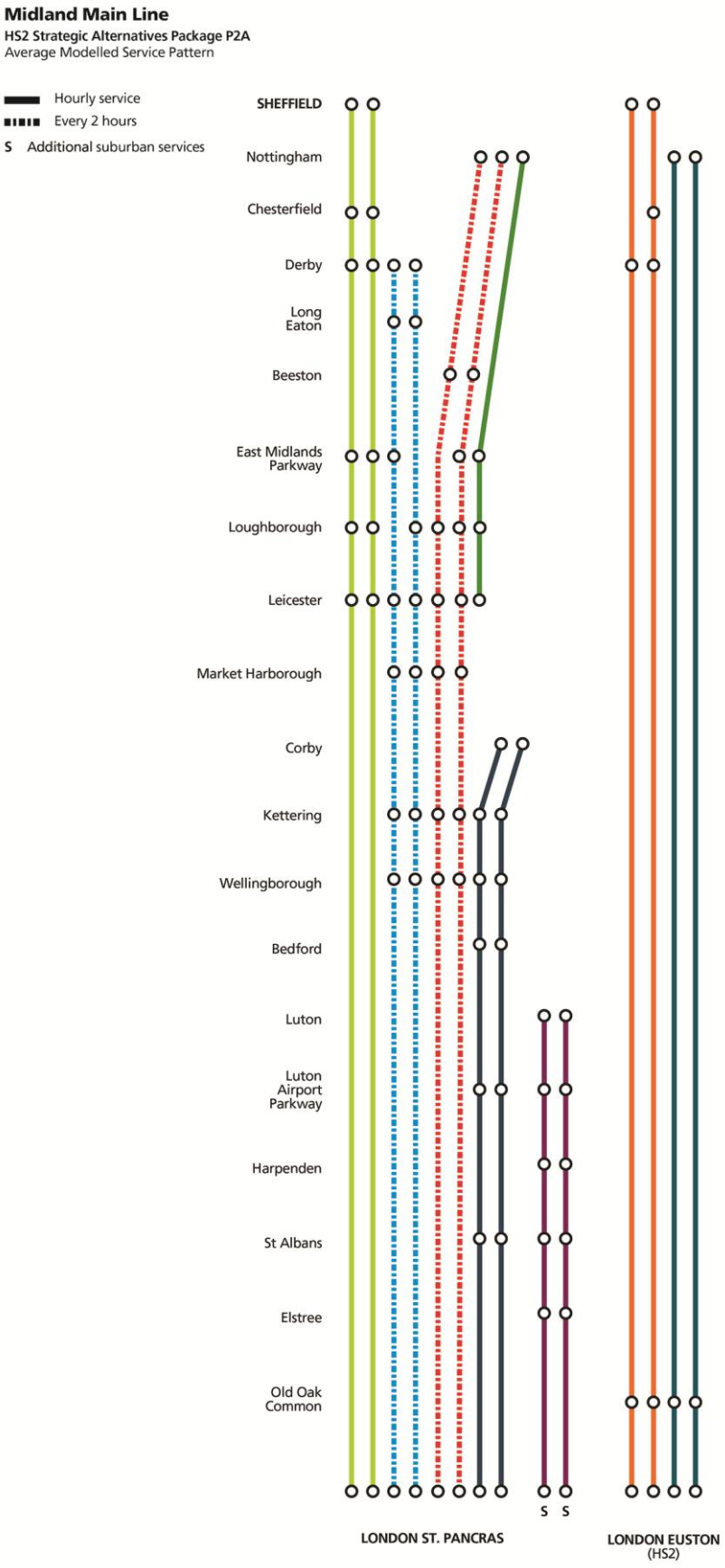


Figure 4-19 Package P2A: WCML Modelled Service Specification

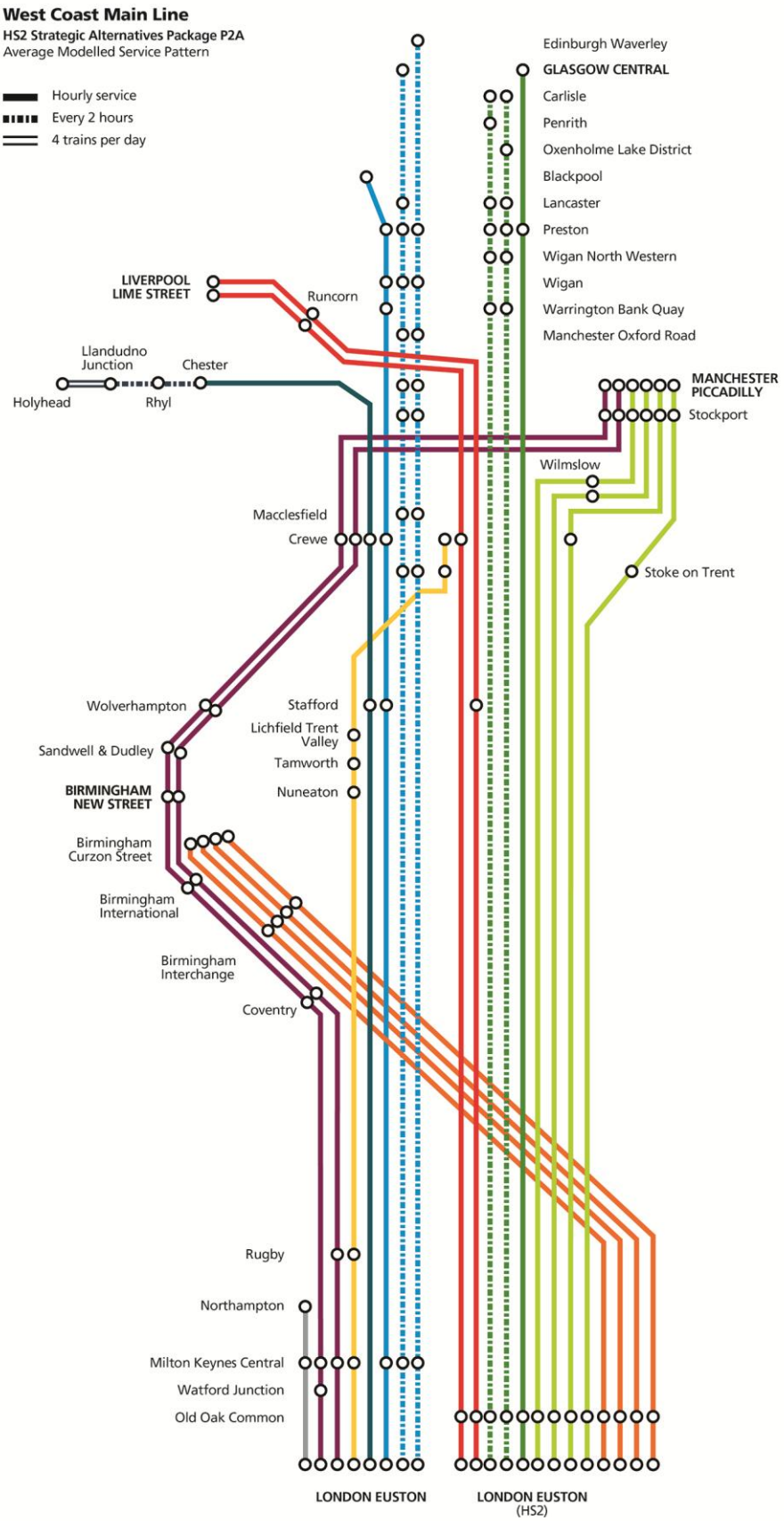


Figure 4-20 Package P2A: Cross Country Modelled Service Specification

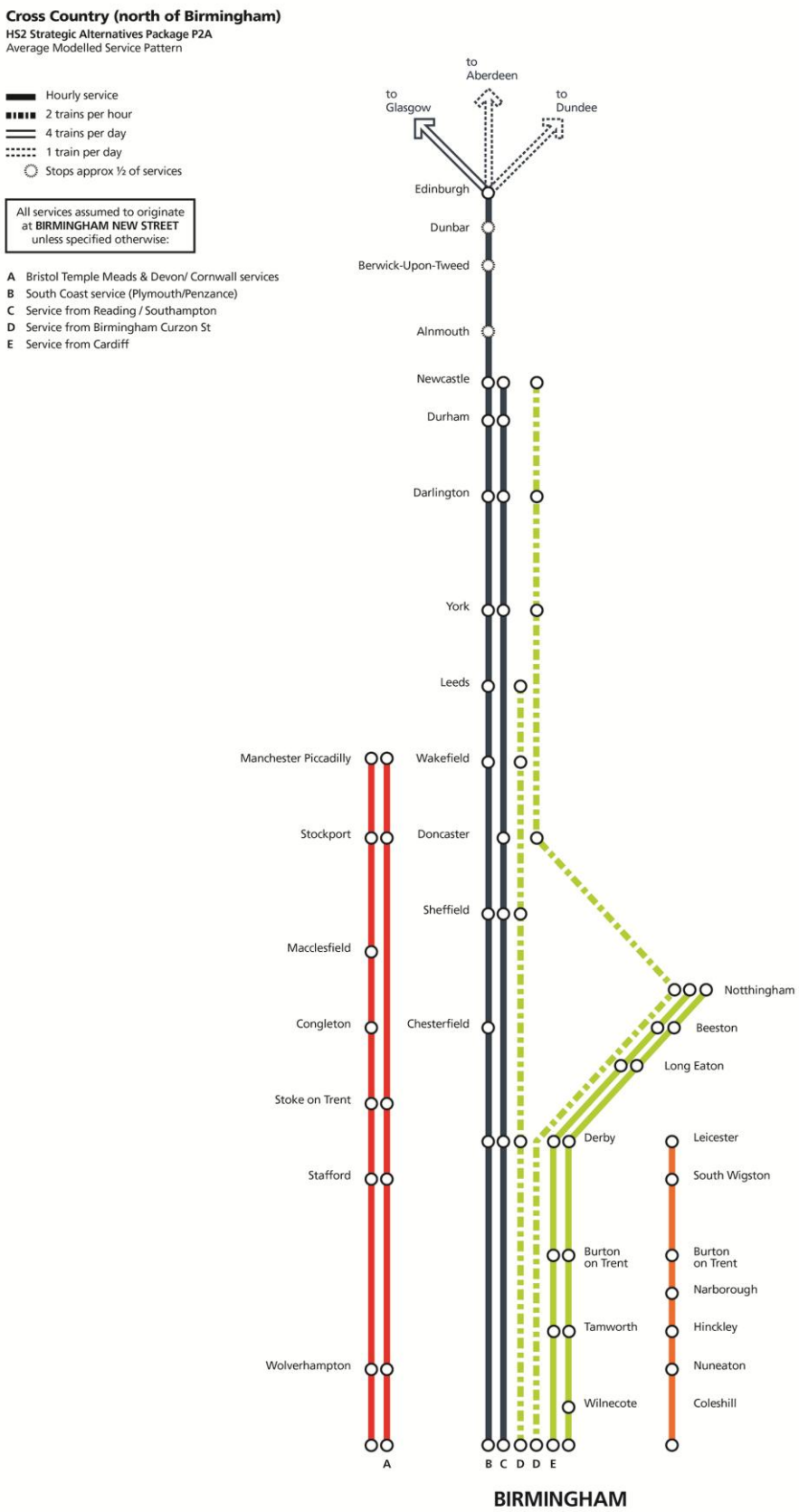


Figure 4-21 Summary of Package P2A Upgrade Projects: North

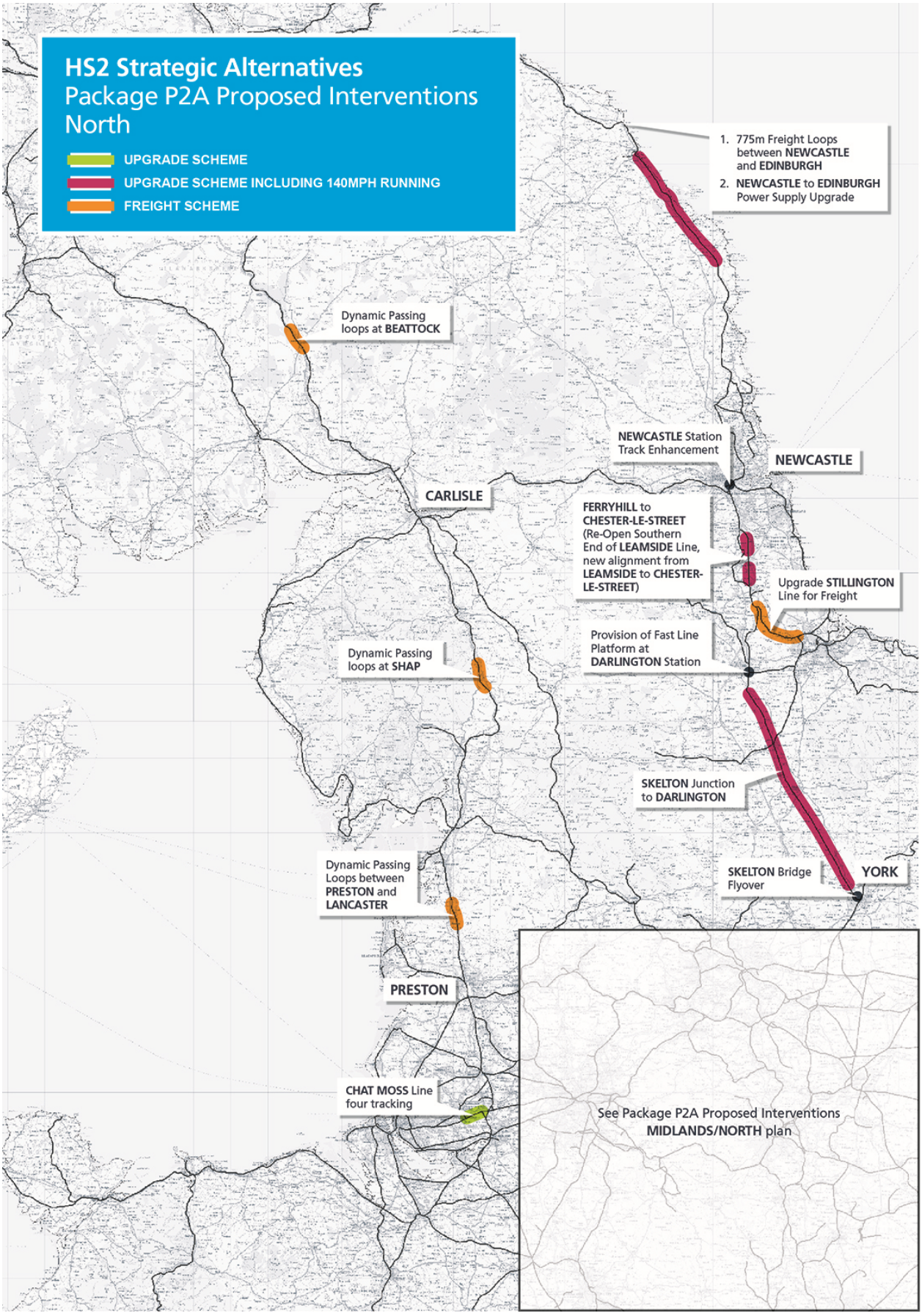


Figure 4-22 Summary of Package P2A Upgrade Projects: Midlands/North

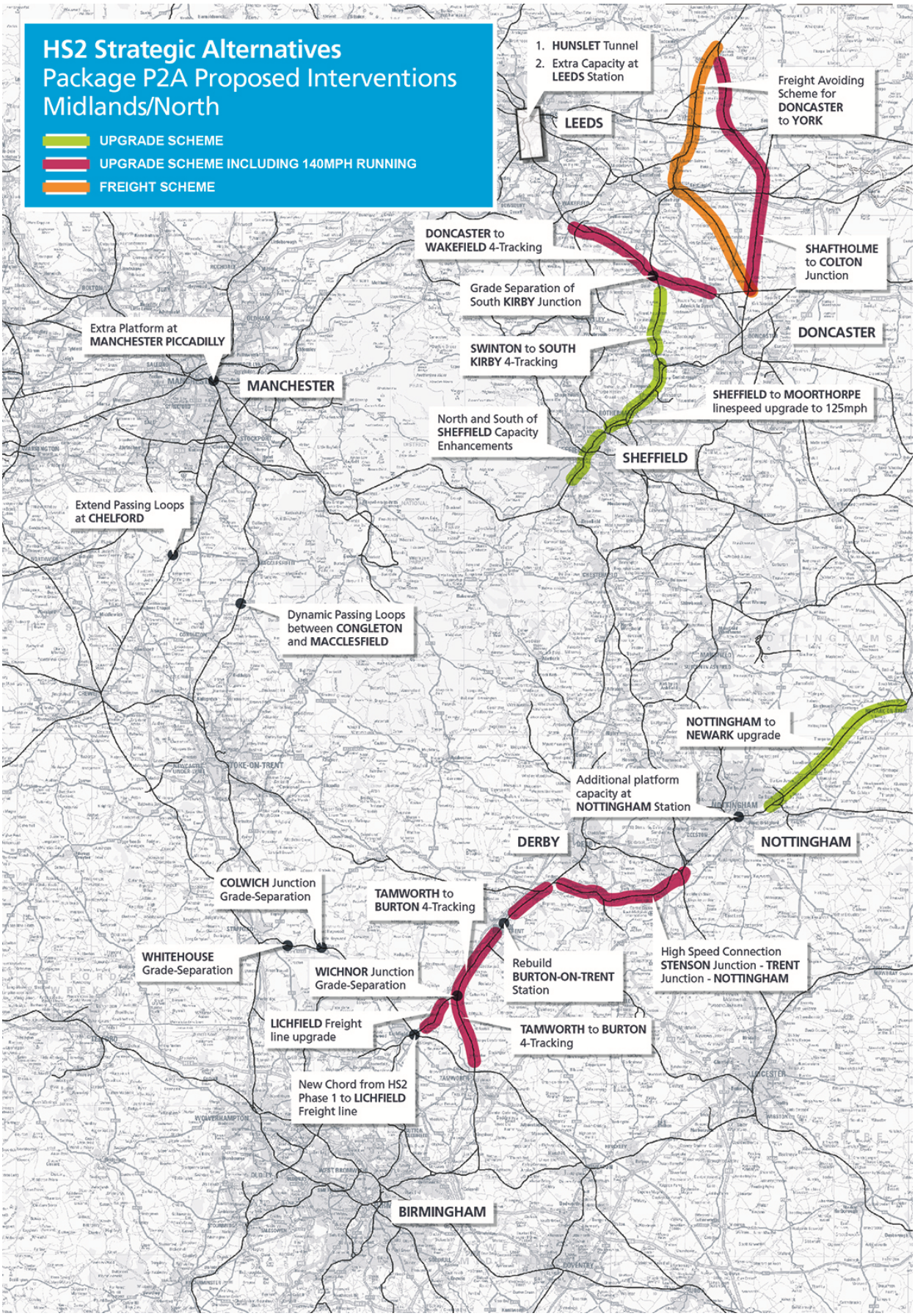
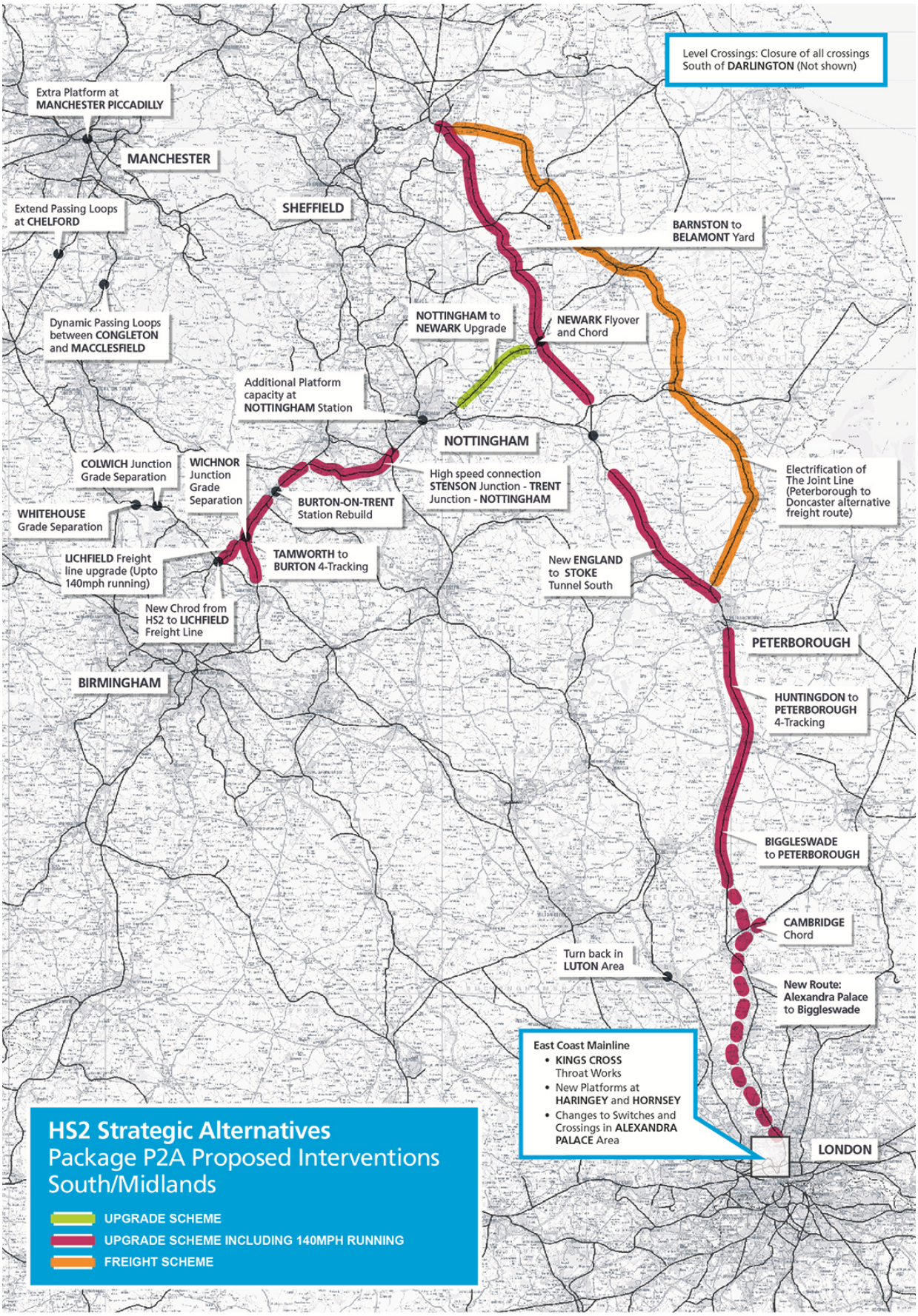


Figure 4-23 Summary of Package P2A Upgrade Projects – South/Midlands



4.6. Upgrade Package P2B

This package is similar to Package P2A with the exception being that fast services to Nottingham are provided via the ECML rather than via the HS2 Phase One. An outline description of what Package P2B is intended to deliver is provided below.

East Coast Main Line

An 11tph timetable is provided for intercity ECML services, with all rolling stock assumed to be operated by 140mph IEP sets segregated from commuter, freight and other services for much of the route between London and Newcastle. This represents an incremental increase of 4tph over the long distance frequency of 7tph in the Do Minimum. Services to Sheffield and Leeds are assumed to be operated by 7 car IEP sets, while services to Bradford are assumed to be operated by 5 car IEP sets (extended to 10 car sets in the peak). Services to Newcastle and Scotland are assumed to be operated by 9 car IEP sets. The assumed service specification is summarised below and shown in Figure 4-24:

- London – Nottingham: (stopping at Grantham only) 2 tph;
- London – Leeds: 4tph (2tph express services stopping Wakefield Westgate only, 2tph via Hambleton extending to Bradford);
- London – Newcastle: 4tph, all stopping York and 3tph extend to Edinburgh (2 fast, 1 semi-fast, 1 stopping); and
- 1tph open access service assumed to continue as per Do-minimum (rolling stock upgraded to IEP to benefit from journey time improvements on ECML).
- An additional 2tph shuttle service between Doncaster and Leeds is also proposed to compensate for the loss of connectivity between Leeds and Doncaster by operating the direct Leeds services non-stop to Wakefield.

Suburban services operating on the ECML are modified to provide the following:

- London – Cambridge: 4tph 'fast', with 1tph extended to Kings Lynn (replacing the current 1 tph to Cambridge and 1tph to Kings Lynn); and
- London – Royston: additional 2tph all-day stopping service.

The fast services to Cambridge are assumed to be operated 5 car IEP sets (extended to 10 car sets in the peak), while Royston services are operated by 4 car Class 350 sets.

Midland Main Line

An 8 tph long distance timetable is provided, with 2tph operated via the HS2 Phase One network. The following service specification is assumed (shown in Figure 4-25):

- London Euston – Derby/Sheffield **via HS2** : 2tph
- London St Pancras – Sheffield: 2tph (fast to Leicester and then calling at intermediate stations between Leicester and Sheffield)
- London St Pancras – Nottingham: 1tph (calling at intermediate stations)
- London St Pancras – Derby: 1tph (calling at intermediate stations)
- London St Pancras – Corby: 2tph

The service frequency shown above is the same as the Do-minimum intercity service frequency of 6tph in terms of departures from London St Pancras. Two additional services are provided to Derby and Sheffield via HS2 from London Euston.

The services to Sheffield and Nottingham via HS2 Phase One are assumed to be operated by 200m HS2 classic compatible sets. The remaining services are assumed to be operated by modern electric loco-hauled 7 car sets as per the Do-minimum, with the exception of the Corby services which are assumed to be operated by 4 car Class 377 sets (extended to 12 car in the peak).

- In addition, an hourly shuttle service between Leicester and Nottingham is proposed to compensate for the loss of connectivity between Leicester and Nottingham by rerouting the London to Nottingham services via the ECML in this scenario.

Suburban capacity on the MML is increased in this scenario through the provision of an additional 2tph all-day between London St Pancras and Luton (assumed to operate through the Thameslink core during off-peak hours).

West Coast Main Line

The WCML service specification in Package P2B is assumed to be the same as that proposed for Package P2A, described in section 4.5.

Cross Country

The Cross Country service specification for Package P2B is assumed to be the same as Package P2A, described in section 4.5.

Table 4-6 and Figures 4-26, 4-27 and 4-28 present a summary of the upgrade projects that have been included in Package P2B.

Table 4-6 Package P2B Intervention Components

Route	Components

East Coast Main Line	• King's Cross throat works, including lengthening all platforms to at least 12-car suburban length, reducing the total number of platforms by 1, and reopening the disused tunnels.
	• Additional 2 tracks between Alexandra Palace and Biggleswade via a combination of tunnel to the M25 and then new alignment broadly following the A1
	• Huntingdon – Peterborough 4 tracking
	• Electrification of Grantham to Nottingham and line speed improvements to 125mph
	• Grantham - 2 additional platforms at Grantham on the Down side of the layout with the single line doubled from Nottingham Branch Junction to Grantham Station
	• Line speed improvements on the fast lines north of Biggleswade on sections as far as Darlington, and on a section south of Berwick through replacing the OLE equipment, and works on the track, structures and formation
	• Level crossings - closure of all level crossings south of Darlington
	• Electrification of the Joint Line through Lincolnshire for freight and diversionary purposes
	• Grade separation at Doncaster to allow for east-west crossings without interfering with the operations of the main line
	• Freight avoiding scheme for Doncaster – York via Barnby Dun and Knottingley
	• Darlington - provision of fast line platform at Darlington Station
	• Northallerton to Newcastle:
	  • Upgrade the Stillington Line – 60 or 75mph with 4 or 5 minute headways
	  • Re-open southern end of Leamside Line for passenger between Tursdale and, via a largely tunnelled new alignment, Chester-le-street (140mph where possible)
	  • Upgrade gauge of Northallerton tunnel and platforms
	• New platforms at Haringey and Hornsey to enable more intensive use of second slow lines for short distance services, leaving slow line 1 clear for longer distance Thameslink services until north of Alexandra Palace
	• Changes to S&C in Alexandra Palace area to help access to and from the fast lines for Thameslink services north of the new tunnel entrance at

Route	Components
	Alexandra Palace • Doncaster - Leeds improvements (4 -tracking between Doncaster and Wakefield, a new tunnelled approach to Leeds and extra platforms at Leeds). • Newcastle - Edinburgh power supply upgrade to allow 3tph London – Edinburgh • Cambridge chord – cut-off route from new Alexandra Palace to Biggleswade line south of Baldock to join line to Cambridge. • 775m Freight loops between Newcastle and Edinburgh • Skelton Bridge Flyover north of York • Additional trackwork at Newcastle station to improve access to the terminating bay platforms • Newark flyover and chord connecting to the ECML

Midland Main Line	• Turn-back in the Luton area - centre turn-back at Linbury
	• 4-track Tamworth to Stenson Junction at 140mph (for HS2 services)
	• Rebuild Burton-on-Trent station (for HS2 services) with platforms on the slow lines
	• Wichnor Junction grade separation (for HS2 services)
	• Lichfield freight line - severe upgrade of to 140mph (for HS2 services)
	• New chord (approx. 1 mile) from HS2 to Lichfield freight line
	• High speed connection Stenson Junction – Trent Junction – Nottingham
	• Nottingham station extra capacity (Part A) - additional platform provided
	• Nottingham station extra capacity (Part B): Over and above that proposed in part A, provide capacity for additional 2tph through-services
	• North of Sheffield capacity enhancements including a tunnel immediately north of the station to segregate long distance from many short distance services, and diverted local services to serve new Meadowhall station
	• South of Sheffield capacity enhancements including 4-tracked approach to Sheffield and a new tunnel avoiding Dore.
	• Sheffield - Leeds improvements:
	  • 4-track between Swinton and Moorthorpe / South Kirby Junction, grade separate South Kirby junction
	  • Upgrade linespeed from Sheffield to Moorthorpe to 125mph
	• Nottingham to Newark upgrade with electrification and line speed increase to 125mph

West Coast Main Line	• Dynamic passing loops at Shap and Beattock • Grade separated Colwich Junction • North of Preston, Dynamic passing loops, & 75mph turnouts between Preston and Lancaster • Dynamic passing loops between Congleton and Macclesfield station • Extend passing loops at Chelford • 1 x Extra Platform at Manchester Piccadilly • Grade separation at Whitehouse Junction (near Shugborough)

Figure 4-24 Package P2B: ECML Modelled Service Specification

Figure 4-25 Package P2B: MML Modelled Service Specification

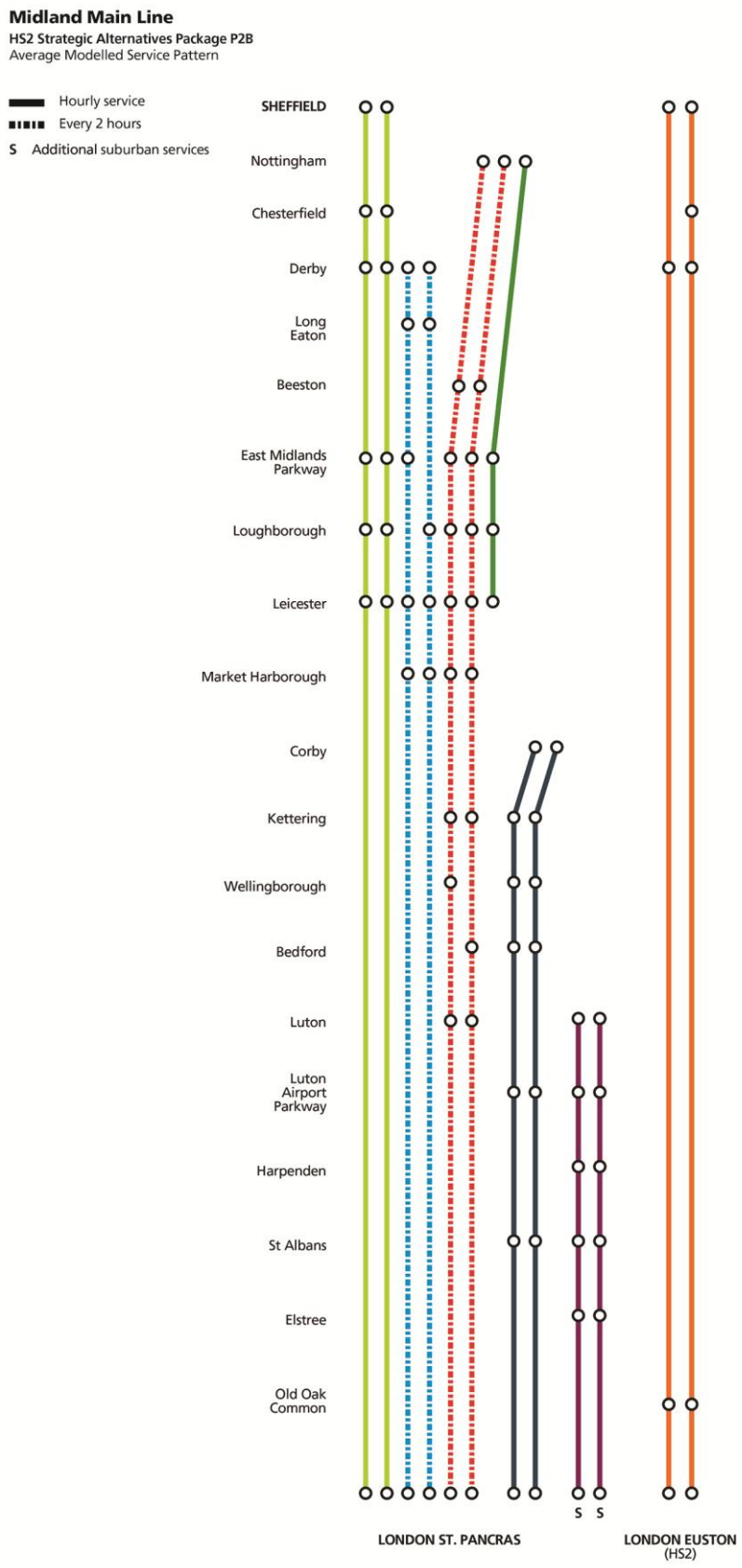


Figure 4-26 Summary of Package P2B Upgrade Projects: North

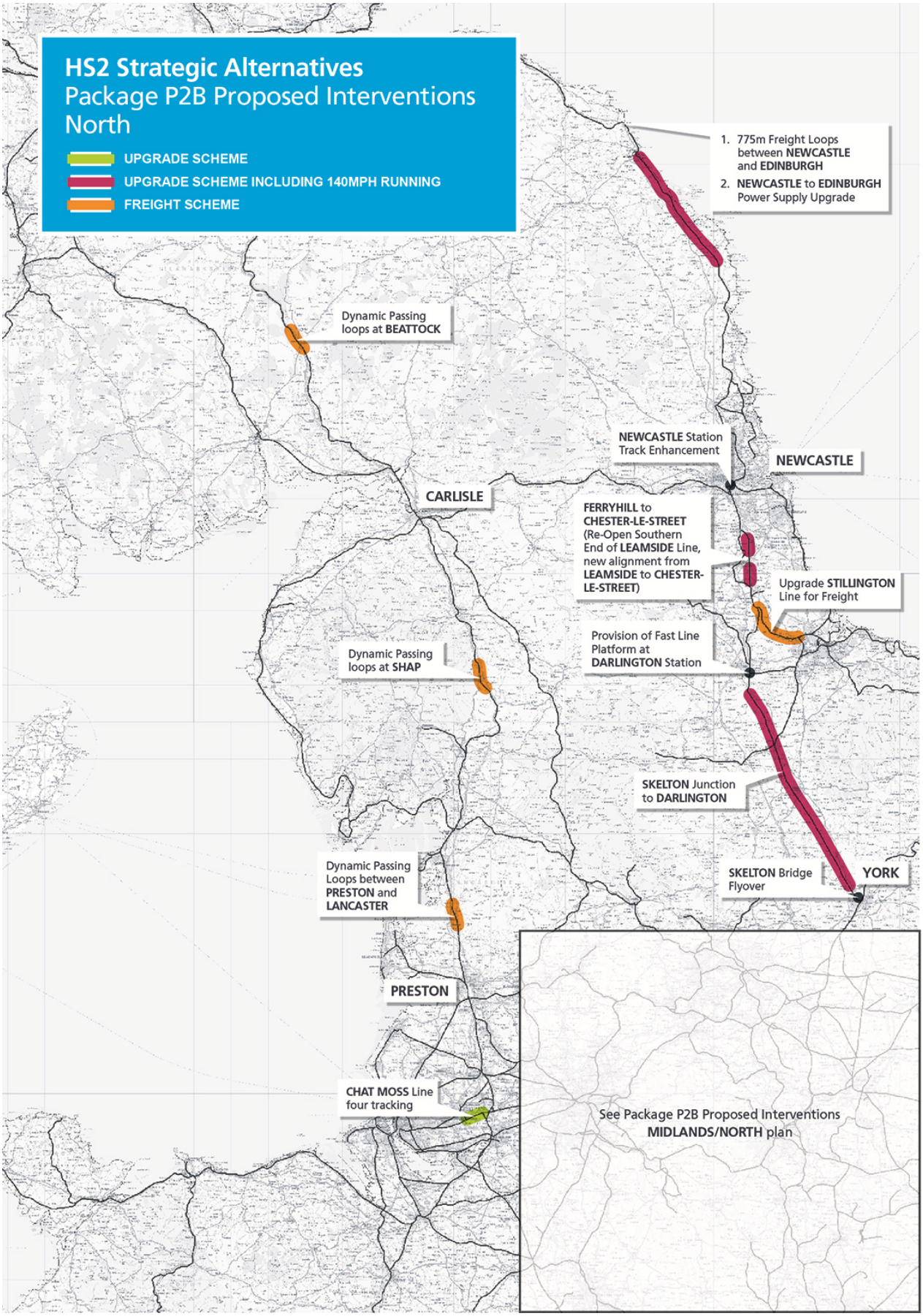


Figure 4-27 Summary of Package P2B Upgrade Projects: Midlands/North

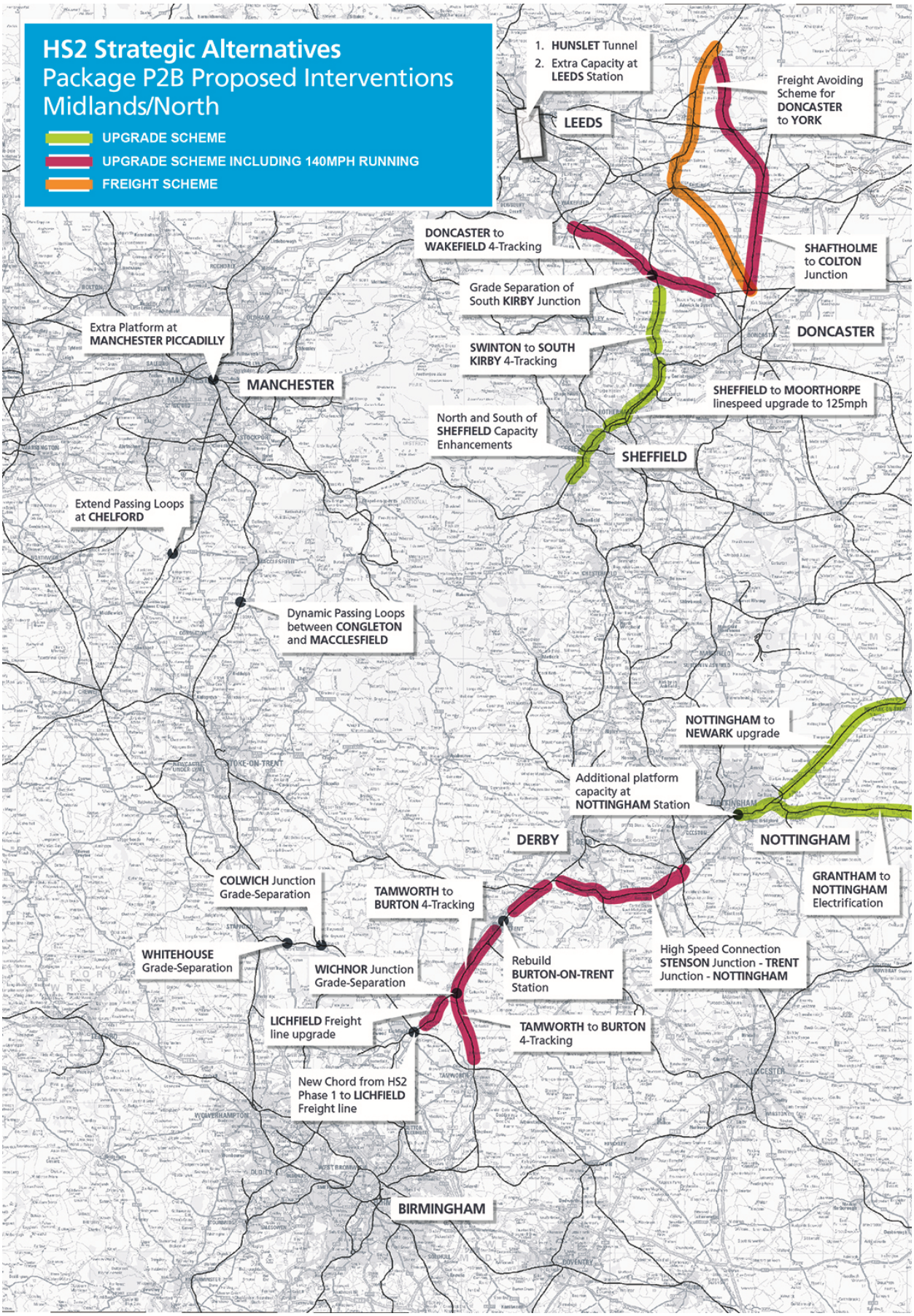
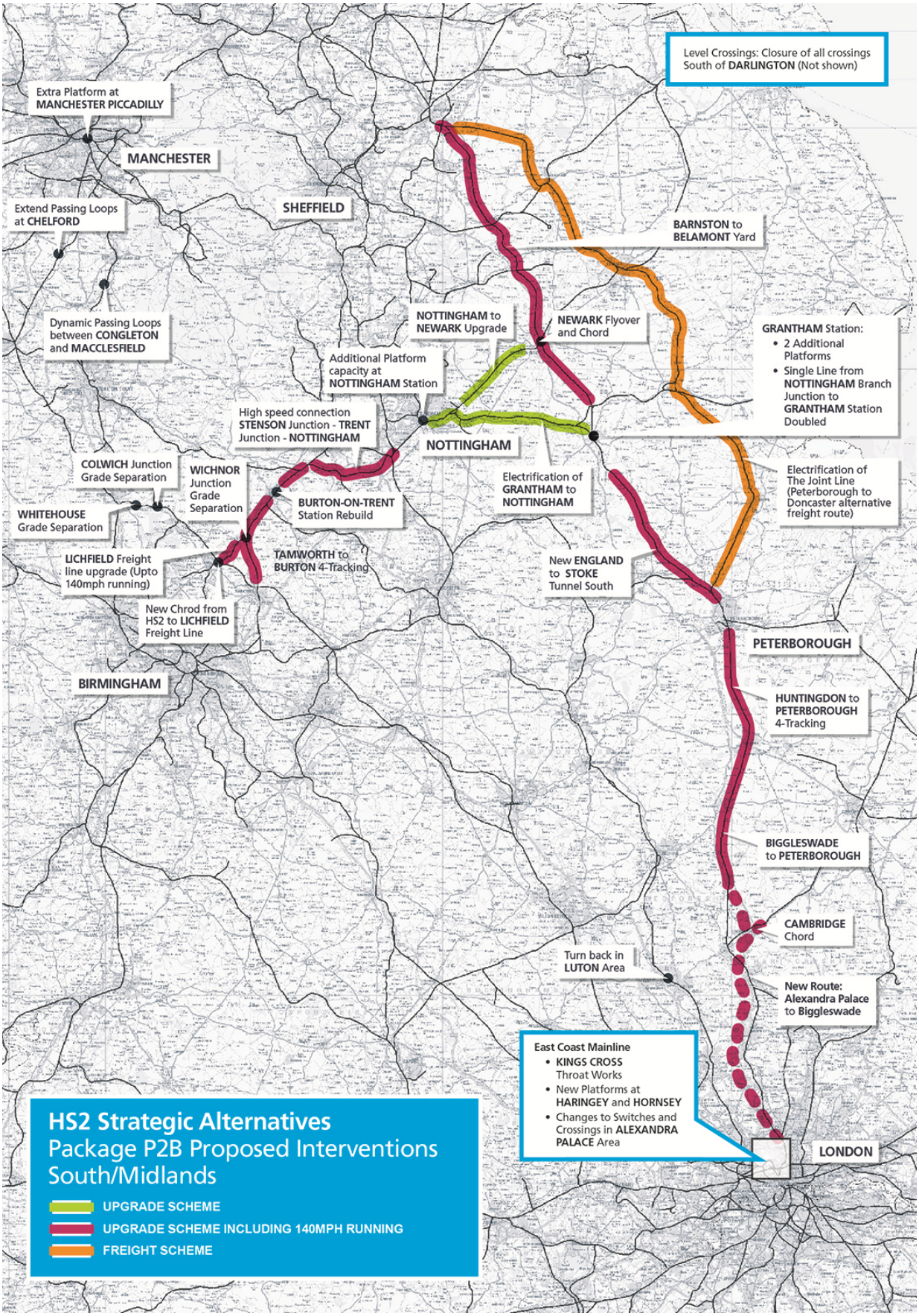


Figure 4-28 Summary of Package P2B Upgrade Projects – South/Midlands



5. Approach to Estimation of Package Costs

This chapter presents the estimated costs of the strategic alternative packages. The costs described in this section fall into two main categories: capital costs and operating costs. Rolling Stock can be treated either as capital cost or as an operating cost subject to the approach taken and is therefore considered separately.

5.1. Capital Costs

The estimated costs of the packages which have been used to inform the economic appraisal, based on information supplied by NR and DfT, are detailed in this section. Should any of the proposals be progressed through the scheme development process, it is noted that the cost estimates would need to be refined.

The capital costs for the interventions were based on using intervention-specific approximate quantities. These approximate quantities were prepared by NR based on their understanding of the proposed intervention. However quantities can only be as accurate as the design that they are based on. Therefore, although quantities were estimated for every potential intervention they are no more accurate than the underlying level of design which is very preliminary.

5.1.1. Estimating Assumptions

The following allowances were applied by NR to the direct cost of each scheme to cover management and execution of the works:

- Design costs: 10% of the direct cost of each scheme;
- Contractors preliminaries: 30% of the direct cost of each scheme;
- Programme Management: 9% of the direct cost of each scheme;
- Disruption: 10% of the direct cost of each scheme[13]; and
- Land costs and statutory processes: 3% of the direct cost of each scheme.

Optimism Bias (OB) was then added at 66% to the total cost of each scheme.

This means that, typically, the direct intervention costs were uplifted by 62% for indirect costs prior to the application of optimism bias. This results in total costs being around 2.7 times direct costs. The use of 66% OB is consistent with standard DfT guidance for projects at a very low level of design development – which the HS2 strategic alternatives packages are.

5.1.2. Capital Cost Estimate

The total capital cost, including OB, of the alternatives (excluding rolling stock) is given in Table 5-1 below.

[13] In order to test this assumption, as a comparison, the revenue loss of having 25% added to all weekend journeys on the ECML, WCML, MML and Cross Country services was modelled for a 15 year period by DfT. It is worth noting that whilst this is not account for the potential long-term impact through damage to the rail brand or for the availability of potential diversion routes, the total revenue was not greater than the 9% cost (plus optimism bias) providing reassurance that the revenue losses included in the appraisal are adequate.

Table 5-1 Summary of Capital Cost of the Interventions (£m, 2011 factor costs)

	Package P1	Package YA	Package YB	Package P2A	Package P2B
ECML		£11,451	£8,063	£11,046	£11,451
MML		£1,146	£2,822	£2,661	£2,065
WCML	£2,464	£2,464	£2,464	£534	£534
Cross Country		£4,142	£3,232	£2,204	£2,800
Total	**£2,464**	**£19,203**	**£16,581**	**£16,445**	**£16,849**

Because of the low level of certainty over the capital costs a sensitivity test has been undertaken with all costs before the application of OB increased by 25% (this is presented as sensitivity tests 2 and 4 in Chapter 6).

No extra allowance was made for the enhanced maintenance and early renewals that will result from running more trains and having more infrastructure. This is because whilst there would be some increased cost, many of the schemes during construction involve completely renewing the structures and other assets and this is a counterbalanced impact that would thereby reduce the need for renewal and reduce maintenance.

5.2. Rolling Stock

5.2.1. Purchase of rolling stock

The additional rolling stock required for the packages could be purchased, and thus treated as a capital cost, or leased, and thus incorporated into the operating costs. DfT advised that, in order to ensure the greatest level of consistency with the work undertaken by HS2 Ltd, additional classic line rolling stock should be assumed to be purchased in the strategic alternatives central case, with a sensitivity test undertaken in which the additional rolling stock is assumed to be leased. Note that for Packages P2A and P2B, HS2 rolling stock is assumed to be purchased even in the sensitivity test where classic line rolling stock is assumed to be leased which is consistent with HS2 Ltd's approach.

5.2.2. Fleet size

The rolling stock assumptions used in the Do-minimum and for the strategic alternative packages are shown in Table 5-2. Further details of underlying fleet size assumptions are given in Appendix C.

Table 5-2 Required Fleet for the Strategic Alternative Packages

Route	Rolling Stock Type	Length	Do-minimum DM1	Do-minimum DM2	Rolling Stock Units Required per Package				
					P1	YA	YB	P2A	P2B
WCML	Class 390 Intercity	6	11	-	32	32	32	32	32
	Class 390 Intercity	9	21	54	-	-	-	34	34
	Class 390 Intercity	11	35	-	65	65	65	-	-
	Class 350 Desiro	4	77	-	77	77	77	-	-
	Class 390 Suburban	11	-	-	21	21	21	-	-
MML	Modern electric loco hauled	7	27	27	-	25	-	24	24
	Class 377	4	-	-	-	4	-	-	4
	TL 8 car	8	-	-	-	6	6	6	6
	IEP	7	-	-	-	-	22	-	-
	IEP	5	-	-	-	-	11	-	-
ECML	IEP	5	22	22	-	57	43	57	57

Route	Rolling Stock Type	Length	Do-minimum DM1	Do-minimum DM2	Rolling Stock Units Required per Package				
					P1	YA	YB	P2A	P2B
	IEP	7	-	-	-	22	11	11	20
	IEP	9	44	44	-	45	45	45	45
	New 125 mph diesel	5	12	12	-	-	-	-	-
	Class 365	4	25	25	-	-	-	-	-
	Class 350 Desiro	4	-	-	-	18	18	18	18
Cross Country	Class 380	4	35	35	-	-	-	-	-
	Class 170	2	4	4	-	9	12	-	
	Class 170	3	5	5	-	-	-	-	-
	IEP	5	-	-	-	64	55	33	33
	IEP	7	-	-	-	-	-	21	21

For High Speed services, it was estimated that an additional 25 classic compatible sets would be required in Package P2A, and an additional 16 classic compatible sets would be required in Packages P2B (incremental on the Do-minimum). In the case of the HS2 services to Birmingham, HS2 Ltd advised that 16x200m captive sets would be required to operate the proposed service specification of 3tph. These services would be operated as 400m sets (i.e. 2x200m sets). The strategic alternatives propose to operate these services as 200m sets, along with a fourth train per hour to Birmingham from London. Analysis found that if the original 3tph operate as 200m sets, then there will be sufficient capacity within the fleet to operate the extra service proposed in Package P2A and P2B without requiring additional units to be purchased.

The following assumptions should be noted with respect to the cost estimates:

- WCML (Packages P2A and P2B) – 20 fewer 9 car Class 390s are required in the packages compared to the Do-minimum, while 21 additional 6 car Class 390s are required compared to the Do-minimum. It is assumed that the 9 car sets would be shortened to 6 car sets and this change would therefore have a neutral purchase cost impact;
- WCML (Packages P1, YA and YB) – The packages require 65 11 car Class 390s to operate the service specification compared to the baseline of 35x11 car and 21x9 car Class 390s. The incremental purchase cost is therefore based on the number of vehicles required to extend the 21x9 car sets to 11 cars, plus the cost of 9 extra 11 car sets;
- ECML – Table 5-2 indicates that 18 Class 350 sets are required in all four Packages to operate services between Doncaster and Leeds, and London to Royston. Although these services have been modelled as Class 350 units, it is assumed that in practice these could be replaced by Class 380 type sets cascaded onto the ECML from Cross Country (which are replaced by IEPs in the upgrade packages), rather than purchasing new Class 350 sets. This change would therefore have a neutral cost impact; and
- MML – Packages YA, P2A and P2B assume that slightly fewer modern electric loco sets are required compared to the Do-minimum. As these sets would have already been purchased in the Do-minimum, a neutral cost impact has been assumed.

The assumed capital costs of rolling stock were provided to Atkins by the DfT. The wider assumptions relating to the purchase of the rolling stock are consistent with those of HS2 Ltd, as follows:

- The initial investment costs were spread equally over a five year period, prior to the scenarios being implemented; and
- All rolling stock was assumed to have a lifecycle of 35 years.

The capital cost of purchasing classic line rolling stock for the first time, and high speed rolling stock, is given in Table 5-3 below, with further underlying assumptions set out in Appendix C.

Table 5–3 Capital Costs of Purchasing Rolling Stock (£m, 2011 factor costs)

	Conventional rolling stock	High speed rolling stock	Total
Package P1	£2,390	n/a	£2,390
Package YA	£5,463	n/a	£5,463
Package YB	£5,519	n/a	£5,519
Package P2A (classic)	£2,655	£1,525	£4,180
Package P2B (classic)	£2,976	£976	£3.952

5.3. Operating Costs

5.3.1. Estimation of Operating Costs

Rail operating costs were estimated for each of the packages using an operating cost model developed by Atkins for the previous Strategic Alternatives studies. The model is an incremental model which estimates base costs for operating WCML, ECML and MML in the Do-minimum and in each of the proposed packages. The difference between the alternative costs and the Do-minimum cost was the figure carried forward to the appraisal. For the current study, the model was extended to include Cross Country and HS2 Phase One, neither of which were previously modelled.

For the current study, DfT undertook a review of the operating cost model and advised Atkins of changes to the operating cost assumptions to ensure consistency between the Strategic Alternatives and HS2 studies. These are listed in Appendix C.

The operating costs shown in this section are total costs and have been calculated to be consistent with the assumed appraisal periods of both the alternatives and full HS2 scheme. As such, the operating costs for Package P1 have been calculated for a period of 60 years, while for the other packages operating costs have been estimated for a period of 67 years. More details on the appraisal period assumptions for the upgrade packages are provided in the value for money section of Chapter 6.

The **Central Case** (i.e. assuming that additional rolling stock is purchased) incremental operating costs for each of the Packages are given in 2011 prices in Table 5-4.

Table 5–4 Central Case Operating Costs (£m, 2011 factor costs)

Package	Total Cost[1]
Package P1	£17,923
Package YA	£36,352
Package YB	£35,075
Package P2A	£27,730
Package P2B	£26,211

[1]Total operating costs for Package P1 are estimated for a period of 60 years; estimated operating costs for Packages YA, YB, P2A and P2B are for a period of 67 years

DfT requested that in addition to the central case, a sensitivity test should be undertaken in which it is assumed that rolling stock is leased. The cost of operations including lease costs, and the costs of leasing rolling stock is shown for each of the packages in Table 5-5.

Table 5–5 Operating Costs Assuming that Rolling Stock is Leased (£m, 2011 factor costs)

	Operating cost assuming leased rolling stock[1]	Costs of leasing rolling stock[1]
Package P1	£26,408	£8,485
Package YA	£58,543	£22,191
Package YB	£55,918	£20,843
Package P2A	£39,994	£12,264
Package P2B	£39,845	£13,635

[1]Total operating costs for Package P1 are estimated for a period of 60 years; estimated operating costs for Packages YA, YB, P2A and P2B are for a period of 67 years.

5.3.2. Treatment of Operating Costs in the Economic Appraisal

The operating costs included in the economic appraisal, which form part of the overall Present Value of Cost (PVC) for each package of rail options, are summarised in Tables 5-6 to 5-8 below.

DfT advised that the following Optimism Bias (OB) allowances should be applied to the classic line rolling stock operating costs:

- Energy consumption: 10% for all classic line rolling stock types
- Maintenance costs: 5% for all rolling stock types
- Staff costs: 1.6%
- Variable Track Access Charges (VTAC): 30%
- Electrification Asset Usage Charge (EAUC): 30%
- Capacity Charge: 30%
- Train Operating Company (TOC) overheads and admin: 20%
- Rolling Stock Insurance: 10%

The above represent a change in approach compared to the previous strategic alternatives studies in order to be consistent with the approach of HS2 who apply different levels of optimism bias to each element of operating cost.

DfT advised the following OB allowances should be applied to high speed train operating costs (where these are different from the values given above for classic units):

- Maintenance costs: 15% for Captive 200m high speed trains, 20% for Classic Compatible 200m high speed trains
- Staff costs: 30%
- Rolling Stock Insurance: 41%

The following information is provided for each package in Tables 5-6 to 5-8:

- Total undiscounted factor costs
- Total undiscounted factor costs including optimism bias
- Discounted operating and maintenance costs including optimism bias
- Discounted leasing costs including optimism bias
- Total discounted operating costs including optimism bias (converted to market prices)

Table 5–6 Real Rail Operating Costs Included in the Economic Appraisal when Rolling Stock is Assumed to be a Capital Cost (£m, 2011 prices)

Package	Total Undiscounted Factor Costs	Total Undiscounted Factor Costs incl. OB	Discounted Operating & Maintenance Costs incl. OB	Discounted Leasing Costs incl. OB	Total Discounted Operating Costs (Market Prices)
Package P1	£17,923	£19,569	£5,182	N/A	£6,166
Package YA	£36,352	£39,665	£9,816	N/A	£11,682
Package YB	£35,075	£38,287	£9,499	N/A	£11,304
Package P2A	£27,730	£31,725	£7,481	N/A	£8,902
Package P2B	£26,211	£29,604	£6,991	N/A	£8,319

Table 5–7 Real Rail Operating Costs Included in the Economic Appraisal when Rolling Stock is Assumed to be Leased (15% OB Applied to Lease Costs) - (£m, 2011 prices)

Package	Total Undiscounted Factor Costs	Total Undiscounted Factor Costs incl. OB	Discounted Operating & Maintenance Costs incl. OB	Discounted Leasing Costs incl. OB	Total Discounted Operating Costs (Market Prices)
Package P1	£26,408	£29,326	£5,182	£2,607	£9,269
Package YA	£58,543	£63,037	£9,816	£5,755	£18,530
Package YB	£55,918	£60,054	£9,499	£5,384	£17,711
Package P2A	£39,994	£43,959	£7,481	£2,837	£12,278
Package P2B	£39,845	£43,208	£6,991	£3,154	£12,072

As part of the value for money assessment presented in Chapter 6, a number of cost-based sensitivity tests has been undertaken to examine the sensitivity of the value for money of the upgrade packages to changes in costs. For clarity, it is noted that the costs shown in Table 5-7 are used in Sensitivity Test 1, which considers the impact of a leased rolling stock approach on the economic performance of the Upgrade Packages.

DfT requested that Atkins undertake a further sensitivity test on the Central Case operating costs using the same operating cost optimism bias assumptions as HS2 Ltd. These costs are shown in Table 5-8, below. The purpose of this test was to understand the impact of the different approaches to OB between the main HS2 scheme and strategic alternatives on the operating costs, and to determine whether it would make a material difference to the value for money of the alternatives. For clarity, it is noted that the costs in Table 5-8 are used in Sensitivity Test 3 in the value for money assessment in Chapter 6.

Table 5–8 Central Case Operating Costs including same OB Assumptions as HS2 (£m, 2011 prices)

Package	Total Undiscounted Factor Costs	Total Undiscounted Factor Costs incl. OB	Discounted Operating & Maintenance Costs incl. OB	Discounted Leasing Costs incl. OB	Total Discounted Operating Costs (Market Prices)
Package P1	£17,923	£21,670	£5,735	N/A	£6,825
Package YA	£36,352	£44,355	£10,965	N/A	£13,049
Package YB	£35,075	£42,750	£10,596	N/A	£12,609
Package P2A	£27,730	£34,127	£8,042	N/A	£9,570
Package P2B	£26,211	£32,321	£7,625	N/A	£9,074

6. Contribution to HS2 Strategic Objectives

6.1. The Strategic Objectives set for HS2

Government has identified two principal objectives for High Speed rail, as set out in the Strategic Case, published in October 2013, as follows:

- The **capacity** objective is to create sufficient capacity to provide for long term demand and improve network resilience and reliability, ensuring that people and goods are able to make the journeys they want; and
- The **connectivity** objective is to improve journey times, making travel quicker, easier, more punctual and more convenient for people and goods, including supporting end-to-end journeys with effective integration and interchange between transport modes and with good connections, including with major airports, for international travel.

HS2 has also considered a number of other factors in assessing options. These factors include: environmental impact; the deliverability of the scheme including disruption during construction; affordability; and value for money.

This chapter presents evidence on the extent to which the five upgrade packages described in Chapter 4 would contribute to these objectives by comparing against an appropriate Do-minimum scenario to determine each package's incremental impact. As described in Chapter 2, two Do-minimum scenarios have been defined:

- DM-1 - No HS2 Do-minimum – used to estimate the impacts of packages P1, YA and YB; and
- DM-2 - With HS2 Phase One Do-minimum – used to estimate the impacts of packages P2A and P2B.

The performances of each of the packages relative to the (appropriate) Do-minimum has been considered for a range of indicators that relate to the strategic objectives set for HS2. The full set of indicators considered is shown in Table 6-1.

It is emphasised that the comparison of the performance of each upgrade package against the (appropriate) Do-minimum is not the same as comparing the packages against HS2. The direct comparison of the performance of the packages against the HS2 investment case was outside the scope of this study.

Table 6-1 Summary of Performance Indicators for Upgrade Packages

Objective	Measure	Metric
Capacity	Passenger Train Capacity	Number of seats.
	Freight Capacity	Potential to accommodate future levels of rail freight demand.
	Resilience to Service Perturbations	Trains per hour for fast lines on WCML, MML and ECML.
Connectivity	Improvements in Journey Times	Journey time savings for journeys between London, Birmingham, Manchester, East Midlands, Leeds, Newcastle and Scotland and between Birmingham and Manchester, East Midlands, Leeds, Newcastle and Scotland. Population within 1, 2 and 3 hours of London. Isochrones of travel time from London.
	Frequency	Change in train frequency on key intercity and commuting flows.
	Reliability	Qualitative assessment.
Other Considerations	Environmental Impact	High level environmental assessment.
	Deliverability	Number of hours possession time and number of weekend possessions where engineering work needed to deliver upgrades would reduce capacity/journey times of main routes.
	Affordability	Total costs to Government, including construction costs, rolling stock capital costs, operating costs and revenue.
	Value for Money	Total benefits and revenues and comparative BCR.
	Wider Economic Impacts	Total benefits attributable to improved productivity.
	Future Proof	Ability of the scheme to cope with demand growth beyond 2036.

6.2. The Capacity Objective

6.2.1. Passenger Train Supply

Package P1 is a potential strategic alternative to providing HS2 Phase One. As described earlier in the report, P1 focuses on infrastructure, train lengthening and service pattern interventions on the WCML. Table 6.2 and Figure 6.1 show the estimated additional seat capacity that could be delivered by Package P1 in the evening peak hour for services operating out of Euston station. It shows estimated seat capacity per hour separately for: intercity services; fast-line commuter services (i.e. serving Milton Keynes and beyond); and slow-line commuter services.

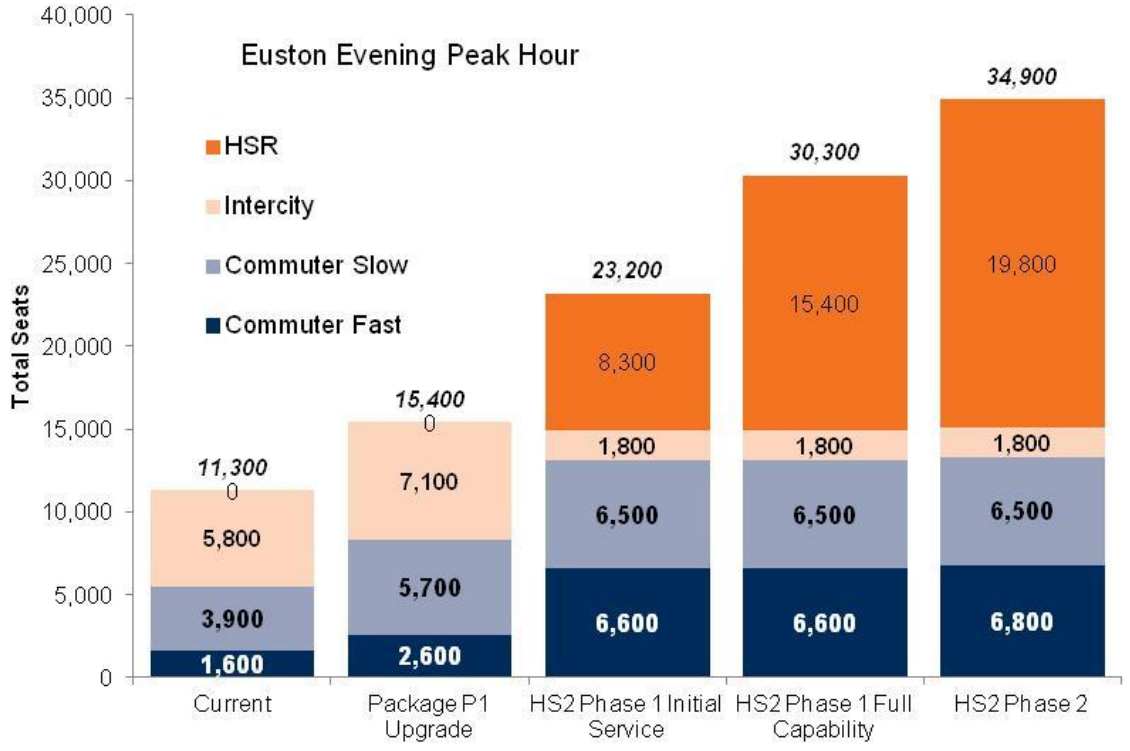
Table 6-2 shows P1 relative to various capacity scenarios for HS2 Phase One and Two. This shows that Package P1 would provide an increase in peak seat capacity from Euston compared to present levels. However, this level of additional capacity is lower than could be provided by HS2. It is noted that these scenarios provide a means of demonstrating the incremental capacity impact of Package P1 consistent with the October 2013 HS2 Strategic Case.

Table 6-2 Additional Passenger Train Capacity - Euston Evening Peak Hour[1, 2]

	Commuter Fast	Commuter Slow	Intercity	HSR	Total
Current	1600	3900	5800	0	11300
Package P1 Route Upgrade	2600	5700	7100	0	15400
HS2 Phase One Initial Service	6600	6500	1800	8300	23200
HS2 Phase One Full Capability	6600	6500	1800	15400	30300
HS2 Phases 1 and 2	6800	6500	1800	19800	34900

[1] Note that some additional infrastructure investment would be required to accommodate this full HS2 Phase One capability over and above what has been included in the economic assessment for HS2 Phase One. [2] Comparison to the modelled no-HS2 Do-minimum is shown in Appendix D.

Figure 6-1 Additional Passenger Train Capacity - Euston Evening Peak Hour[1]



[1]Note that some additional infrastructure investment would be required to accommodate this full HS2 Phase One capability over and above what has been included in the economic assessment for HS2 Phase One.

The modelled capacities for P1 and the other four upgrade packages are presented in Appendix D. This is based upon all day modelling. Seat capacities presented in the Appendix use capacity assumptions that differ slightly to those presented above (which reflect DfT's and HS2 Ltd's most up to date view of expected Euston evening peak seat capacity). Appendix D also presents the modelled crowding effects based upon an all day assessment. Care needs to be taken when interpreting the modelled crowding effects given that load factors in the peak will be considerably higher than is suggested by the all day numbers presented in the Appendix.

6.2.2. Freight Capacity

NR have reported on the ability of the individual route components to accommodate the levels of future growth in freight demand. NR has considered that each of the route-based packages taken forward in the multi-route packages may accommodate these forecasts. (It is noted that this was not the case with the

rejected 'Low' packages, and hence, by implication, in the Do-minimum). In the case of P1 some additional paths are created at the northern end of the line, but do not create any additional freight capacity at the southern end.

6.2.3. Resilience to Service Perturbations

The implications of investments and changes in rail services for resilience and reliability on the rail network have not been directly estimated as part of this work. A previous assessment of RP2 by NR suggested that for this package there were considerable performance risks for the WCML as a result of the more intensive use of the network. These arguments are still relevant for package P1.

Similar arguments apply for other route upgrades in the packages considered in this study. Table 6-3 and 6-4 show the number of trains running on each route under the different packages. There is an over 50% increase in utilisation of the fast lines on the ECML, which rises from 7 to up to 11 trains per hour on some sections in YA. Infrastructure upgrades required to facilitate this improved service pattern would also aid the performance of the network in general, which may suggest the implications for network resilience and reliability may be smaller than those noted for WCML packages. However increased utilisation may be indicative of a rail network which has less scope to manage service perturbations (i.e. the impact of incidents on train operations that could range from equipment failures, adverse weather conditions, line obstructions to passenger issues) and the loss of this resilience could impact on reliability of the network.

Table 6-3 Estimated Trains per Hour on Fast Lines for Upgrade Packages

Route	Do-minimum (DM1)	P1	YA	YB
ECML	7	7	11[1]	10
WCML	13	16	16	16
MML	6	6	6	8

[1] 15tph on the very southern end of the ECML in YA on the new build section from Alexandra Palace to the Baldock chord.

Table 6-4 Estimated Trains per Hour on Fast Lines – Packages P1, YA and YB

Route	Do-minimum (DM2)	P2A	P2B
ECML	7	9	11
WCML	12	12	12
MML	6	6	6

6.3. The Connectivity Objective

6.3.1. Improvements in Journey Times

6.3.1.1. Journey Time Savings

Tables 6-5 and 6-6 present estimated journey time savings for each of the five upgrade packages for journeys between major centres compared to the (appropriate) Do-minimum. Times relate to the rail journey times between city centre station locations (unless noted in the table). P1, YA and YB time saving are relative to the DM1 Do-minimum (i.e. no HS2). Packages P2A and P2B are relative to DM2 (i.e. with HS2 Phase One). It is noted that there are a range of train times between each of these city pairs depending on the stopping patterns of each service, so the times below are only illustrative of the fastest regular journey times. The Do-minimum times are taken from modelling undertaken for HS2; the journey times for the packages are estimated based on a combination of information provided by NR and assumptions on intermediate run times calculated on a high level basis by DfT and Atkins, reviewed at the same level by NR as being realistic. Total journey times are taken into account in the estimation of user benefits as part of the value for money assessment (see below).

Improvements in journey times in the packages arise as a result of:

- Line speed improvements, for example the upgrading of sections of the ECML to 140mph running;
- Schemes that reduce journey times through parts of the network that currently act as capacity constraints and which deliver additional capacity and journey time reductions, such as the grade separation of Colwich Junction on the WCML; and
- Changes to train service specifications made possible by having higher frequencies which can be used to reduce the average typical number of stops per train at intermediate stations without, overall, changing the number of trains per day serving these stations– typically improving journey times for through passengers by approximately four minutes per stop omitted on intercity services.

Table 6-5 Journey Times for Upgrade Packages P1, YA and YB between Major Centres (in minutes)[1]

		Typical journey times						Change from Do-minimum				
		Do-minimum dm1	Package P1	Package YA	Package YB	HS2 Phase One	HS2 Phase One + Phase Two	Package P1	Package YA	Package YB	HS2 Phase One	HS2 Phase One + Phase Two
London	Birmingham	84	73	73	73	49	45	-11	-11	-11	-35	-39
London	Manchester	127	122	122	122	100	68	-5	-5	-5	-27	-59
London	Liverpool	131	126	126	126	106	93	-5	-5	-5	-25	-38
London	Glasgow	260	245	245	245	234	217	-15	-15	-15	-26	-43
London	Nottingham	93	93	70	73	93	51[2]	0	-23	-20	0	-42
London	Sheffield	115	115	101	105	115	70[3]	0	-14	-10	0	-45
London	Leeds	126	126	96	99	126	82	0	-30	-27	0	-44
London	York	104	104	94	97	104	81	0	-10	-7	0	-23
London	Newcastle	155	155	141	144	155	138	0	-14	-11	0	-17
London	Edinburgh	245	245	220	223	245	222	0	-25	-22	0	-23
Birmingham	Nottingham	72	72	30	37	72	19[4]	0	-42	-35	0	-53
Birmingham	Sheffield	77	77	50	56	77	38[5]	0	-27	-21	0	-39
Birmingham	Leeds	122	122	78	84	122	55	0	-44	-38	0	-67
Birmingham	York	140	140	79	88	140	63	0	-61	-52	0	-77
Birmingham	Newcastle	199	199	130	139	199	127	0	-69	-60	0	-72
Birmingham	Edinburgh	306	306	260	260	306	209	0	-46	-46	0	-97

[1] HS2 information from HS2 Ltd. Journey times represent typical best times between centres in 2036 [2] Journey time is to Toton Interchange station. HS2 Ltd advised that a further 12 mins should be added to this time for an equivalent journey time to Nottingham Station. [3] Journey time is to Sheffield Meadowhall Interchange station. [4] Journey time is to Toton Interchange station. HS2 Ltd advised that a further 12 mins should be added to this time for an equivalent journey time to Nottingham Station. [5] Journey time is to Sheffield Meadowhall Interchange station

Table 6–6 Typical Journey Time Savings for Upgrade Packages P2A and P2B between Major Centres (in minutes)[1]

		Typical journey times			Change from Do-minimum	
		Do-minimum DM2	Package P2A	Package P2B	Package P2A	Package P2B
London	Birmingham	49	49	49	0	0
London	Manchester	100	103	103	3	3
London	Liverpool	106	106	106	0	0
London	Glasgow	234	234	234	0	0
London	Nottingham	93[2]	67	70	-26	-23
London	Sheffield	115[3]	86	86	-29	-29
London	Leeds	126	96	96	-30	-30
London	York	104	94	94	-10	-10
London	Newcastle	155	141	141	-14	-14
London	Edinburgh	245	220	220	-25	-25
Birmingham	Nottingham	72[4]	27	27	-45	-45
Birmingham	Sheffield	77[5]	45	45	-32	-32
Birmingham	Leeds	122	73	73	-49	-49
Birmingham	York	140	78	78	-62	-62
Birmingham	Newcastle	199	129	129	-70	-70
Birmingham	Edinburgh	306	260	260	-46	-46

[1] HS2 information from HS2 Ltd. Journey times represent typical best times between centres in 2036. [2] Journey time is to Toton Interchange station. HS2 Ltd advised that a further 12 mins should be added to this time for an equivalent journey time to Nottingham Station. [3] Journey time is to Sheffield Meadowhall Interchange station. [4] Journey time is to Toton Interchange station. HS2 Ltd advised that a further 12 mins should be added to this time for an equivalent journey time to Nottingham Station. [5] Journey time is to Sheffield Meadowhall Interchange station

The improvements in journey times drive a significant proportion of the overall value for money offered by these packages (see section 6.4.4), but also creates a challenge to deliver sufficient additional capacity to meet the combined growth in underlying demand and the additional passengers generated by the faster journeys. The tables show that the packages can generate time savings for passengers travelling to London of up to 30 minutes and over 1 hour for some inter-regional passengers.

The package of interventions on the WCML route offer journey time savings of up to 15 minutes to Birmingham, and savings of 7 and 6 minutes to Manchester and Liverpool respectively. These improvements are driven primarily by modified stopping patterns, the changes to which are facilitated by the additional fast line services in this package. This route specific package is present in packages YA and YB.

The Medium output route level package for ECML (contained in the YB upgrade package) delivers journey time savings of up to 30 minutes for Leeds, while more modest improvements are delivered for York and Newcastle. The additional investment contained in the High ECML route level package (in the YA package) delivers a further 3 minutes time saving to many destinations along the ECML. Such additional investment includes the chord at Baldock which connects to the new alignment between Alexandra Palace and Biggleswade, delivering time savings to Cambridge of up to 13 minutes. Additional time savings to Edinburgh are delivered by upgrades north of York, though it should be noted that these schemes could also be included in the HS2 business case if they were thought appropriate.

Options for upgrading the MML could also deliver time savings to many locations. The high investment scenario on the MML (included in the YB upgrade package) delivers journey time savings of up to 20 minutes to Nottingham, and 10 minutes to Sheffield. There are few journey time savings on the MML itself in YA, although it should be noted that Nottingham and Sheffield are served via the ECML by the same train in this package, with a 31 minute journey time between the two cities. Further savings can be achieved in the

packages with High Speed 2 Phase One, with some services being routed via HS2 to Nottingham, Derby and Sheffield, and journey time savings of around 30 minutes due to the use of High Speed and upgraded/new infrastructure in the East Midlands.

Cross Country services are substantially improved through a mixture of upgrades to the MML and ECML, re-routing via Newark to make more use of the ECML and infrastructure upgrades along routes served by Cross Country between Birmingham and Derby/Nottingham. Journey times from Birmingham to Nottingham and Leeds in the no HS2 scenarios could be reduced by up to 45 minutes, while journey times to Newcastle could be reduced by over an hour. Further time savings could be achieved in the packages with HS2 Phase One by the routeing of services to the East Midlands from Birmingham Curzon Street via the HS2 Phase One network to Lichfield.

6.3.1.2. Isochrone Analysis

Table 6-7 provides an estimate of the total population within hourly time bands from central London for each of the five upgrade packages.

Table 6-7 Estimated Population within hourly travel time bands from London by Upgrade Package

	DM1	DM2	P1	YA	YB	P2A	P2B
< 1hr	16.7	20 0	16.7	16.9	17.1	20.2	20.5
< 2hr	36.4	41.6	36.9	40.4	39.9	45.2	45.2
< 3hr	51.9	52.4	52.1	52.2	52.2	52.5	52.5

Table Notes: Population figures based on 2011 census data

Figures 6-2 to 6-6 present analysis of travel times from London to different parts of the country as isochrone diagrams for each of the upgrade packages. Isochrones are lines connecting places from which it takes the same time to travel to a certain point, in this case London termini. They illustrate the London terminal to city centre station travel time for each package.

Figure 6-2 Isochrones for Journey Time from London – Package P1 compared to Do Minimum 1

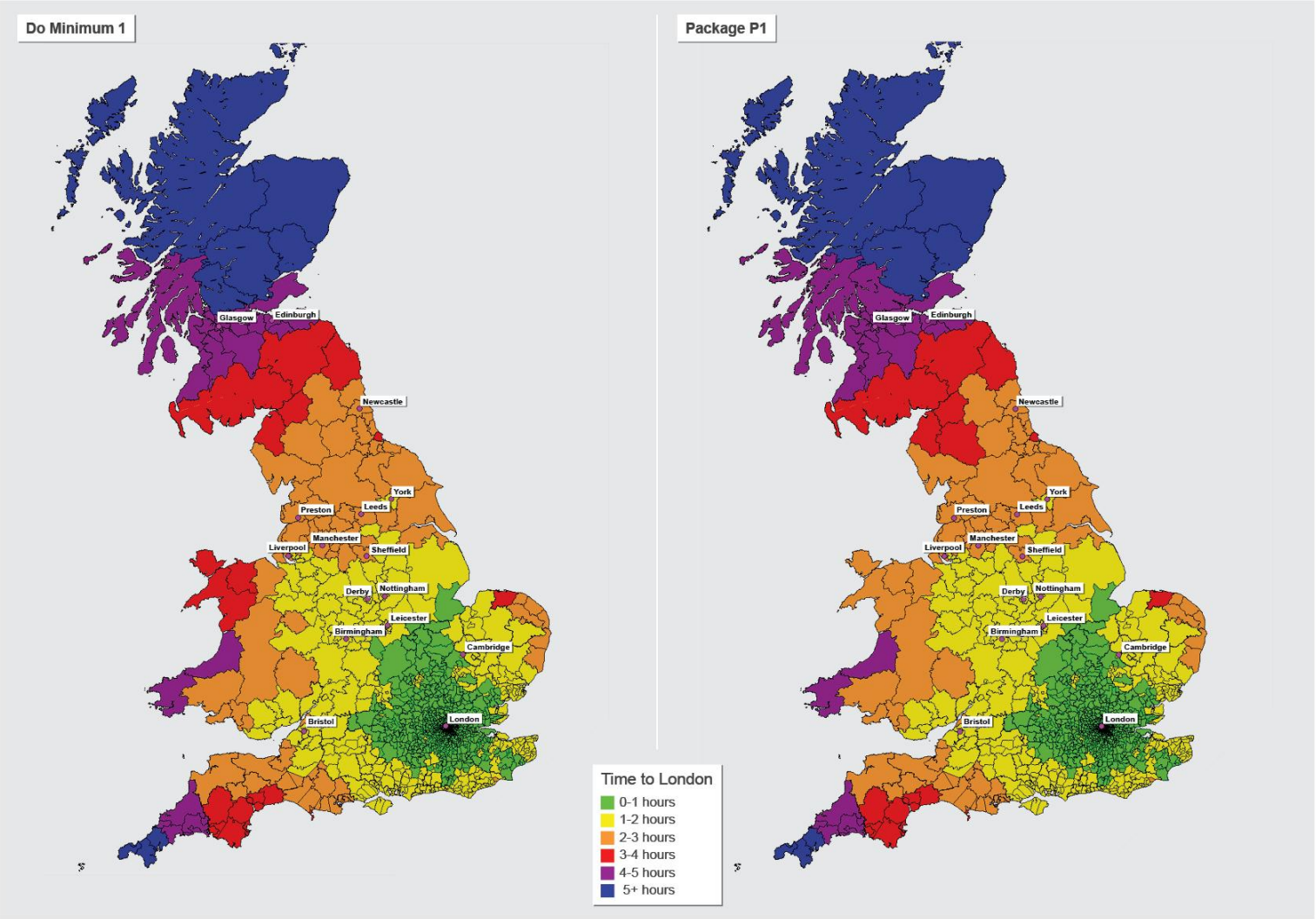


Figure 6-3 Isochrones for Journey Time from London – Package YA compared to Do Minimum 1

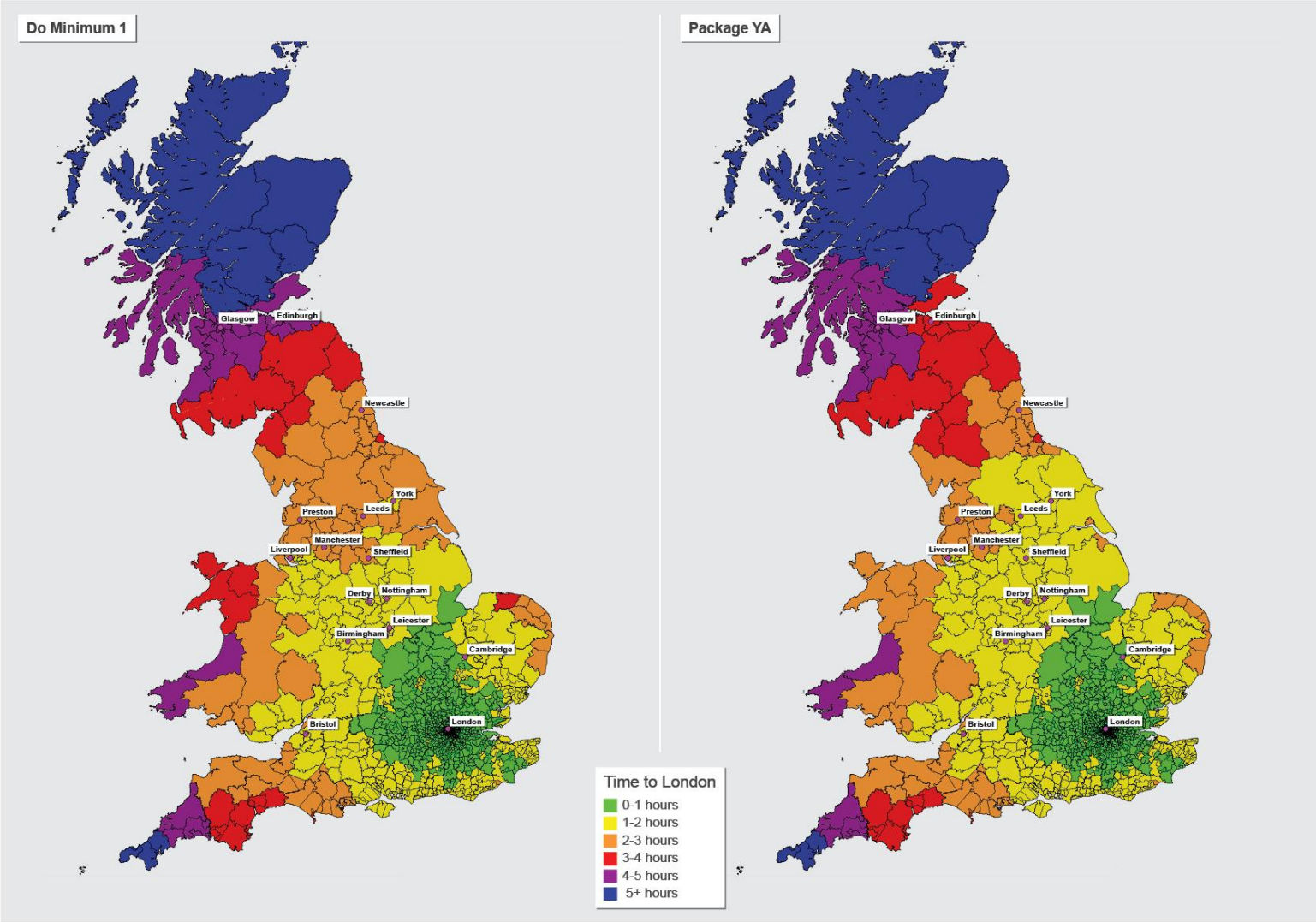


Figure 6-4 Isochrones for Journey Time from London – Package YB compared to Do Minimum 1

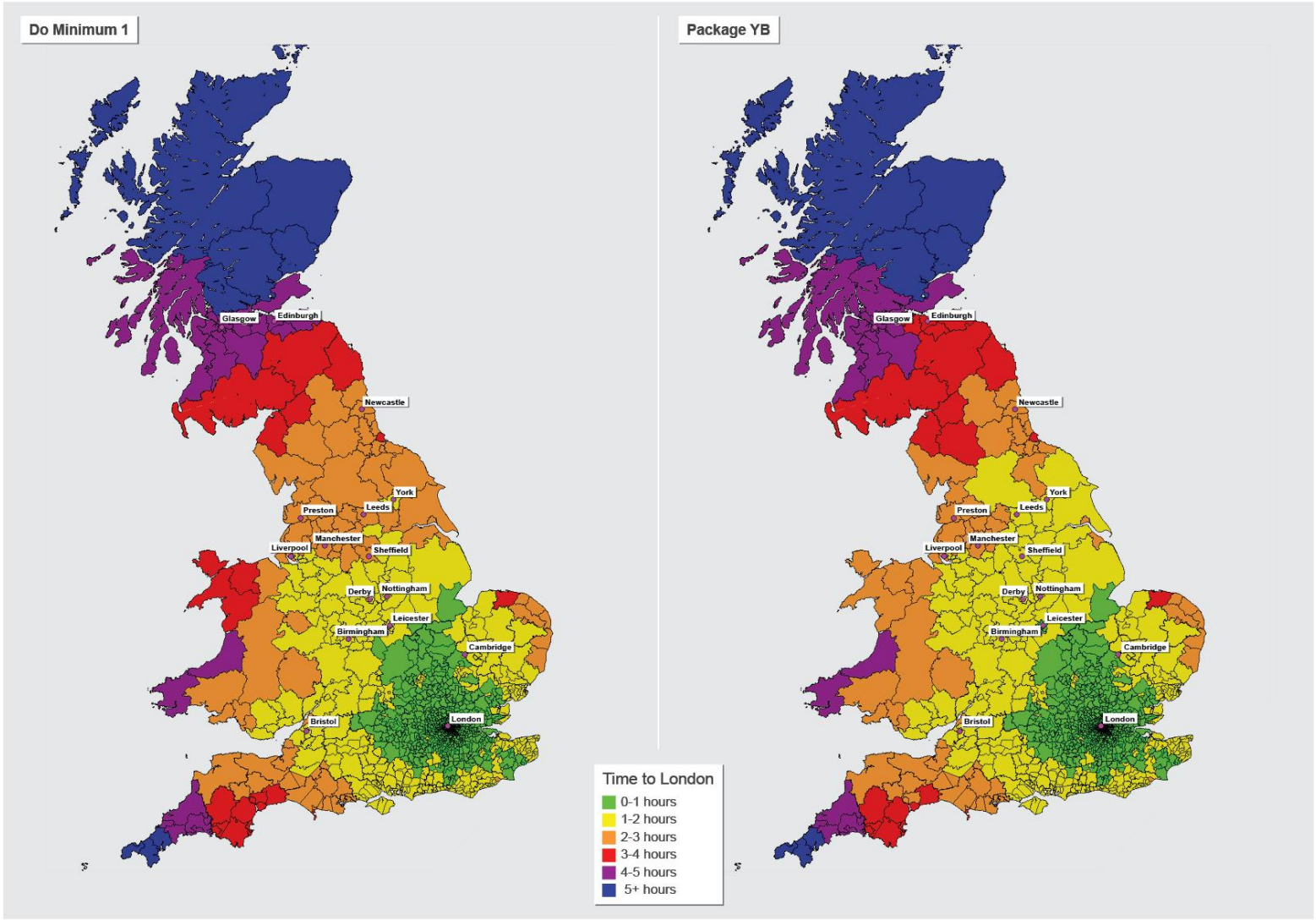


Figure 6-5 Isochrones for Journey Time from London – Package P2A compared to Do Minimum 2

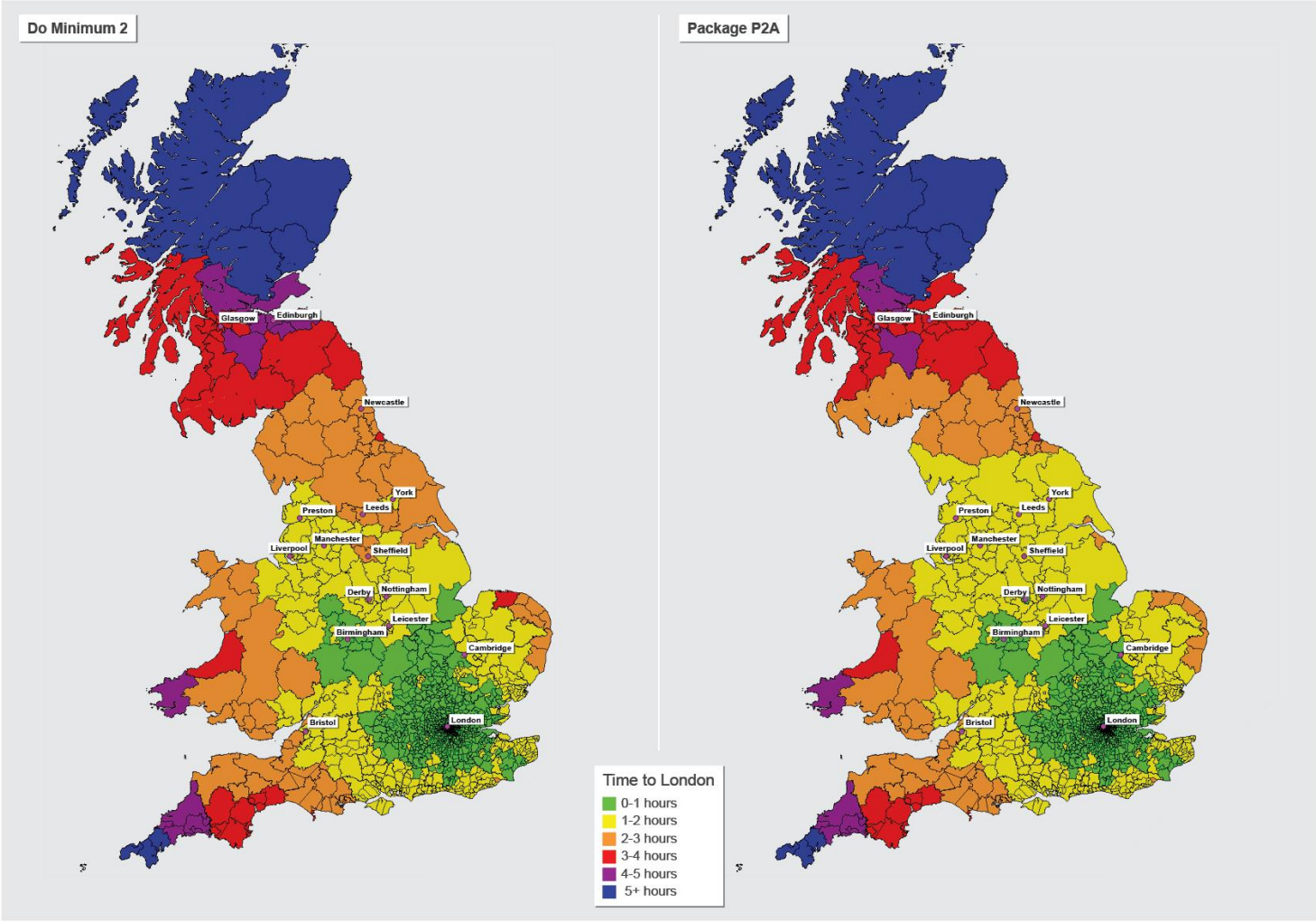


Figure 6-6 Isochrones for Journey Time from London – Package P2B compared to Do Minimum 2

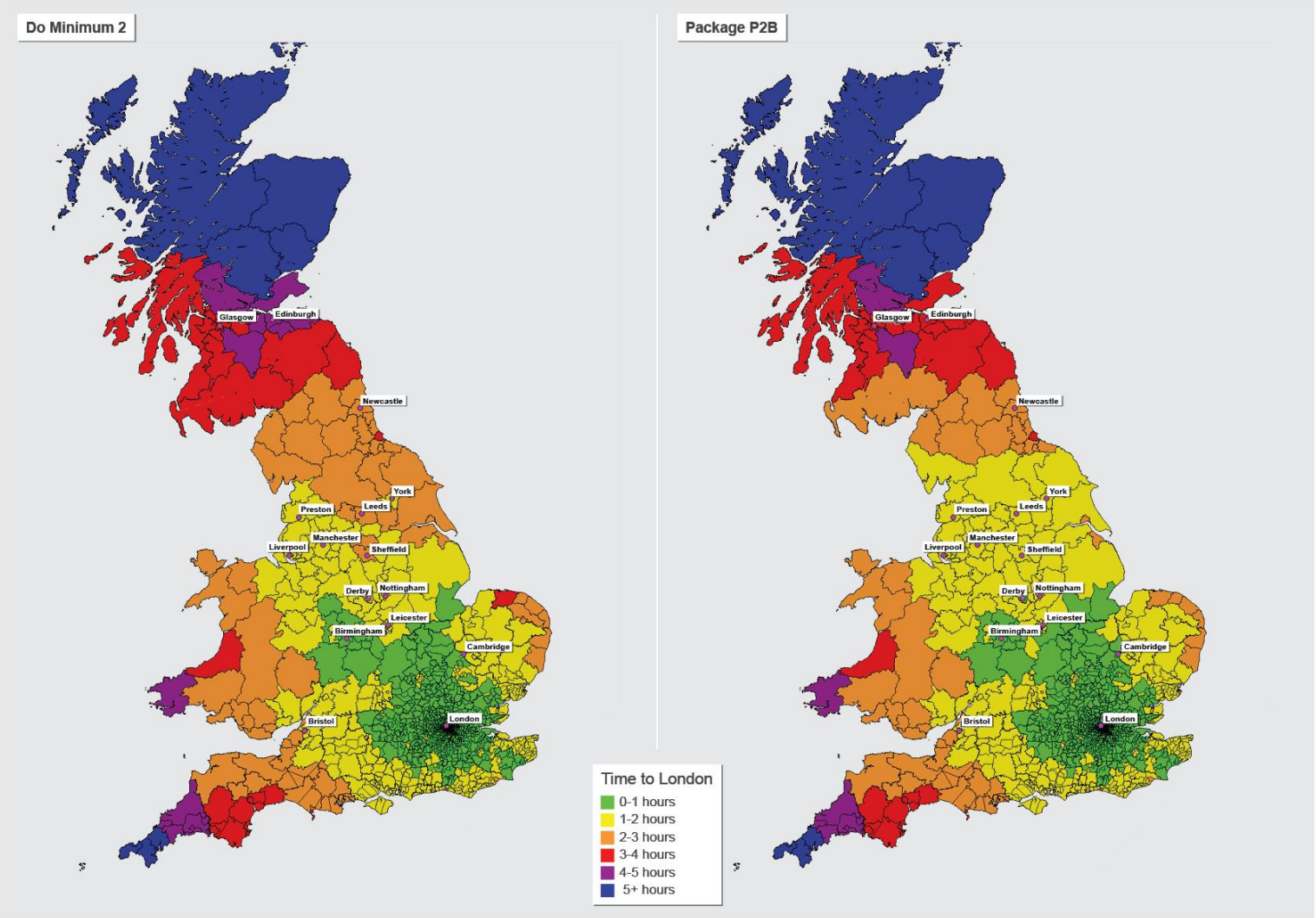


Table 6-8 highlights those areas which switch to a lower time band (lower travel time to London) as a result of implementation of the packages[14].

Table 6-8 Isochrone Analysis

Areas moving from one time band to a higher one (relative to the relevant Do-minimum) as a result of implementation of package of measures				
Package	**Newly less than 1 hour from London with package**	**Newly less than 2 hours from London with package**	**Newly less than 3 hours from London with package**	**Newly less than 4 hours from London with package**
P1	South-east Midlands	North-west Midlands	North Wales	-
YA	South-east Midlands	Leeds and north Yorkshire; North West Midlands	North Wales	Edinburgh area
YB	East Midlands	Leeds and parts of North Yorkshire; North West Midlands	North Wales	Edinburgh area
P2A	-	North Lancashire; Leeds and north Yorkshire	South-east Scotland	Edinburgh area
P2B	-	North Lancashire; Leeds and north Yorkshire	South-east Scotland	Edinburgh area

Each package offers connectivity benefits relative to the Do-minimum. P1 offers less extensive coverage of northern England and eastern Scotland than either of the Y packages. For the with HS2 Phase One scenario, the impacts of P2A and P2B are broadly similar.

6.3.2. Frequency

Table 6-9 presents the assumed train frequency (in trains per hour) between London and key city centres for upgrade packages P1, YA and YB compared to the without HS2 Do-Minimum (DM1). Table 6-10 presents equivalent information for packages P2A and P2B relative to the with HS2 Phase One Do-minimum (DM2). Train service frequencies have been increased as part of the package development process described in Chapter 3 to improve connectivity between key cities. The additional services also contribute to the capacity objective, as they result in the provision of more seats.

[14] While most areas which switch from one time band to another are switching to a lower time band (lower travel time to London), there are a small number of areas which switch to a higher time band. In each case this is due to marginal journey time changes in the model.

Table 6–9 Change in Frequency on Key Intercity Routes (off-peak - to/from London) – Packages P1, YA and YB

	Frequency (Trains per Hour)[1,7]				Difference		
Destination	DM1	P1	YA	YB	P1 – DM1	YA – DM1	YB- DM1
Birmingham	3	4	4	4	1	1	1
Manchester	3	4	6[2]	6[2]	1	3	3
Liverpool	1	2	2	2	1	1	1
Glasgow	1	2	2	2	1	1	1
Sheffield	2	N/A	4[3]	2	-	2	0
Nottingham	2	N/A	3	3	-	1	1
Lincoln	0[4]	N/A	0	1	-	0	1
Leeds[6]	3	N/A	4	6	-	1	3
Bradford[5]	0	N/A	2	2	-	2	2
Newcastle	3	N/A	4	4	-	1	1
Edinburgh	2	N/A	3	3	-	1	1
Derby	2	N/A	3	3	-	1	1
Leicester	4	N/A	4	6	-	0	2

[1]Frequency includes the total number of services to a given destination and therefore includes services which either pass through or terminate there
[2] Frequency to Manchester is increased by the provision of an additional direct hourly service and also through the extension of two Birmingham services via Wolverhampton to Manchester. This also provides improved connectivity between Birmingham and Manchester
[3]Connectivity to Sheffield is improved in Package YA by operating 2tph via the MML and 2tph via the ECML and Nottingham
[4]1 train per day from London in Do-minimum
[5]1 train per day from London in Do-minimum. Connectivity from London to Bradford is substantially improved in Packages YA and YB by the extension of 2tph from Leeds
[6]Connectivity to Leeds is improved by the provision of an additional 1tph in Packages YA & YB. In YB connectivity is further enhanced by the extension of St Pancras to Sheffield services north to Leeds
[7]The above table presents changes in intercity frequency to/from London only. It should be noted that Package YA delivers connectivity improvements between London and Cambridge (2 additional fast trains per hour). There are also connectivity improvements to Cross Country services between Birmingham and Leeds (additional 2tph in Package YA) and Birmingham to Newcastle (additional 2tph achieved by extending Cardiff to Nottingham services to Newcastle) in both Packages YA and YB

Table 6–10 - Change in Frequency on Key Intercity Routes (off-peak - to/from London) – Packages P2A and P2B

	Frequency (Trains per Hour) [1,8]			Difference	
Destination	DM2	P2A	P2B	P2A – DM2	P2B- DM2
Birmingham	5	6	6	1	1
Manchester	4	7[2]	7[2]	3	3
Glasgow	1.5	1.5	1.5	0	0
Leeds	3	4	4	1	1
Bradford[3]	0	2	2	2	2
Newcastle	3	4	4	1	1
Edinburgh	2	3	3	1	1
Sheffield	2	4[4]	4[4]	2	2
Nottingham	2	3	3	1	1
Derby	2	5	5	3	3
Leicester	4	4	4	0	0
Liverpool	2	2	2	0	0
Carlisle	1	1[6]	1[6]	0	0
Stoke on Trent	1	3	3	2	2

[1]Frequency includes the total number of services to a given destination and therefore includes services which either pass through or terminate there

[2] Frequency to Manchester is increased by the provision of an additional hourly service via HS2 Phase One (calling at Stoke) and also through the extension of two Birmingham services via Wolverhampton to Manchester. This also provides improved connectivity between Birmingham and Manchester
[3] 1 train per day from London in Do-minimum. Connectivity from London to Bradford is substantially improved in Packages P2A and P2B by the extension of 2tph from Leeds
[4] Connectivity to Sheffield is improved by the provision of 2 tph via HS2 Phase One in addition to existing services via the MML
[5] Derby benefits from a substantial improvement in connectivity in both Packages, achieved via the provision of 2tph via HS2 Phase One and 3pth on the MML
[6] Although frequency is not increased, connectivity to Carlisle is improved by the provision of a dedicated HS2 service to Carlisle achieved by extending the HS2 service to Preston in the with-HS2 Do-minimum scenario north. As a consequence, classic line services to Glasgow are no longer assumed to stop at Carlisle
[7] Frequency to Stoke is improved compared to the Do-minimum by the introduction of an additional HS2 service to Manchester, which calls at Stoke, as well as the introduction of an additional classic line service to Crewe via Stoke and Alsager
[8] The above table presents changes in intercity frequency to/from London only. It should be noted that both packages deliver connectivity improvements between London and Cambridge with 2 additional fast trains per hour provided. There are also connectivity improvements to Cross Country services in both packages between Birmingham Curzon Street and Leeds (additional 2tph) and Newcastle (additional 2tph via Nottingham)

6.3.3. Reliability

The implications of the packages for the resilience and reliability of the network has already been discussed above. In general, an increase in utilisation, as seen on the WCML and ECML may be indicative of a reduced scope to handle service perturbations and would in any case be likely to result in increased costs to maintain and operate the line in order to maintain existing performance levels.

No allowance has been made for either increased costs of operating and maintaining the routes as a result of increased utilisation, nor has there been an allowance for impacts on the reliability of the network within the appraisal.

6.3.4. Summary of connectivity

Improved connectivity is offered by each of the packages (relative to their respective Do-minimums) in the following way:

- Faster journey times. The packages can generate time savings for passengers travelling to London of up to around 30 mins, and over 60 minutes for some inter-regional passengers (tables 6-5 and 6-6);
- Improved journey times resulting in significant increases in population moving to a lower band (lower journey time) in terms of journey time to London. With package P2B for instance the size of population within less than 2 hour journey time (from their nearest station to a Central London terminal) increases from around 36.5 million in the Do-minimum to around 45 million with the package (table 6-7); and
- More frequent services between key urban centres (tables 6-9 and 6-10).

6.4. Other Considerations

6.4.1. Environmental Impact

Environmental impact has been assessed at a high level in terms of two aspects – sustainability (with reference to the work undertaken for HS2) and noise. These are described in turn below.

6.4.1.1. Appraisal of Sustainability

In order to ensure a consistent approach, and allow a direct comparison of the packages, the Appraisal Framework developed for use in this study has been based on the Appraisal Framework used for HS2 as far as possible. The approach to the appraisal of packages is broadly based on the HS2 Appraisal of Sustainability (AoS) method. The method applies a framework comprising sustainability criteria to each of four option appraisal stages (longlisting, shortlisting, finalising of options and proposed scheme). The packages are at the equivalent of the HS2 Longlisting stage, and the appraisal of the packages has been against the sustainability information used to inform the HS2 Longlisting sift, with some modifications[15].

[15] The longlisting sift is an initial appraisal that takes into account the most sensitive environmental receptors. Not all of the sustainability objectives defined in the HS2 AoS have been considered in the strategic alternatives study.

For those HS2 AoS objectives and evaluation criteria that have been used for assessment of the packages, a summary is set out below.

Climate Factors and Adaptability (HS2 AoS 1.1)

The Climate Factors and Adaptability Core Sustainability Objective was appraised by considering the number of flood zones (FZ) 2 and 3 that the schemes would intersect or abut. The performance of the packages against this objective are summarised in Table 6-11 below.

Each of the packages has schemes that comprise new sections of railway that cross FZ2 or 3. Schemes comprising new sections of railway corridor crossing the flood zone could disrupt surface flood water flows and / or be at risk from flooding. Schemes comprising works to the existing railway corridor are unlikely to result in increased flood risk away from the railway or be at additional risk from flooding than the present situation.

Landscape (HS2 AoS 3.1)

The Landscape Core Sustainability Objective was appraised by considering the number of National Parks and Area of Outstanding Natural Beauty (AONB) crossed by or within the study area of the schemes. All of the packages performed equally against this objective; no National Parks are within the study area of any of the packages and one AONB is within the study area of each of the four packages. The Cannock Chase AONB is within 1km of the WCML grade separated Colwich Junction scheme which is in all packages.

Townscape and Cultural Heritage (HS2 AoS 4.2)

The Townscape and Cultural Heritage Core Sustainability Objective was appraised by considering the number of World Heritage Sites, Scheduled Monuments, Grade I registered parks and gardens, Grade I Listed Buildings crossed by the schemes or within the study area.

The scheme on ECML for additional trackwork at Newcastle Station forms part of all four packages other than P1 and is within close proximity to the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site.

All packages other than P1 comprise schemes with Scheduled Monuments within the study area and scheduled monuments are crossed or abutted by schemes in all packages other than P1 as summarised in Table 6-11.

No Grade I Listed Buildings would be directly impacted by any of the schemes. All the packages other than P1 have a number of Grade I Listed Buildings within the study area as shown in Table 6-11.

There are no Grade I Registered Parks and Gardens within the study area of any of the schemes for any of the packages.

The degree to which the settings of World Heritage Sites, Scheduled Monuments and Grade I Listed Buildings are affected by each of the packages would be dependent on the nature of the works for each of the relevant schemes and local conditions such as topography and the presence of any screening structures or vegetation between the works and the heritage assets.

In addition, schemes are likely to require some demolition of residential and commercial properties at specific locations, for example four-tracking schemes are likely to acquire land outside the existing railway boundary which could result in property demolition. Exceptional care will need to be taken to minimise the extent of demolitions in the towns and villages that could be affected by these schemes.

Biodiversity and Geodiversity (HS2 AoS 5.1)

The Biodiversity and Geodiversity Core Sustainability Objective was appraised by considering the number of Ramsar Sites, Special Areas of Conservation (SAC), Special Protection Areas (SPA), National Nature Reserves (NNR), and Sites of Special Scientific Interest (SSSI) within the study area and the number of these sites that would be crossed or abutted by the schemes.

The Upper Nene Valley Gravel Pits Ramsar Site would be intersected by the MML Wellingborough by-pass scheme which is in package YB. No Ramsar Sites are within the study area of the remaining packages.

SACs and SPAs together form the Natura 2000 network of conservation sites. All of the packages have SACs and SPAs within the study area as shown in Table 6-11.

The number of NNRs within the study area for each of the packages is as shown in Table 6-11.

All of the packages include scheme ECML C (Huntington – Peterborough area) which is adjacent to Holme Fen NNR and could be directly impacted depending on the nature of the proposed scheme.

All of the packages comprise schemes that would intersect or abut a number of SSSIs and have a further number of SSSIs within the study area as shown in Table 6-11.

There is potential for direct impacts to occur to the SSSIs that abut or are intersected by the schemes. The greatest potential for impact is attributed to the SSSIs abutted or crossed by schemes comprising new railway corridor.

Water Resources (HS2 AoS 6.1)

The Water Resources Core Sustainability Objective has been appraised by considering the number of river crossings and Source Protection Zones 1 and 2 that are crossed by the schemes. The number of river crossings (including canals, drains, and other named water courses) for each package is as shown in Table 6-11.

All of the packages comprise schemes that cross SPZs 1 and 2 other than P1 as shown in Table 6-11.

The schemes themselves are unlikely to have an impact on the SPZs once operational, but impacts could occur during construction particularly if any deep piling is required which could create pollution pathways to the underlying groundwater. Best practice measures including following the relevant Environment Agency guidelines would minimise any impacts to SPZs.

Flood Risk (HS2 AoS 6.2)

The Flood Risk Core Sustainability Objective has been appraised by considering the number of areas of Flood Zone (FZ) 3 that would be crossed or abutted by the schemes. All the packages comprise schemes that cross or abut areas designated as FZ3 as shown in Table 6-11.

The schemes that comprise new sections of railway corridor are at greatest risk from flooding depending on the final scheme design. Placing the new railway on embankment in these locations would reduce the risk of flooding to the scheme, but may also disrupt surface water flows within the flood plain. This could change the characteristics of the flood plain and potentially result in new or increased risks of flooding to other areas.

Table 6-11 Summary of environmental assessment

	P1	YA	YB	P2A	P2B
Crosses floodzone 2 or 3	4	144	117	140	145
Scheduled monuments in the study area	0	22	16	22	22
Scheduled monuments crossed or abutted	0	3	2	5	5
Grade 1 listed buildings within the study area	0	8	8	7	7
SAC/SPAs within the study area	1	8	6	9	9
NNRs within the study area	0	5	4	4	5
SSSIs within the study area	2	49	46	44	49
SSSIs intersected or abutted	2	14	9	10	12
River crossings	8	119	102	111	118
Crosses SPZ 1 and 2	0	24	16	36	35
Crosses flood zone 3	3	77	63	74	77

6.4.1.2. Noise Assessment

This assessment identifies the potential noise impacts of a number of rail packages of interventions. The assessment has at this stage sought only to establish the relative noise impacts value of the various packages, based upon a preliminary and high level judgement of populations affected and assuming any uncertainty equally applies to all options. P1 is estimated to have least impact, followed by P2A, P2B, YA and YB (in that order of increasing impact).

6.4.2. Deliverability

NR has undertaken a high-level assessment of the deliverability of the scale of the infrastructure upgrades included in the High, Medium and Low output route-based infrastructure packages (described in Chapter 3) and for each of the five strategic alternative upgrade packages (set out in Chapter 4). This deliverability assessment is presented in Section 8 of the NR October 2013 report in Appendix A and summarised below.

NR has estimated the extent of disruption that might occur, by comparing to the disruption impacts of previous large scale projects undertaken by NR. Their approach involved estimating the number of hours of possessions required for a given level of expenditure, with an adjustment made to exclude the off-line scheme at Alexandra Palace to Biggleswade.

The estimated number of weekend possessions required to deliver all of the infrastructure works for the options is described in Table 6-12 below. It makes no allowance for any efficiencies that might be derived by simultaneous delivery of works.

Table 6-12 Summary of Disruptive Possessions Required by Package

	Package P1	Package YA	Package YB	Package P2A	Package P2B
Total hours of closures for all three routes	21,000 hours	144,900 hours	144,000 hours	123,600 hours	126,600 hours
Total weekend closures for all three routes	410 weekends	2,790 weekends	2,770 weekends	2,380 weekends	2,430 weekends

Assuming that all three routes would be worked on concurrently, undertaking multiple schemes on a given route simultaneously is possible but would bring additional logistical challenges. These include the nature and extent of the project, the availability of equipment and personnel, and the need to resource other construction activities elsewhere on the network. It has not been possible at this early level of development to provide a detailed assessment of the opportunities that might be available for work to be undertaken at more than one point on the network at a time. However, to give an indication of the time savings that might be realised, NR have looked at the effect of one, two and three schemes being delivered at the same time.

Table 6-13 summarises the estimated level of disruption arising from the delivery of the packages, taking into account the above factors. This is presented both in terms of the total number of hours of disruptive possessions required as well as the equivalent number of Saturday / Sunday blockades required to deliver those hours. Equivalent weekends are calculated by dividing the number of hours by 52 hours (the length of a weekend possession) and further dividing by 52 weekends per year. The critical path is determined by the route that has the highest level of disruptive works, which is the East Coast Main Line in all packages with the exception of package P1. Within the critical path window, it is assumed that works on the other routes take place within this timescale to ensure delivery by the planned high speed rail delivery dates of 2026 and 2033 for Phase 1 and Phase 2 respectively.

The table shows likely duration of disruption based on one, two and three schemes taking place on each route every weekend of the year at any one time. It also shows the length of disruption assuming 24 hour working all year. In practice however, the latter would not be possible.

It should be noted that these estimates are illustrative and would require considerable additional planning and refinement before they could be considered robust. Nevertheless, the exercise provides an idea of the scope of disruption that would occur should such a programme be instigated.

Table 6-13 Summary of Disruptive Possessions Required by Package

	Package P1	Package YA	Package YB	Package P2A	Package P2B
Most affected route, which drives critical path	WCML	ECML	ECML	ECML	ECML
Number of hours of possessions	21,000 hours	77,000 hours	72,000 hours	74,000 hours	77,000 hours
Number of weekends of possessions (at 52 hours per weekend)	410 weekends	1,500 weekends	1,380 weekends	1,420 weekends	1,500 weekends
Years of disruption every weekend of the year assuming 1 scheme on each route at any one time	8 years	29 years	26 years	27 years	29 years
Years of disruption every weekend of the year assuming 2 simultaneous schemes on each route at any one time	4 years	14 years	13 years	14 years	14 years
Years of disruption every weekend of the year assuming 3 simultaneous schemes on each route at any one time	3 years	10 years	9 years	9 years	10 years
Years of disruption working 24 hours a day, all year with 3 simultaneous worksites.	0.8 years	2.9 years	2.7 years	2.8 years	2.9 years

Table 6.13 shows that:

- If simultaneous work is carried out across the three lines **and** at **two** separate work sites on the same line (e.g. EMCL) packages YA, P2A and P2B could be delivered in 14 years, and package YB within 13;
- If simultaneous work is carried out across the three lines **and** at **three** separate work sites on the same line (e.g. EMCL) packages YA and P2B could be delivered in 10 years, and package YB and P2A within 9;
- P1 could be delivered within 4 or 3 years depending on whether 2 or 3 concurrent work sites are assumed on WCML; and
- If a 24/7 construction regime was implemented, delivery periods of between 0.8 years (P1) and 2.9 years would be achievable.

With the exception of P1, NR's overall conclusion is that it is not possible to have an upgrade programme of this magnitude without it resulting in significant disruption to weekend rail travel on multiple routes over a lengthy period of time of at least 9 to 14 years. This does not mean that the whole lines would be closed for these durations, as works take place only at specific geographic locations. Good planning, careful staging of works and the use of diversionary routes could serve to mitigate in part the impact on passengers. Nevertheless, NR 's conclusion is that there is no way to undertake upgrade programmes of this magnitude without it resulting in significant disruption to weekend rail travel on multiple routes over a lengthy period of time.

6.4.3. Affordability

Estimates of the cost of implementing each of the upgrade packages have been made as described in Chapter 5. Capital infrastructure costs for the strategic alternatives are presented in Table 6-14. These represent undiscounted real capital costs, in 2011 prices, expressed in factor cost unit of account[16]. The costs do not include an allowance for future inflation (capex inflation is assumed to increase in line with general prices), to be consistent with the approach of HS2 Ltd.

Table 6–14 Undiscounted Real Scheme Capital Costs (£m, 2011 prices)

	Base Costs	Optimism Bias	Total Scheme Costs
Package P1	£1,484	£980	£2,464
Package YA	£11,568	£7,635	£19,203
Package YB	£9,989	£6,593	£16,581
Package P2A	£9,907	£6,538	£16,445
Package P2B	£10,150	£6,699	£16,849

In order to be consistent with the appraisal assumptions of HS2 Ltd, the central case assumes that the additional rolling stock fleet required to operate each package would be purchased. These costs are presented in Table 6-15. As per HS2 Ltd, it was assumed the rolling stock fleet would be replaced every 35 years.

An optimism bias allowance of 15% has been applied to classic line rolling stock purchase costs in the central case. This is consistent with the lower rate of OB applied to HS2's captive rolling stock (as opposed to the classic compatible stock which has an OB rate of 20%). DfT considered this to be an appropriately conservative assumption for the strategic alternatives given that the stock assumed in the strategic alternatives is either already operational on the UK rail network, or has been ordered but is not yet running, or a UK price has been indicated by manufacturers.

Packages P2A and P2B require the purchase of additional 200m classic compatible High Speed units. An OB rate of 20% was applied to these costs consistent with HS2 Ltd's assumption.

Table 6–15 Undiscounted Real Capital Cost of Rolling Stock – Central Case (£m, 2011 prices)

	Base Costs	Optimism Bias	Total Scheme Costs
Package P1	£2,390	£359	£2,749
Package YA	£5,463	£385	£5,848
Package YB	£5,519	£382	£5,901
Package P2A	£4,180	£325	£4,505
Package P2B	£3,952	£222	£4,174

The total scheme capital costs, including both infrastructure works and rolling stock purchase for each Package are shown in Table 6-16.

[16] See webTAG 3.5.9. http://www.dft.gov.uk/webtag/documents/expert/pdf/u3_5_9-scheme-costs-120723.pdf

Table 6–16 Undiscounted Total Scheme Capital Costs including Rolling Stock Purchase costs – Central Case (£m, 2011 prices)

	Base Costs	Optimism Bias	Total Scheme Costs
Package P1	£3,874	£1,339	£5,213
Package YA	£17,031	£8,020	£25,051
Package YB	£15,508	£6,975	£22,482
Package P2A	£14,087	£6,863	£20,950
Package P2B	£14,102	£6,921	£21,023

6.4.4. Value for Money

A value for money (VfM) assessment has been undertaken for each upgrade package using the Department's standard approach to the economic appraisal of transport infrastructure investment. The approach is described in more detail in Appendix D. All of the commentary below, which describes the relationship of the Benefit Cost Ratio (BCR) to the DfT Value for Money Categories (Poor, Low, Medium, High, Very High), assumes there are no significant non-monetised impacts in the appraisal.

The upgrade packages were assessed using the PLANET framework model (PFM v4.3) developed by HS2 Ltd specifically for assessing the HS2 Proposition. The HS2 models have been used to ensure consistency between the appraisal of the HS2 Scheme and the Alternatives. A common Do-minimum has also been agreed between the two studies, enabling comparisons to be undertaken on the same basis.

Model runs were undertaken for both 2026 and 2036, and an economic appraisal undertaken consistent with the approach taken by HS2 Ltd.

The economic appraisal has been undertaken using the same bespoke spreadsheet model developed by HS2 Ltd for appraising the HS2 scheme. This process uses outputs from the PLANET Strategic model in conjunction with economic parameters and formulae contained in the DfT's WebTAG Unit 3.5.6. The appraisal is based on the same 60-year appraisal period as for HS2 Ltd. For the HS2 Phase One alternatives (Package P1), it was assumed that the infrastructure works in the package are completed for opening in 2026.

For Packages YA and YB and Phase Two of HS2 (Packages P2A and P2B), it was assumed that works on the WCML are completed for opening in 2026, with the works on the ECML , MML and Cross Country routes undertaken for opening in 2033. This approach is consistent with the HS2 Ltd assumption that if the decision is taken to proceed with the full HS2 scheme, Phase One would open in 2026, with Phase Two opened in 2033. The total appraisal period for these packages is therefore from 2026 through to 2092.

Summary economic statistics for the central case scenario, which assumes that additional rolling stock is assumed to be purchased with 15% OB applied to classic line rolling stock costs (with the exception of IEP rolling stock for which firm contract prices have been secured), are presented in Table 6-17.

Table 6–17 Economic Summary Statistics – Central Case (£m, 2011 prices and values)

Economic Summary Statistic	PVB	PVC	NPV	BCR
Package P1	£7,423	£4,273	£3,150	1.7
Package YA	£25,326	£9,796	£15,530	2.6
Package YB	£23,104	£8,605	£14,499	2.7
Package P2A	£18,111	£9,030	£9,080	2.0
Package P2B	£17,967	£8,539	£9,429	2.1

The results in Table 6-17 show that all of the packages have BCRs of greater than 1, reflecting the fact that the Present Value of Benefits (PVB) is higher than the Present Value of Costs (PVC). In the case of Packages YA and YB, the BCRs are both greater than 2 meaning that these packages can be characterised

as providing 'high' value for money. The BCR for Package P1 is 1.7 and therefore provides 'medium' value for money.

The BCR for Packages P2A and P2B are 2.0 and 2.1 respectively. The PVB for both of these packages is lower by approximately £7bn than the 'Y' network alternatives, while the scheme costs are of a similar magnitude to the scheme costs for Packages YA and YB. Both of these elements combine to produce comparatively lower BCRs. Nevertheless, both BCRs are either equal to or greater than 2.0 meaning that these packages can be characterised as providing 'high' value for money.

As described in Chapter 5, a number of sensitivity tests have been undertaken making different assumptions about the cost element of the VfM case, recognising the uncertainty associated with the cost of the packages. Table 6-18 provides a summary of the sensitivity tests undertaken, the results of which are described further below.

Table 6–18 Summary of Central Case and Sensitivity Tests used for Value for Money

Test	Rolling stock costs	Capital Cost additional uplift	Operating cost OB assumptions
Central Case	Purchased – included as capex	n/a	As per section 5.3.2 appropriate to classic rolling stock
Sensitivity test 1	Leased – included as opex	n/a	As per section 5.3.2 appropriate to classic rolling stock
Sensitivity test 2	Purchased – included as capex	+25% (prior to application of OB)	As per section 5.3.2 appropriate to classic rolling stock
Sensitivity test 3	Purchased – included as capex	n/a	OB assumptions employed by HS2 for high speed rail rolling stock applied to classic rolling stock
Sensitivity test 4	Purchased – included as capex	+25% (prior to application of OB)	OB assumptions employed by HS2 for high speed rail rolling stock applied to classic rolling stock

Summary economic statistics for sensitivity test 1 where rolling stock is assumed to be leased with 15% optimism bias applied to the classic line rolling stock lease costs (with the exception of IEP rolling stock) are presented in Table 6-19.

Table 6–19 Economic Summary Statistics – Sensitivity 1 (£m, 2011 prices and values)

Economic Summary Statistic	PVB	PVC	NPV	BCR
Package P1	£7,423	£5,954	£1,469	1.2
Package YA	£25,326	£13,954	£11,371	1.8
Package YB	£23,104	£12,300	£10,804	1.9
Package P2A	£18,111	£11,312	£6,799	1.6
Package P2B	£17,967	£11,063	£6,904	1.6

The effect of assuming that rolling stock is leased rather than purchased is to increase the present value of costs for all of the packages. This means that under this scenario, the BCRs of all of the packages are lower than when the additional rolling stock is assumed to be purchased. Nevertheless, the BCRs are all still greater than 1, and in the case of Packages YA and YB, the BCRs are greater than 1.5 meaning that these packages can be characterised as providing 'medium' value for money. The impact on the BCRs for Packages P2A and P2B is less marked as there is a lower proportion of leased rolling stock in these two scenarios, but they remain medium value for money.

Three further sensitivity tests were undertaken to investigate the impact of different cost assumptions on the Central Case BCRs. These are summarised as follows:

- **Sensitivity 2** - scheme cost sensitivity test with a 25% uplift applied to the scheme capital cost estimates to consider the impact of uncertainty in the cost estimates on the BCRs;
- **Sensitivity 3** – operating costs using the same optimism bias assumptions as HS2 Ltd for their operating cost estimates for the main HS2 scheme, to understand the impact of the different approaches to OB assumptions between the main HS2 scheme and strategic alternatives (scheme capital costs as per Central Case); and
- **Sensitivity 4 –** a combination of the above two sensitivity tests i.e. scheme capital costs uplifted by 25% and operating costs using the same optimism bias assumptions as HS2 Ltd, to understand the combined impact of the cost changes on the BCRs.

Table 6–20 Cost Sensitivity Test Results

Package	Central Case BCRs	Sensitivity Test 2 - BCRs including 25% Uplift in Scheme Capital Costs	Sensitivity Test 3 - BCRs including same opex assumptions as HS2	Sensitivity Test 4 -BCRs including 25% Uplift in Scheme Capital Costs & same opex assumptions as HS2
Package P1	1.7	1.6	1.5	1.4
Package YA	2.6	2.0	2.3	1.8
Package YB	2.7	2.0	2.3	1.8
Package P2A	2.0	1.6	1.9	1.5
Package P2B	2.1	1.6	1.9	1.5

Table 6-20 shows that applying an uplift of 25% to the scheme capital costs reduces the BCRS for packages YA and YB to 2.0; despite this, the BCRs for both packages can be characterised as still providing high value for money. The BCRs for Packages P1, P2A and P2B are also reduced, though all three are still characterised as providing medium value for money.

The impact of applying the same OB assumptions to the strategic alternatives operating costs as used by HS2 Ltd for the main HS2 scheme has a less marked impact on the central case BCRs. The BCRs for packages YA and YB both remain as greater than 2.0, and so still provide high value for money. The BCRs for Packages P2A and P2B are both reduced to 1.9, implying both packages still provide medium value for money.

The combined impact of the cost changes is to reduce the BCRs for Packages YA and YB to 1.8, suggesting that both packages provide medium value for money. The BCRs for Packages P2A and P2B fall to 1.5, while the BCR for Package P1 is reduced to 1.4.

Comparison of the Value for Money of Alternatives from Previous Studies

As described in section 1.4, a number of previous studies of strategic alternatives has been undertaken. Value for money assessments of the strategic alternatives considered were undertaken as part of these studies.

Four of the five strategic alternative upgrade packages taken forward for appraisal in this study are not directly comparable to packages examined in the previous studies on alternatives. The Y-network alternatives (YA and YB) are significantly different from the alternatives considered by previous studies. Packages P2A and P2B, which are potential alternatives to Phase Two in a scenario where HS2 Phase One is built, were not considered by earlier studies.

The most direct comparison can be made between the alternatives to HS2 Phase One, P1 presented in this report and Rail Package 2 (RP2) as presented in the January 2012 'High Speed 2 Strategic Alternatives Study- Update Following Consultation' report. Package P1 includes a number of different interventions seeking to increase capacity and improve connectivity (which has led to an increase in cost relative to the last version of RP2). In addition, the method used to estimate operating costs has been updated. In line with the modelling and appraisal work on HS2, there have also been changes to the Do-minimum assumptions, and changes to the model and appraisal methodology including the way crowding is treated. As a consequence, the BCR of P1 is calculated to be lower than that for RP2 presented in January 2012.

6.4.4.1. Disaggregation of Rail Passenger User Benefits

Table 6-21 gives a breakdown of the Present Value of Benefits for the Central Case analysis demonstrating that rail user benefits (both for consumers and business) form the dominant element of the overall PVB.

Table 6–21 Disaggregation of Present Value of Benefits

	Package P1	Package YA	Package YB	Package P2A	Package P2B
Rail User Benefits – Consumer	2,633	9,760	9,218	6,577	6,540
Rail User Benefits – Business	4,983	16,076	14,458	11,893	11,755
Road User Benefits – Consumer	159	606	528	426	447
Road User Benefits – Business	95	360	310	253	267
Noise	4	18	17	13	13
Local Air Quality	-	-	-	-	-
Accidents	54	229	214	163	164
Loss of Indirect Tax	-506	-1,724	-1,642	-1,215	-1,219
Present Value of Benefits	7,423	25,326	23,104	18,111	17,967

User benefits for rail passengers are comprised of a number of different components. To understand how the rail user benefits for each of the packages reported in the previous section have been generated, a disaggregation is shown in Table 6-22.

Table 6–22 Disaggregation of Rail User Benefits

	Package P1	Package YA	Package YB	Package P2A	Package P2B
Journey Time Savings	2,739	14,323	12,154	12,053	11,970
Crowding Benefits	2,760	6,020	5,747	2,562	2,607
Wait Time Savings	2,378	6,160	6,360	2,905	3,116
Boarding Penalty Savings	-356	-555	-529	750	638
Access/Egress & Walk Time Savings	96	-112	-57	200	-36
Total Rail User Benefits	**7,617**	**25,836**	**23,676**	**18,470**	**18,295**

The benefits for Package P1 are generally split equally between journey time savings, crowding benefits and wait time savings (frequency benefits). The benefits for the other packages are much more heavily weighted towards journey time savings. For Packages YA and YB, journey time savings comprise over 50% of the total rail user benefits reflecting the substantially reduced journey times in these two scenarios on the ECML and Cross Country routes. Whilst the journey times between major cities are almost always slower than for HS2, some benefits are accrued from improved journey times to smaller cities and large towns where the routes which serve them have been speeded up. This is particularly the case on the eastern side of the country. This helps to explain how reasonably large time savings benefits, although still significantly smaller than for HS2, are achieved. For packages P2A and P2B, the proportion is greater, with journey time savings comprising around two-thirds of the total rail user benefits. Crowding and wait time savings are much lower in these two packages compared to Packages YA and YB, as the benefits delivered on the WCML in YA and YB are no longer present due to the introduction of HS2 Phase One.

6.4.5. Wider Economic Impacts

WebTAG Unit 3.5.14 identifies four 'wider economic impacts' which are not captured by conventional economic analysis[17]; namely: agglomeration effects (the productivity gains resulting from firms clustering with other firms and employees), labour market effects (resulting from reduced commuting travel costs), the impacts of jobs moving to more productive locations and the impacts of increased output in imperfectly competitive markets.

Agglomeration and labour market impacts were estimated using the same process developed for the HS2 Business Case, drawing on the changes in generalised cost and demand matrices from the PLANET models and the Department for Transport's WITA software and associated economic dataset.

In line with WebTAG guidance, the impacts of jobs relocating to more productive locations were not estimated, as no appropriate land use and transport interaction model exists to represent the impacts of the packages. The impact of the additional value of increased output in imperfectly competitive markets was estimated using the approach set out in WebTAG of equating the value to an uplift of 10% on the value of business user impacts.

Table 6-23 provides a summary of the estimated Wider Economic Impacts for each of the modelled packages.

[17] due to the underlying theoretical assumptions that the economy behaves in a 'theoretically perfect' way

Table 6–23 Conventional and Wider Economic Impacts by Package (£ million, 2011 present value)

	Package P1	Package YA	Package YB	Package 2A	Package 2B
Net Conventional Transport Benefits (PVB)	**£7,423**	**£25,326**	**£23,104**	**£18,111**	**£17,967**
Agglomeration	£530	£3,573	£3,435	£2,717	£2,809
Labour Market Impacts	£26	£184	£169	£163	£21
Output in Imperfect Competition	£508	£1,644	£1,477	£1,215	£1,202
Net Benefits including Wider Economic Impacts	**£8,487**	**£30,727**	**£28,184**	**£22,205**	**£21,999**
WEI as % Conventional PVB	14%	21%	22%	23%	22%

For Packages YA, YB, P2A and P2B, the combined effect of the Wider Economic Impacts is equivalent to over 20% of the Present Value of conventional benefits. Approximately 65% to 70% of the Wider Economic Impacts are derived from agglomeration effects and 30% from the impact of increased competition in imperfectly competitive markets, with the remainder attributable to labour market effects.

The key influences on Wider Economic Impacts differ from those for the conventional user benefits of the packages as agglomeration and labour market effects are driven largely by shorter distance, intra-urban movements, rather than the long distance inter-urban movements that are typically more influential for conventional benefits. The patterns of benefits are therefore most strongly influenced by improvements in travel costs within urban areas, due to journey time improvements and/or crowding relief due to capacity increases. So, quicker and more frequent services for relatively short journeys is driving this pattern of benefits, for instance Wakefield to Leeds.

For Package P1 negative local impacts, although having a relatively limited impact on conventional benefits, have a more significant impact on Wider Economic Impacts, reducing their net scale. For P1, increases in journey costs on some journeys within the West Midlands lead to dis-agglomeration effects, offsetting some of the benefits elsewhere so that agglomeration impacts only equate to 7% of total conventional benefits and contributing only 50% of the total wider impacts.

The impact of the Wider Economic Impacts on the Central Case BCRs is shown in Table 6-24. The impact of the Wider Economic Impacts on the sensitivity test BCRs is shown in Table 6-25.

Table 6–24 Effect of Wider Economic Impacts on Central Case BCRs

Economic Summary Statistic	BCR Excluding WEIs	BCR Including WEIs
Package P1	1.7	2.0
Package YA	2.6	3.1
Package YB	2.7	3.3
Package P2A	2.0	2.5
Package P2B	2.1	2.6

Table 6–25 Effect of Wider Economic Impacts on Sensitivity Test BCRs

Package	Sensitivity Test 1		Sensitivity Test 2		Sensitivity Test 3		Sensitivity Test 4	
	BCR Excluding WEIs	BCR Including WEIs	BCR Excluding WEIs	BCR Including WEIs	BCR Excluding WEIs	BCR Including WEIs	BCR Excluding WEIs	BCR Including WEIs
Package P1	1.2	1.4	1.6	1.8	1.5	1.7	1.4	1.6
Package YA	1.8	2.2	2.0	2.4	2.3	2.8	1.8	2.2
Package YB	1.9	2.3	2.0	2.5	2.3	2.8	1.8	2.2
Package P2A	1.6	2.0	1.6	1.9	1.9	2.3	1.5	1.8
Package P2B	1.6	2.0	1.6	2.0	1.9	2.4	1.5	1.8

Table 6-25 shows that across all four sensitivity tests, the inclusion of Wider Economic Impacts into the appraisal leads to the BCRs for Packages YA and YB being greater than 2.0, meaning that these packages can be characterised as remaining as high value for money under all sensitivity tests used. With the exception of Sensitivity Test 1 for P1, the BCRs for Packages P1, P2A and P2B are over 1.5 for the sensitivity tests meaning that the result of including the wider economic impacts is that the value for money of these packages appears remain as ‘medium’ under all sensitivity tests.

6.4.6. Future Proof

The packages identified in this study have been developed with the view to achieve the strategic objectives as far as possible; while also ensuring that they are realistic and feasible. Despite this there are clearly challenges for the packages. There are questions about the extent to which the packages can truly be delivered when considering the complexity of delivering the required upgrades simultaneously across multiple routes.

This suggests that while the packages are likely to be relatively future proof in relation to downside risks (where lower demand can be accommodated through reduced crowding and de-scoping of some interventions), there is likely to be less scope to address higher demand growth, or continued growth beyond the 'cap year' (i.e. 2036). Given that, even on the basis of current demand forecasts, peak crowding levels are high, increases in demand would probably require additional capacity to be found.

There is scope within the existing packages, particularly for MML, ECML and Cross Country, to provide some extra capacity through train lengthening but there is more limited scope to increase capacity through frequency enhancements without further considerable infrastructure investments. Discussions in this study did not identify any obvious further infrastructure investments which were likely to boost capacity and offer value for money.

Appendix A. Options for Potential Capacity and Connectivity Enhancements to the Existing Network

This appendix, written by Network Rail, has been published separately to this report. Please see www.gov.uk/government/publications/rail-alternatives-to-hs2.

Appendix B. Route Package details

B.1. Introduction

Potential interventions were identified and developed for each of ECML, WCML and MML by NR drawing upon knowledge of existing and future network constraints on a route section by route section basis. These constraints are set out in greater detail in the NR October 2013 report in Appendix A. NR – supported by DfT and Atkins – combined the interventions into route-specific packages representing Low, Medium and High capacity and connectivity outputs. The extent to which each of the Low, Medium and High route-based packages could deliver capacity and connectivity improvements was assessed. This included introduction of some new schemes and removal of others, leading to the creation of refined route-based packages for each route. The refinements of interventions which was undertaken as part of this process is set out in detail in the tables below, for each route package in turn.

Table B-1 Summary of Interventions in ECML Route-Based Packages

Intervention	Rationale for Intervention	NR Package A – High Output	NR Package B – Medium Output	NR Package C – Low Output	Refined Package EC1	Refined Package EC2	Comments
775m Freight loops between Newcastle and Edinburgh	Facilitates increase in long-distance frequency between London and Edinburgh to 3tph				•	•	Refined package train service specification proposed 3tph to Edinburgh (compared with 2tph in NR service packages). DfT agreed with NR that this would necessitate the provision of additional infrastructure for freight.
Additional 2 tracks between Alexandra Palace and Biggleswade via a combination of tunnel to the M25 and then new alignment broadly following the A1	Addresses the capacity constraint at Welwyn Viaduct - facilitates increase in long-distance frequency to 11 tph & journey time improvements through 140mph running	•			•		
Increased capacity and speed on the corridor between Sheffield and Leeds Two options: either re-opening of the North Midlands Route from Rotherham/Swinton area to Leeds/Woodlesford area or upgrading the existing route to provide four tracking between Swinton and Moorthorpe	Facilitate increase in Cross Country services and journey time improvements	•					This scheme was omitted from the refined 'high' package and replaced by an alternative scheme, Sheffield to Leeds improvements. See below for details.
Upgrade Leeds – Sheffield route via Barnsley	Facilitates increase in Cross Country services between Sheffield and Leeds		•				Omitted from the refined packages and replaced by an alternative scheme - Sheffield to Leeds improvements (minor). See below for details
Sheffield to Leeds improvements - 4-track between Swinton and Moorthorpe / South Kirby Junction, grade separate South Kirby junction and upgrade line speed from Sheffield to Moorthorpe to 125mph					•		This intervention was proposed by DfT/Atkins for the refined 'high' package. It replaced the options put forward by NR for increasing capacity and speed on the Sheffield to Leeds corridor in the NR high package (described above).
Sheffield to Leeds improvements (minor) - grade separate South Kirby junction and upgrade line speed from Sheffield to Moorthorpe to 125mph						•	This intervention was proposed by DfT/Atkins for the refined 'medium' package. It replaced the option proposed by NR for upgrading the Sheffield to Leeds route via Barnsley in the NR medium package (described above).
Additional track work at Newcastle station (to assist movements into bay platforms)	Additional scheme to accommodate additional Cross Country services from Birmingham				•	•	Refined package train service specifications propose additional Cross Country services to Newcastle compared to the NR packages, necessitating work to accommodate these services at Newcastle station
Cambridge chord – cut-off route	Enable fast suburban services to Cambridge via new				•		Refined high package proposes additional fast

Intervention	Rationale for Intervention	NR Package A – High Output	NR Package B – Medium Output	NR Package C – Low Output	Refined Package EC1	Refined Package EC2	Comments
from new Alexandra Palace to Biggleswade line south of Baldock to join line to Cambridge.	Alexandra Palace to Biggleswade alignment facilitating journey time and frequency improvements.						services (4tph) to Cambridge to improve suburban connectivity between Cambridge and London using the new alignment. This infrastructure is required to facilitate this. The NR packages did not include these services.
Changes to switches and crossovers in Alexandra Palace area	Improves crossover speed of all fast line to slow line and slow line to fast line crossovers at Alexandra Palace and Finsbury Park (north of the new tunnel entrance at Alexandra Palace)	•			•		
Darlington - provision of fast line platform at Darlington Station	Facilitates Darlington call in long-distance services	•	•		•	•	
Doncaster - Leeds improvements	Delivers journey time enhancements and enables fast London – Leeds services to operate via Doncaster and Wakefield				•	•	The NR packages proposed fast services to Leeds via Hambleton Junction/Micklefield and included infrastructure to facilitate this. This intervention enables fast services to operate via Wakefield instead.
Doncaster Station grade separation	Required to allow for freight and suburban services alongside increased long-distance frequency - facilitates increase in long-distance frequency above 8tph	•	•		•	•	
Dynamic Loop between Micklefield and Leeds	Facilitates increase in long-distance frequency via Micklefield to Leeds above 1tph (see note A)	•	•				Omitted from the refined package as fast Leeds services changed to operate via Wakefield instead of via Micklefield in refined packages
Dynamic loop between Peterborough and Doncaster	Provides dynamic overtaking facility to allow for a mix of different speed services over this section and therefore supports speed increases for non-stop long-distance services over this section - facilitates increase in long-distance frequency above 8tph (see note B)	•	•				Omitted from refined packages as DfT/Atkins considered it likely to be able to deliver the train service specification without this infrastructure
Electrification of Grantham to Nottingham, and line speed improvements to 125mph	Facilitates operation of fast services to Nottingham via ECML	•			•		
Electrification on the GN/GE Joint Line	Facilitates increase in long-distance passenger services by providing a segregated route for electrified freight. Removal of freight traffic also facilitates higher speed running and journey time reductions	•	•		•	•	
Freight avoiding scheme for Doncaster – York via Barnby Dun	Facilitates increase in long-distance passenger services by providing an alternative route for freight	•	•		•	•	

Intervention	Rationale for Intervention	NR Package A – High Output	NR Package B – Medium Output	NR Package C – Low Output	Refined Package EC1	Refined Package EC2	Comments
and Knottingley	therefore freeing up capacity on main-line ECML						
Grantham - 2 additional platforms at Grantham on the Down side of the layout with the single line doubled from Nottingham Branch Junction to Grantham Station	Facilitates operation of fast services to Nottingham via ECML	•			•		
Huntingdon – Peterborough area - 4 tracking	Facilitate increase in long-distance frequency of 8tph to a maximum of 12tph alongside freight growth and outer suburban services	•	•	•	•	•	
King's Cross throat works, including lengthening all platforms to at least 12-car suburban length, reducing the total number of platforms by 1, and reopening the disused tunnels.	Facilitate increase in Intercity service quantum and length (minimum of 8tph up to maximum of 12tph)	•	•	•	•	•	
Leeds Station capacity increase	Facilitates increase in Cross Country services to Leeds from Birmingham	•	•		•	•	
Level crossings - closure of all level crossings south of Darlington[18]	Required to facilitate journey time savings from linespeed improvements to 140 mph running	•	•		•	•	
Line speed improvements to the fast line between Biggleswade and Darlington	Provides journey time reductions between Biggleswade and Darlington as a result of upgrading sections of the ECML to 140mph running (see note C)	•			•	•	The journey time improvements are dependent on completion of schemes in the package to facilitate capacity for freight and regional services. This removes the speed differential constraint which exists at multiple locations on the route, and the journey time improvement cannot be achieved without these schemes
New platforms at Haringey and Hornsey	Enables segregation of inner suburban, suburban and Intercity services north of King's Cross facilitating more intensive use of second slow lines for short distance services, leaving slow line 1 clear for longer distance Thameslink services until north of Alexandra Palace	•	•	•	•	•	
Newark Grade Separation and chord to ECML	Facilitates increase in long-distance frequency above 8tph by addressing the capacity constraint arising from the flat crossing at Newark for east-west traffic. Also enables services to/from Nottingham to access the ECML via new chord	•	•		•	•	

[18] Note that the cost of closing all level crossings between London and Edinburgh has been included in the appraisal

Intervention	Rationale for Intervention	NR Package A – High Output	NR Package B – Medium Output	NR Package C – Low Output	Refined Package EC1	Refined Package EC2	Comments
Newcastle - Edinburgh power supply upgrade – to allow 3tph London – Edinburgh	Facilitates increase in long-distance frequency between London and Edinburgh to 3tph				•	•	Refined package train service specification proposed 3tph to Edinburgh (compared with 2tph in NR service packages). DfT agreed with NR that this would necessitate the provision of additional infrastructure for freight.
Re-open and upgrade the Leamside line between Tursdale Junction and Pelaw with new alignment to Chester-Le-Street	Facilitates increase in long-distance frequency alongside freight growth north of York, along with journey time savings due to 140mph running	•			•	•	This scheme was included in both the high and medium refined packages
Re-open Leamside Line for freight use	Provides capacity for freight to allow for increases in long-distance frequency (to 5tph north of York)		•				This scheme is a lower output Leamside scheme designed to provide freight capacity to enable the mainline to be used for long-distance passenger traffic. Not included in the refined packages as the higher output scheme (see above) was included in both the high and medium refined packages
Skelton Bridge Flyover (north of York)	Replaced the York Station northern access improvements in the refined packages				•	•	This scheme replaced the York Station northern access improvements in the NR packages
Upgrade the Stillington Line	Provides capacity for freight to allow for increases in long-distance frequency (to 5tph north of York)	•	•		•	•	
Welwyn Tunnel 4 tracking	Addresses the capacity constraint at Welwyn Viaduct - alternative scheme to Alexandra Palace to Biggleswade, facilitates a lower increase in long-distance frequency though		•			•	
York Station – northern access improvements	Facilitates long-distance frequency of 7tph north of York alongside freight growth, without impacting on journey time	•	•				This scheme was replaced by an alternative scheme in the refined packages (Skelton Bridge Flyover)

Table B-2 Summary of Interventions in WCML Route-Based Packages – No HS2 Phase One Scenario

Intervention	Rationale for Intervention	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Refined Package – WC1	Notes
Three additional platforms at London Euston	Required to facilitate increase in fast line frequency to 16tph (see note A)	•	•	•		Omitted from the refined packages following subsequent consultation with Network Rail, who confirmed that it would be possible to operate a 16tph fast line timetable without additional platforms at Euston if turnaround times are reduced. It is noted that additional platforms at Euston would be desirable if the construction cost provided value for money.
Reinstate Primrose Hill station and 3 tracks at Camden Rd (North London Line)	Enables London Overground services to be diverted onto the North London line and to release platform capacity at Euston, providing 4 additional slow line paths per hour (see note B)	•	•			Following initial testing of the NR 'high' package, all interventions associated with extending the Bakerloo Line to Watford and removing London Overground services from Euston to create additional slow line paths for commuting services were omitted from the refined package. Initial testing found that these interventions provided low value for money.
4th rail, Signalling and power upgrade between Harrow & Wealdstone and Watford (DC)	Required to extend Bakerloo Line from Harrow to Watford to provide additional commuting capacity. Enables London Overground services to be diverted onto the North London line and to release platform capacity at Euston, providing 4 additional slow line paths per hour (see note B)	•	•			
Platform works (stepping distances) between Harrow & Wealdstone and Watford (DC)	Required to extend Bakerloo Line from Harrow to Watford to provide additional commuting capacity. Enables London Overground services to be diverted onto the North London line and to release platform capacity at Euston, providing 4 additional slow line paths per hour (see note B)	•	•			
Additional turn back facility at Watford Junction	Required to extend Bakerloo Line from Harrow to Watford to provide additional commuting capacity. Enables London Overground services to be diverted onto the North London line and to release platform capacity at Euston, providing 4 additional slow line paths per hour (see note B)	•	•			
Grade separation (flyover junction) at Wembley	Facilitates increase in slow line capacity by 4tph (see note C)	•				Omitted from the refined package as NR advised that this intervention cannot easily be built.
Grade separation at Ledburn	Required to facilitate increase in capacity of fast lines	•	•	•	•	
Remodelling of Milton Keynes & Northampton	Required to enable extension of WCML suburban (slow line) services to 16 car operation (see note D)	•				All interventions associated with 16 car suburban service operation were omitted from the refined package as initial testing found that these interventions provided low value for money.
Platform extensions at stations between London and Northampton	Required to enable extension of WCML suburban (slow line) services to 16 car operation (see note D)	•				
Resignalling of London to Northampton route	Required to enable extension of WCML suburban (slow line) services to 16 car operation (see note D)	•				
Line Speed Improvements between	Delivers journey time improvements in the Northampton area	•	•	•	•	

Intervention	Rationale for Intervention	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Refined Package – WC1	Notes
Hanslope Jn, Northampton and Rugby						
Four tracks between Beechwood Tunnel and Stechford	Required to facilitate increase in capacity of fast lines	•	•	•	•	
Four tracks between Sandwell and Dudley and Wolverhampton	Provides additional capacity to facilitate increase Cross Country service frequency between Birmingham and Manchester (see note E)	•	•			All interventions associated with increased frequency of Cross Country services between Birmingham to Manchester were omitted from the refined package. Following initial testing of the NR high package, DfT considered that improved connectivity between Birmingham and Manchester could be more cost-effectively achieved through extension of the 2tph London Euston to Wolverhampton services north to Manchester
Three tracks between Smethwick Galton Bridge and Sandwell and Dudley	Provides additional capacity to facilitate increase Cross Country service frequency between Birmingham and Manchester (see note E)	•	•			
Dynamic passing loops (5 miles long) between Macclesfield and Congleton	Facilitates an increase in Cross Country capacity for services between Birmingham and Manchester (+1tph) if routed this way	•			•	
Line speed improvements between Birmingham and Manchester	Delivers journey time improvements for Cross Country services between Birmingham and Manchester (see note F)	•	•			All interventions associated with journey time improvements on Cross Country services between Birmingham to Manchester were omitted from the refined package. Following initial testing of the NR high package, DfT considered that improved journey times between Birmingham and Manchester could be more cost-effectively achieved through extension of the 2tph London Euston to Wolverhampton services north to Manchester.
Four tracks between Attleborough to Brinklow (Rugby to Nuneaton)	Required to facilitate increase in capacity of fast lines	•	•	•	•	
Grade separation (flyover junction) at Colwich Junction	Removal of capacity constraint at flat junction caused by trains to Manchester having to cross the junction. Delivers an increase in fast line capacity	•			•	
A new two track railway bypassing Stafford (Colwich Jn to Norton Bridge)	Required to facilitate increase in capacity of fast lines (see note G)	•	•			Omitted from refined packages as DfT/Atkins considered it likely to be able to deliver the TSS without this infrastructure. This assumption is consistent with the January 12 Strategic Alternatives update, where this scheme was not deemed necessary due to the Stafford Area Improvement scheme and introduction of a grade-separated junction at Colwich
Four tracks between Winsford and	Required to facilitate increase in long-distance frequency to Liverpool	•	•	•		Omitted from refined packages as DfT/Atkins

Intervention	Rationale for Intervention	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Refined Package – WC1	Notes
Weaver Junction	and Glasgow to 2tph (see note H)					considered it likely to be able to deliver the TSS without this infrastructure
Remodelling of Winsford, Hartford and Acton Bridge stations	Required as part of four-tracking of Winsford to Weaver (see note H)	•	•			
Four tracks throughout on the Chat Moss line (approx 3 miles)	Facilitates increased long-distance frequency between London and Liverpool	•	•	•	•	
Platform extensions at Warrington Bank Quay	Required to facilitate increase in frequency to Liverpool/Glasgow of 2tph	•			•	
Remodelling of Crewe, Wigan North Western and Preston	Facilitates increase in long-distance frequency to Glasgow (to 2tph) (see note I)	•	•	•		Omitted from refined packages as DfT/Atkins considered it likely to be able to deliver the TSS without this infrastructure
Dynamic passing loops (5 miles long) between Preston and Lancaster	Facilitates increase in long-distance frequency between London and Glasgow to 2tph by providing facility for freight trains to be overtaken by passenger services	•			•	
Dynamic passing loops (5 miles long) between Oxenholme and Carstairs	Facilitates increase in long-distance frequency between London and Glasgow to 2tph by providing facility for freight trains to be overtaken by passenger services	•	•		•	
Infrastructure works at Reading depot	Required to accommodate 10 car trains on Cross Country services between Reading and Newcastle (see note J)	•	•	•		Omitted as the refined package does not include proposals to extend Cross Country services to 10 car operation between Reading and Newcastle.
Four tracks between Duddeston Jn and Water Orton (approx 8 miles) including re-building Water Orton Station.	Facilitates increase frequency and journey time improvements for Cross Country services between Birmingham and the East Midlands	•	•		•	
Four tracks from Kingsbury Jcn to Tamworth (approx 6 miles) Incl. - building intermediate stations at Wilnecote and Tamworth	Facilitates increase frequency and journey time improvements for Cross Country services between Birmingham and the East Midlands	•			•	
140mph line speed improvements between Birmingham and Tamworth (including platform works at intermediate stations, etc).	Delivers journey time improvements for Cross Country services between Birmingham and the East Midlands	•			•	
Additional platform at Manchester Piccadilly	Increased platform capacity to accommodate additional Cross Country services from Birmingham to Manchester				•	The refined package includes two additional trains per hour from Birmingham to Manchester. DfT agreed with NR that additional platform capacity would be required to accommodate these services.
Re-instate Camp Hill chords and additional platforms at Birmingham	Facilitates use of Birmingham Moor Street station for additional Cross Country services				•	The refined packages propose additional Cross country services between Birmingham

Intervention	Rationale for Intervention	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Refined Package – WC1	Notes
Moor Street						and the East Midlands/South and West Yorkshire. To address capacity constraints at New Street station, it is proposed to operate these services to/from Moor Street by re-instating the two out-of-use south side platforms and the Camp Hill Chords.
Extend passing loops at Chelford	Facilitates increased Cross Country frequency between Birmingham and Manchester				•	This scheme was considered necessary by DfT/Atkins to facilitate 2 additional Cross Country services per hour between Birmingham and Manchester. This assumption was agreed with Network Rail.

Table B-3 Summary of Interventions in WCML Route-Based Packages - With HS2 Phase One Scenario

Intervention	Rationale for Intervention	NR Package D – High Output	NR Package E – Medium Output	NR Package F – Low Output	Refined Package – WC2	Notes
A new two track railway bypassing Stafford (Colwich Junction to Norton Bridge)	Required to facilitate increase in capacity of fast lines	•	•			Omitted from refined packages as DfT/Atkins considered it likely to be able to deliver the TSS without this infrastructure. This assumption is consistent with the January 12 Strategic Alternatives update, where this scheme was not deemed necessary due to the Stafford Area Improvement scheme and introduction of a grade-separated junction at Colwich. An additional scheme involving grade separation at Whitehouse has also been included.
Grade separation (flyover junction) at Colwich Junction	Removal of capacity constraint at flat junction caused by trains to Manchester having to cross the junction. Delivers an increase in fast line capacity	•	•	•	•	
140 mph capability Handsacre Junction to Weaver Junction and in-cab signalling (known as ETCS)	Delivers journey time improvements on the WCML between Handsacre and Weaver	•				Omitted from refined package as initial testing of NR's 'high' package concluded that this intervention provided low value for money
Increase in fast line speed through Crewe Station from 80 mph to 140 mph	Delivers journey time improvements in the Crewe area	•				Omitted from refined package as initial testing of NR's 'high' package concluded that this intervention provided low value for money
Increase in fast line speed through Crewe Station from 80 mph to 125 mph	Linespeed improvements through Crewe station deliver journey time savings in the Crewe station area		•			Omitted from refined package as initial testing of NR's 'high' package concluded that this intervention provided low value for money
Increase in fast line speed through Crewe Station from 80 mph to EPS speed	Linespeed improvements through Crewe station deliver journey time savings in the Crewe station area			•		Low output scheme therefore not considered for refined package
Four tracks between Winsford and Weaver Junction	Required to facilitate increase in long-distance frequency to Liverpool and Glasgow to 2tph	•	•	•		Omitted from refined packages as DfT/Atkins considered it likely to be able to deliver the TSS without this infrastructure
Remodelling of approach lines to Crewe, Wigan North Western and Preston	Facilitates increase in long-distance frequency to Glasgow (to 2tph)	•	•	•		Omitted from refined packages as DfT/Atkins considered it likely to be able to deliver the TSS without this infrastructure
Dynamic passing loops (5 miles long) between Preston and Lancaster	Facilitates increase in long-distance frequency between London and Glasgow to 2tph by providing facility for freight trains to be overtaken by passenger services	•			•	
Dynamic passing loops (5 miles long)	Facilitates increase in long-distance frequency between London and	•	•		•	

Intervention	Rationale for Intervention	NR Package D – High Output	NR Package E – Medium Output	NR Package F – Low Output	Refined Package – WC2	Notes
between Oxenholme and Carstairs	Glasgow to 2tph by providing facility for freight trains to be overtaken by passenger services					
Line speed improvements between Birmingham and Manchester	Delivers journey time improvements for Cross Country services between Birmingham and Manchester	•	•			All interventions associated with journey time improvements on Cross Country services between Birmingham to Manchester were omitted from the refined package. Following initial testing of the NR high package, DfT considered that improved journey times between Birmingham and Manchester could be more cost-effectively achieved through extension of the 2tph London Euston to Wolverhampton services north to Manchester.
Four tracks between Sandwell and Dudley and Wolverhampton	Provides additional capacity to facilitate increase Cross Country service frequency between Birmingham and Manchester	•	•			
Three tracks between Smethwick Galton Bridge and Sandwell and Dudley	Provides additional capacity to facilitate increase Cross Country service frequency between Birmingham and Manchester	•	•			
Dynamic passing loops (5 miles long) between Macclesfield and Congleton	Facilitates an increase in Cross Country capacity for services between Birmingham and Manchester (+1tph) if routed this way	•	•		•	
Infrastructure works at Reading depot	Required to accommodate 10 car trains	•	•	•		Omitted as the refined package does not include proposals to extend Cross Country services to 10 car operation between Reading and Newcastle.
Four tracks between Duddeston Junction and Water Orton (approx 8 miles) including re-building Water Orton Station. This will include upgrade of existing goods lines.	Facilitates increase frequency and journey time improvements for Cross Country services between Birmingham and the East Midlands	•	•			These schemes have been omitted as the refined packages propose to operate Cross Country services from Birmingham Curzon Street to the East Midlands and beyond via HS2 Phase One to Lichfield and then via the upgraded Lichfield Freight Line to Wichnor Junction. This means that these schemes are no longer required.
Four tracks from Kingsbury Junction to Tamworth (approx 6 miles) Incl. re-building intermediate stations at Wilnecote and Tamworth	Facilitates increase frequency and journey time improvements for Cross Country services between Birmingham and the East Midlands	•				
140mph line speed improvements between Birmingham and Tamworth (including platform works at intermediate stations, etc).	Delivers journey time improvements for Cross Country services between Birmingham and the East Midlands	•				
125 mph capability Euston to Glasgow and in-cab signalling (known as ETCS)	Provides journey time reductions between Euston and Glasgow as a result of 125mph running		•			Refined package has not assumed any linespeed improvements north of Handsacre, therefore not included in refined package
Static 775m passing loops provided at Shap and Beattock in CP5	Facilitates increase in long-distance frequency between London and Glasgow to 2tph by providing freight overtaking facility			•		Low output scheme therefore not considered for refined package
Additional platform at Manchester Piccadilly	Increased platform capacity to accommodate additional Cross Country services from Birmingham				•	The refined package includes two additional trains per hour from Birmingham to Manchester. DfT agreed with NR that

Intervention	Rationale for Intervention	NR Package D – High Output	NR Package E – Medium Output	NR Package F – Low Output	Refined Package – WC2	Notes
						additional platform capacity would be required to accommodate these services.
Grade separation at Whitehouse	Lower cost alternative scheme to Colwich to Norton Bridge scheme				•	This scheme facilitates an increase in fast line capacity between Colwich and Stafford
Extend passing loops at Chelford	Facilitates increased Cross Country frequency between Birmingham and Manchester				•	This scheme was considered necessary by DfT/Atkins to facilitate 2 additional Cross Country services per hour between Birmingham and Manchester. This assumption was agreed with Network Rail.

Table B-4 Summary of Interventions in MML Route-Based Packages – No HS2 Scenario

Intervention	Rationale for Intervention	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Service Package G – High Output via ECML	Refined Package – MM1	Refined Package – MM2	Notes
One additional platform at St Pancras – convert 1 existing platform to domestic use	Provides capacity for increased Intercity frequency & train lengthening	•	•	•	•			Omitted from refined packages as not considered sufficient for train service specification
Second additional platform at St Pancras – cantilever over Midland Road.	Provides capacity for increase Intercity frequency, train lengthening and 4 additional commuter services to Luton	•			•	•	•	
Carlton Road to Finchley Road Tunnel (Kentish Town Tunnel – 1.5 miles of twin track)	Provides capacity for six Intercity trains and four additional commuter services to Luton	•			•			Replaced by alternative scheme in refined packages (tunnel from Canal Tunnel Junction to Kentish Town)
Tunnel from Canal Tunnel Junction to Kentish Town	Alternative tunnel scheme to the Carlton Road To Finchley Road Tunnel					•		This is an alternative scheme proposed by DfT/Atkins (and agreed with NR) to the Carlton Road to Finchley Road tunnel to provide additional capacity on the approach to St Pancras Station
Hendon Lines – upgrade to 110 mph	Provides capacity for four additional commuter services	•	•		•			Omitted as not needed to deliver the train service specification in the refined packages
High speed grade separated junction between Harpenden and Luton Airport Parkway	Increases capacity at the junction	•			•			Replaced by St Albans grade-separation scheme in refined packages
Grade separation south of St Albans	Grade-separation to reduce conflicts in St Albans area					•		This is an alternative scheme proposed by DfT/Atkins and replaces the grade-separated junction between Harpenden and Luton Airport Parkway in the refined package
Turn-back in the Luton area	Provides turn-back facility for four additional commuter services t o Luton.	•	•		•	•	•	
Wellingborough bypass: construction of 2 straight tracks on a viaduct	Delivers journey time savings as a result of trains being able to bypass the station which is on a curve	•			•	•		
Market Harborough bypass: construction of 2 straight tracks on a viaduct	Delivers journey time savings as a result of trains being able to bypass the station which is on a curve	•			•	•		
Loughborough to Trent linespeed improvements - line straightening to support 140 mph	Delivers journey time savings through linespeed improvements	•			•	•		
Erewash electrification linespeed work to increase line speeds to	Delivers journey time savings through linespeed improvements and electrification	•	•		•			Omitted as initial testing of NR high package indicated that this scheme had

Intervention	Rationale for Intervention	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Service Package G – High Output via ECML	Refined Package – MM1	Refined Package – MM2	Notes
140 mph								poor value for money. A de-scoped scheme (electrification and linespeed upgrade to 110mph) was included in the refined package instead.
Erewash electrification and linespeed work to increase line speeds to 110 mph	Facilitates operation of services from ECML/Nottingham to Sheffield & delivers journey time improvements						•	This is a de-scoped version of the previous scheme with linespeed upgrades to 110mph rather than 140mph
Connecting Corby to Nottingham through refurbishment and realignment to 140 mph	Alternative way of providing additional capacity and connectivity to Nottingham	•						Omitted as testing of NR high package indicated that this scheme had poor value for money, and also not required for train service specification in refined packages
4-track Tamworth to Burton/Stenson at 140 mph	Delivers journey time savings through increased line speeds and facilitates increase in Cross Country frequency between Birmingham and the East Midlands	•			•	•	•	
Rebuild Burton-on-Trent station to accommodate fast line down centre of station	Delivers journey time savings through increased line speeds and facilitates increase in Cross Country frequency between Birmingham and the East Midlands	•			•	•	•	
Grade separated Stenson Junction	Delivers journey time savings through increased line speeds and facilitates increase in Cross Country frequency between Birmingham and the East Midlands	•			•			Superseded by the Stenson Junction – Trent Junction – Nottingham high speed connection scheme in the refined packages
Chesterfield station – one additional platform	Facilitates increase in Cross Country frequency between Sheffield & Leeds	•			•		•	
Chesterfield station – platform extensions	Facilitates increase in Cross Country frequency between Sheffield & Leeds	•	•	•	•			Omitted as not needed to deliver the train service specification in the refined packages
Chesterfield-Dore line upgrade to 140 mph (including doubling of Dore South junctions)	Facilitates increase in Cross Country frequency between Sheffield & Leeds	•	•		•		•	
Manton freight loops to accommodate 775m freight	Provides capacity to run long-distance services north of Corby alongside freight trains	•	•		•			Omitted as following a review of the schemes the trigger for this scheme appeared to be unrelated to HS2SA requirements
Elford Freight loop	Freight loop to accommodate freight growth alongside faster Cross Country service		•					Not needed as section to be 4 tracked in refined packages
Remodel Sheffield station to include one new platform and	Capacity for at least two additional trains into Sheffield station (Cross Country and Intercity)	•			•			

Intervention	Rationale for Intervention	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Service Package G – High Output via ECML	Refined Package – MM1	Refined Package – MM2	Notes
remove conflicts								
Nottingham to Newark Upgrade	Facilitates operation of electric Cross Country trains from Nottingham to ECML via Newark chord, and consequently delivers journey time improvements	•			•		•	
Power supply upgrade	Required to facilitate increase in long-distance frequency	•			•			Omitted from refined packages as potential double counting with other upgrade items
Electrify Corby – Manton	Enables electric trains to run north of Corby	•			•			Omitted as not needed to deliver the train service specification in the refined packages
Selective linespeed improvements between Leicester & Bedford	Delivers journey time improvements through linespeed improvements	•			•	•		
Nottingham station extra capacity (Part A) – additional platform	Additional platform to enable 2tph long-distance to terminate or pass through station – facilitates extension of Nottingham services via ECML to Sheffield in refined packages						•	The train service specifications in the refined packages include proposals to operate services to Nottingham via the ECML which are then extended to Sheffield. This infrastructure is needed to facilitate this. Note that these services were not included in the NR service specifications.
Nottingham station extra capacity (Part B) – provide capacity for additional 2tph through services	Over and above Part A, provides capacity for an additional 2tph through services (associated with Cross Country upgrades) through platform splitting or short platform provision.						•	The train service specifications in the refined packages include proposals to operate additional Cross Country services to Nottingham over the services proposed in the NR service specifications. DfT agreed with NR that this would necessitate the provision of additional platform capacity at Nottingham station
South of Sheffield capacity enhancements	Capacity enhancements to facilitate an increase in frequency for Cross Country services between Sheffield and Leeds						•	The train service specifications in the refined packages include proposals to operate additional Cross Country services towards Sheffield over the services proposed in the NR service specifications. DfT agreed with NR that capacity enhancements on the MML south of Sheffield would be required to facilitate an increase in service frequency.
North of Sheffield capacity enhancements	Capacity enhancements to facilitate an increase in frequency for Cross Country services between Sheffield and Leeds					•	•	The train service specifications in the refined packages include proposals to operate additional Cross Country services

Intervention	Rationale for Intervention	Service Package A – High Output	Service Package B – Medium Output	Service Package C – Low Output	Service Package G – High Output via ECML	Refined Package – MM1	Refined Package – MM2	Notes
								between Sheffield and Leeds compared to the NR service specifications. DfT agreed with NR that capacity enhancements would therefore be required to the north of Sheffield
High speed (140mph) connection between Stenson Junction – Trent Junction - Nottingham	Provides a high speed connection between Stenson Junction and Nottingham via Trent Junction, and delivers journey time improvements for Cross Country services between Birmingham and Nottingham					•	•	This intervention was proposed by DfT/Atkins as a means of providing a high speed direct connection between Stenson Junction and Nottingham to deliver journey time improvements. This scheme removes the need for Cross Country services between Birmingham and Nottingham to operate via Derby.

Table B-5 Summary of Interventions in MML Route-Based Packages – With HS2 Scenario

Intervention	Rationale for Intervention	Service Package D – High Output	Service Package E – Medium Output	Service Package F – Low Output	Service Package H – High Output via ECML	Refined Package – MM3	Refined Package – MM4	Notes
One additional platform at St Pancras – convert 1 existing platform to domestic use	Provides capacity for increased Intercity frequency & train lengthening	•	•	•	•			Omitted from refined packages as not required to deliver the train service specification
Second additional platform at St Pancras – cantilever over Midland Road.	Provides capacity for increase Intercity frequency, train lengthening and 4 additional commuter services to Luton	•			•			
Carlton Road to Finchley Road Tunnel (Kentish Town Tunnel)	Provides capacity for six Intercity trains and four additional commuter services to Luton	•			•			
Hendon Lines	Provides capacity for four additional commuter services	•			•			
High speed grade separated junction between Harpenden and Luton Airport Parkway	Increases capacity at the junction	•						
Erewash electrification linespeed work to increase line speeds to 140 mph	Delivers journey time savings through linespeed improvements and electrification	•			•			
Turnback in the Luton area	Provides turn-back facility for four additional commuter services t o Luton.	•	•		•	•	•	
Wellingborough bypass	Delivers journey time savings as a result of trains being able to bypass the station which is on a curve	•			•			These schemes were omitted from the refined packages as journey time savings to Sheffield/Nottingham provided by operating fast services via either HS2 Phase One or the ECML
Market Harborough bypass	Delivers journey time savings as a result of trains being able to bypass the station which is on a curve	•			•			
Sileby - Loughborough lines	Delivers journey time savings through linespeed improvements	•			•			
4-track Tamworth to Burton/Stenson at 140 mph	Delivers journey time savings through increased line speeds and facilitates increase in Cross Country frequency between Birmingham and the East Midlands				•	•	•	
Rebuild Burton-on-Trent station	Delivers journey time savings through increased line speeds and facilitates increase in Cross Country frequency between Birmingham and the East Midlands	•			•	•	•	
Grade separated Stenson Junction	Delivers journey time savings through increased line speeds and facilitates increase in Cross Country frequency between Birmingham and the East Midlands	•			•			Superseded by the Stenson Junction – Trent Junction – Nottingham high speed connection scheme in the refined packages
Chesterfield station – new	Facilitates increase in Cross Country frequency between	•			•	•	•	

Intervention	Rationale for Intervention	Service Package D – High Output	Service Package E – Medium Output	Service Package F – Low Output	Service Package H – High Output via ECML	Refined Package – MM3	Refined Package – MM4	Notes
platform	Sheffield & Leeds							
Chesterfield station – platform extensions	Facilitates increase in Cross Country frequency between Sheffield & Leeds	•	•	•	•			Omitted from refined packages as not required to deliver the train service specification
Chesterfield-Dore	Facilitates increase in Cross Country frequency between Sheffield & Leeds	•			•	•	•	
Manton freight loop	Provides capacity to run long-distance services north of Corby alongside freight trains	•	•		•			Omitted as following a review of the schemes the trigger for this scheme appeared to be unrelated to HS2SA requirements
Elford Freight loop	Freight loop to accommodate freight growth alongside faster Cross Country service		•					Not needed as section to be 4 tracked in refined packages
Wichnor Grade separation at 140 mph	Facilitates provision of services to East Midlands/Sheffield via HS2 Phase One	•			•	•	•	
Severe upgrade of Lichfield freight line at 140 mph	Facilitates provision of services to East Midlands/Sheffield via HS2 Phase One	•			•	•	•	
Chord from HS2 to Lichfield freight line to allow 140 mph	Facilitates provision of services to East Midlands/Sheffield via HS2 Phase One	•	•		•	•	•	
Wichnor junction minor upgrade – at 70 mph	Facilitates provision of services to East Midlands/Sheffield via HS2 Phase One		•					Refined packages assume high speed upgrade of Wichnor Junction and Lichfield Freight Line, so these schemes have been omitted from the refined packages
Minor upgrade of Lichfield freight line	Facilitates provision of services to East Midlands/Sheffield via HS2 Phase One		•					
Remodel Sheffield station - one new platform and removal of conflicts	Capacity for at least two additional trains into Sheffield station (Cross Country and Intercity)	•			•			
Nottingham to Newark Upgrade to 125 mph	Facilitates operation of electric Cross Country trains from Nottingham to ECML via Newark chord, and consequently delivers journey time improvements	•			•	•	•	
Power supply	Required to facilitate increase in long-distance frequency	•			•			Omitted from refined packages as potential double counting with other upgrade items
Electrify Corby – Manton	Enables electric trains to run north of Corby	•	•		•			Omitted from refined packages as not required to deliver the train service specification
Selective linespeed improvements (140mph)	Delivers journey time improvements through linespeed improvements	•	•		•			These schemes were omitted from the refined packages as journey time savings

Intervention	Rationale for Intervention	Service Package D – High Output	Service Package E – Medium Output	Service Package F – Low Output	Service Package H – High Output via ECML	Refined Package – MM3	Refined Package – MM4	Notes
between Leicester & Bedford								to Sheffield/Nottingham provided by operating fast services via either HS2 Phase One or the ECML
High speed (140mph) connection between Stenson Junction – Trent Junction - Nottingham	Provides a high speed connection between Stenson Junction and Nottingham via Trent Junction, and delivers journey time improvements for Cross Country services between Birmingham and Nottingham					•	•	This intervention was proposed by DfT/Atkins as a means of providing a high speed direct connection between Stenson Junction and Nottingham to deliver journey time improvements. This scheme removes the need for Cross Country services between Birmingham and Nottingham to operate via Derby.
Nottingham station extra capacity (Part A) – additional platform	Additional platform to enable 2tph long-distance to terminate or pass through station – facilitates extension of Nottingham services via ECML to Sheffield in refined packages					•	•	The train service specifications in the refined packages include proposals to operate services to Nottingham via the ECML which are then extended to Sheffield. This infrastructure is needed to facilitate this. Note that these services were not included in the NR service specifications.
Nottingham station extra capacity (Part B) – provide capacity for additional 2tph through services	Over and above Part A, provides capacity for an additional 2tph through services (associated with Cross Country upgrades) through platform splitting or short platform provision.					•	•	The train service specifications in the refined packages include proposals to operate additional Cross Country services to Nottingham over the services proposed in the NR service specifications. DfT agreed with NR that this would necessitate the provision of additional platform capacity at Nottingham station
South of Sheffield capacity enhancements	Capacity enhancements to facilitate an increase in frequency for Cross Country services between Sheffield and Leeds					•	•	The train service specifications in the refined packages include proposals to operate additional Cross Country services towards Sheffield over the services proposed in the NR service specifications. DfT agreed with NR that capacity enhancements on the MML south of Sheffield would be required to facilitate an increase in service frequency.
North of Sheffield capacity enhancements	Capacity enhancements to facilitate an increase in frequency for Cross Country services between Sheffield and Leeds					•	•	The train service specifications in the refined packages include proposals to operate additional Cross Country services between Sheffield and Leeds compared to

Intervention	Rationale for Intervention	Service Package D – High Output	Service Package E – Medium Output	Service Package F – Low Output	Service Package H – High Output via ECML	Refined Package – MM3	Refined Package – MM4	Notes
								the NR service specifications. DfT agreed with NR that capacity enhancements would therefore be required to the north of Sheffield
London to Nottingham via HS2 Phase One						•		In this package, the train service specification sees fast services between London and Nottingham being operated via HS2 Phase One
London to Nottingham via East Coast Mainline							•	In this package, the train service specification sees fast services between London and Nottingham being operated via the ECML and an upgraded Grantham- Nottingham route

Appendix C. Cost Estimation

C.1. Introduction

This Annex sets out further detail in relation to the assumptions underlying the cost estimates as set out in Chapter 5 of this report.

C.2. Estimating fleet size

It was agreed with DfT that the size of fleet required to operate the services proposed by the strategic alternatives would be estimated using the following method:

- For a given service, calculate the length of each journey leg on average;
- Add on an allowance for turnaround time – assumed to be 1/6 of the total journey time but for intercity services not less than 30 minutes;
- Add on an allowance for timetable inefficiency – calculated for standard hour services as 60/(2*standard hour frequency). Services with the same rolling stock length and stock type (i.e. services that could be run interchangeably) were grouped together. The extra minutes were then multiplied by 1.5 to allow for the fact that the inefficiency factor is greater outside of a London terminus;
- Divide the above by the service headway; and
- Multiply by 2 to allow for two way journeys

For additional peak-only trains the number of extra trains running in each direction was added on to the number of sets required to operate the standard hour timetable. Each peak train was equal to one additional train set.

The final step involved adding an allowance for spare sets. This was assumed to be 10% of the total required fleet. This assumption was confirmed by DfT.

It was also necessary in certain instances to use the above approach to estimate the size of the fleet in the Do-minimum scenarios. DfT advised that the size of fleet required to operate the classic line timetables assumed in HS2's PLANET Framework model (both Do-minimum and HS2 Phase One scenarios) had not been calculated, as HS2 Ltd use a cost per mile approach to calculate leasing and maintenance costs on the classic network. This meant that Do-minimum fleet sizes were not available for the strategic alternatives. Thus, for the strategic alternatives, where the Do-minimum timetable assumptions either in terms of the services operated or rolling stock type used to operate the services had materially changed compared to the present day timetable, the above approach was used to calculate the Do-minimum fleet requirement. It was also used where, for a given TOC, the strategic alternatives were making changes to individual services e.g. Great Northern 'fast' services between London and Cambridge, to estimate the size of fleet required for these particular services.

The approach was not applied in the following cases:

- Virgin West Coast: timetable was not materially different to the present day timetable therefore the Do-minimum fleet in Packages P1, YA and YB was based on the current fleet size of 56 Class 390 Pendolinos (21 x 9 car, 35 x 11 car sets);
- London Midland: timetable not materially different to present day timetable;
- East Coast: based on number of units ordered for the ECML IEP Phase Two timetable; and
- Rolling stock requirements for services between London and Birmingham on HS2 Phase One were provided by HS2 Ltd.

C.3. Other Operating Cost Assumptions

Key changes to the operating cost model made for the current study as a result of liaison with DfT / HS2 Ltd are as follows:

- The model was updated to include operating costs for a number of additional rolling stock types, reflecting the wider scope of the current study. This included operating cost assumptions for High Speed rolling stock which were provided by HS2 Ltd;
- Electricity costs were updated with the latest IAG 2012 electricity price series;
- A revised staff cost growth forecast (based on OBR Average Earnings Projection) was introduced to be consistent with HS2 Ltd. Staff cost growth was capped from 2036 onwards (consistent with HS2);
- Staff costs were adjusted to take account of revenue from on-board sales. The previous version of the model considered this a separate revenue line;
- A revised maintenance cost growth forecast was introduced to be consistent with HS2. Growth was capped from 2036 onwards; and
- Change to the approach to calculating TOC variable overheads. Variable overheads in the previous opex model were calculated based on a proportion (15%) of combined traincrew and insurance costs. For the current study, DfT requested a change to the methodology to be consistent with HS2, as follows:
    - The net change in commission costs was calculated as £0.0344 * change in net revenue between the DM and with-package. The commission cost multiplier was based on observed data from the ICWC and ICEC long-form accounts;
    - The net change in catering cost was based on the change in passenger numbers between the DM and with-package and multiplied by an average per passenger cost of £0.44 (derived from the ICWC and ICEC long-form accounts); and
    - The change in variable HQ staff costs was calculated based on the change in passenger numbers between the DM and with-package multiplied by a per passenger cost of £0.37 (derived from the ICWC and ICEC long-form accounts).

Appendix D. Demand Forecasting and Appraisal Approach

D.1. Introduction

The PLANET Framework Model (PFM) version 4.3 was developed by HS2 Ltd to assist with the overall assessment of the main HS2 scheme. This Framework Model was used to assess the strategic alternatives packages. Using the same modelling base ensures consistency between the appraisal of the proposed high speed rail routes and the strategic alternative packages.

The model is comprised of PLANET Long Distance (PLD), which is a multi-modal model used to model and appraise strategic journeys made by rail, highway and air, and three regional uni-modal rail models that model local rail journeys. These models are PLANET South, PLANET Midlands and PLANET North. In addition, there is an Airport Demand Model (ADM), which models surface access to Heathrow for onward international travel.

All of the assessments summarised in this report have been undertaken using the latest PFMv4.3. It is important to note that the purpose of this report is not to provide detail of the model function or the approach to the appraisal of HS2. This is detailed within the HS2 reporting process.

D.2. Future Year Do-minimum

The first step in forecasting the demand for the alternative interventions is to construct a future year base scenario (referred to as the 'Do-minimum'), against which the alternatives can be compared and assessed. The Do-minimum scenario was developed by HS2 Ltd both in terms of demand and supply. No further changes have been made to the parameters and/or the inputs associated with the model as part of this study.

In line with the HS2 Ltd work on the proposed 'Y' network, two future year horizons have been examined: 2026 and 2036. The latter – often referred to as the 'cap year' – has been determined as a realistic level of future demand that might be reached given the evidence available. This assumption is subject to considerable uncertainty, and for this reason HS2 Ltd has undertaken a range of risk analysis to understand the implications of this uncertainty. Comparable analysis has not been possible for this study, however it is noted that if the demand cap were specified for a later year that the value for money case for the alternatives would be stronger (as it is for HS2). However the higher level of demand associated with a later cap year would also create further challenges for the strategic alternative packages in providing sufficient capacity to meet this demand.

It is noted that PFMv4.3 has been subject to modification since the previous Alternatives Report was issued in January 2012. Details of these changes are documented within the HS2 reporting process.

D.3. Modelling of Rail Packages

D.3.1. Introduction

The service specifications associated with each of the packages were coded into the PLANET Framework Model and run for the years 2026 and 2036. It is important to note that for Packages P2A and P2B, HS2 Phase One was incorporated into the Do-minimum.

This section summarises the change in demand associated with each of the packages, highlighting the impact of the packages on both capacity and crowding on the major routes under consideration.

For non-HS2 services, no changes to performance were assumed either due to increased network utilisation or improved network robustness due to the additional infrastructure provided in each of the packages. However, the additional HS2 services assumed in Packages P2A and P2B assumed a similar level of reliability improvement as for other HS2 Phase One services.

D.3.2. Strategic Alternatives to the 'Y' Network

D.3.2.1. Impact on Demand

The total additional rail trips that are estimated to occur as a result of the proposed rail interventions for the 2036 forecast year, compared to the Do-minimum, are summarised in Table D-1. The impact is very similar in both packages, which is to be expected given that they serve a similar set of geographical locations.

The increases in rail demand are spread across the country, with the largest increases between London and the West Midlands, East Midlands, and Yorkshire. Additionally, there are substantial increases between Birmingham and the East Midlands and Yorkshire.

The differences in additional rail demand when comparing Packages YA and YB are small. There is more demand between the East Midlands and other locations in Package YB, which reflects the enhanced service on the Midland Mainline to/from London, as well as improved connections to Leeds. More demand between Yorkshire and other locations in Package YA reflects the enhanced ECML package and additional connections between Birmingham and Leeds.

Table D-1 Estimated 2036 Modal Transfer and Rail Trip Generation (total trips per day)

	Modal Transfer from Air	Modal Transfer from Highway	Generated Rail Trips	Total Additional Rail Trips
Package YA	2,200	7,800	42,900	52,900
Package YB	2,100	7,700	42,200	52,000

D.3.3. Strategic Alternative to Phase One

D.3.3.1. Impact on Demand

Table D-2 shows the total additional rail trips that are estimated to occur as a result of the proposed rail interventions for the 2036 forecast year, compared to the Do-minimum.

Transfer from air is almost entirely to/from Scotland, with journeys to/from London and the South East providing the majority of these trips. This is driven by the improved service between London and Glasgow in this package.

Transfer from highway is widespread, though it is notable that trips between London and the West Midlands contribute around one third of the total trips transferring.

Increases in rail demand are, as expected, focussed along areas served by the WCML: the West Midlands, North West, and Scotland. It is also worth noting a sizeable increase in demand between London and the East Midlands however, which reflects the improved service between London and Northampton.

Table D-2 Estimated 2036 Modal Transfer and Rail Trip Generation (total trips per day)

	Modal Transfer from Air	Modal Transfer from Highway	Generated Rail Trips	Total Additional Rail Trips
Package P1	500	1,800	13,800	16,100

D.3.4. Phase Two Alternatives

D.3.4.1. Impact on Demand

Table D-3 shows total additional rail trips that are estimated to occur as a result of the proposed rail interventions for the 2036 forecast year, compared to the Do Minimum.

The two packages deliver very similar changes in demand.

In absolute terms, the largest increases in rail demand are seen between London and the East Midlands and Yorkshire. There are also substantial increases in demand between London and Scotland and the North East, as well as trips internal to Yorkshire and to the North West.

The West Coast interventions in these packages offer little over and above the HS2 Phase One Do-minimum to/from major destinations in the West Midlands and the North West, and this is reflected in the changes in demand. However, it should be noted that there is a small increase in demand, particularly between London and the North West, as the West Coast interventions improve service levels at other destinations such as Blackpool, Crewe and Stockport.

Table D-3 Estimated 2036 Modal Transfer and Rail Trip Generation (total trips per day)

	Modal Transfer from Air	Modal Transfer from Highway	Generated Rail Trips	Total Additional Rail Trips
Package P2A	1,500	5,600	29,900	37,000
Package P2B	1,500	5,500	30,000	37,000

D.4. Seating Capacity

The extent to which each of the five upgrade packages is estimated to provide additional capacity in the north-south corridors is shown Tables D-4 and D-5. The tables show the estimated, modelled, number of daily weekday passenger seats provided on the WCML, ECML and MML for each upgrade package, and for HS2 for the with HS2 scenarios. The forecasts of seats for each upgrade package are based on a timetable assumed to be operating in 2036 and represent all trains (intercity services and commuter services, and HS2 for the with-HS2 scenarios) arriving into London between 07.00 and 23.00. Note that the % increase in peak hours for the alternatives may be lower. The tables also show seat capacity for the two Do-minimum scenarios. The incremental impact of the upgrade packages (and the with HS2 scenarios) is shown, being the difference between the upgrade package and the (appropriate) Do-minimum. It is noted that for Packages P2A and P2B, the Do-minimum (DM2) includes HS2 Phase One.

Table D-4 Summary of All Day Additional Passenger Train Capacity – Packages P1, YA and YB[1]

Upgrade Package/HS2 Scenario	Weekday Passenger Seats (A)	Weekday Passenger Seats (Do-minimum DM1) (B)	Additional Passenger Seats provided by Upgrade Package (C) = (A)-(B)	% increase from Do-minimum (D) = (C) / (B)
Euston arrivals only				
P1	216,100	128,200	*87,900*	69%
HS2 Phase One	*238,600*	128,200	*110,400*[2]	86%
Arrivals at Euston, King's Cross and St. Pancras				
YA	578,800	434,100	*144,700*	33%
YB	569,900	434,100	*135,800*	31%
HS2 Phase One + Phase Two	*652,600*	434,100	*218,500*[3]	50%

[1] Passenger seats based on number of seats per day provided on services arriving from the north into Euston, King's Cross and St. Pancras (Euston only for P1 and HS2 Phase One) between 07.00 and 23.00, estimated for 2036 weekday timetable. Information on HS2 provided by HS2 Ltd. [2]When cross-referencing to table 6-2 the potential full capacity of HS2 Phase One is 15, 400 * 16 hours (246,400 all day) therefore representing a significant capacity increase compared to the modelled P1. Note that some additional infrastructure investment would be required to accommodate this full HS2 Phase One capability over and above what has been included in the economic assessment for HS2 Phase One. [3]This is the modelled HS2 Phase One and Phase Two value and does not represent the full all day potential capacity capability

Table D-5 Summary of Additional Passenger Train Capacity – Packages P2A and P2B[1]

Upgrade Package/HS2 Scenario	Weekday Passenger Seats (A)	Weekday Passenger Seats (Do-minimum (DM2) (B)	Additional Passenger Seats provided by Upgrade Package (C) = (A)-(B)	% increase from Do-minimum (D) = (C) / (B)
Arrivals at Euston, King's Cross and St. Pancras				
P2A	611,700	544,500	67,200	12%
P2B	608,100	544,500	63,600	12%
HS2 Phase One + Phase Two	*652,600*	*544,500*	108,100[2]	20%

[1]Passenger seats based on number of seats per day provided on services arriving from the north into Euston, King's Cross and St. Pancras between 07.00 and 23.00, estimated for 2036 weekday timetable. Information on HS2 provided by HS2 Ltd. [2]This is the modelled HS2 Phase One and Phase Two value and does not represent the full all day potential capacity capability

D.5. Crowding

The modelled capacities used for the crowding analysis are based upon all day modelling. Seat capacities presented use capacity assumptions that differ slightly to those presented in chapter 6 (the latter of which reflect DfT's most up to date view of expected Euston evening peak seat capacity under P1). The section below presents the modelled crowding effects based upon an all day assessment. Care needs to be taken when interpreting the modelled crowding effects given that load factors in the peak will be considerably higher than is suggested by the all day numbers.

Tables D-6 and D-7 present estimated average daily load factors on the WCML, ECML and MML for each upgrade package according to train operating company. This identifies intercity and commuter services operating on each of WCML, MML and ECML routes. Load factor is defined as the average daily number of passengers for all services into London arriving at the London terminals divided by the number of available seats. Load factors of >100% therefore indicate that on average some people will be standing on trains, noting that specific routes or times of day may have significantly higher load factors than the average. The values given are average daily; factors for peak hours will be higher.

The impact on load factors is slightly less for the higher level of investment on the ECML (shown in YA), in part because additional trips are induced, compared to YB, by the better service offer in YA.

Table D-6 All day Modelled Crowding Changes - Package P1, YA and YB compared to no-HS2 Do-minimum (DM1)[1]. Factors are average daily values.[2]

	Do-minimum (DM1)	Package P1		Package YA		Package YB	
	All day load factor	All day load factor	Change	All day load factor	Change	All day load factor	Change
East Coast	64%	63%	-1%	54%	-10%	49%	-15%
Midland Mainline	56%	54%	-2%	50%	-6%	54%	-2%
West Coast	78%	56%	-22%	55%	-23%	55%	-23%
London Midland	100%	47%	-53%	47%	-53%	47%	-53%
Great Northern	43%	43%	0%	47%	4%	43%	0%
Thameslink (King's Cross)	75%	75%	0%	62%	-13%	68%	-7%
Thameslink (St Pancras)	89%	89%	0%	77%	-12%	74%	-15%

[1] Load factor is derived from the number of passengers arriving from the north into Euston, St Pancras and King's Cross between 07.00 and 23.00 divided by number of seats available over the same time period. [2] The values given are average daily load factors from the model. Crowding for peak hours will be significantly higher than the values given in this table. P1 has a minor impact on ECML and MML load factors due to passengers redistributing to the WCML from these routes.

Table D-7 All Day Modelled Crowding Changes - Package P2A and P2B compared to with-HS2 Phase One Do-minimum (DM2)[1]. Factors are average daily values.[2]

	Do-minimum (DM2)	Package P2A		Package P2B	
	All day load factor	All day load factor	Change	All day load factor	Change
East Coast	61%	50%	-12%	47%	-15%
Midland Mainline	53%	44%	-9%	45%	-8%
West Coast	55%	47%	-8%	47%	-8%
HS2	50%	51%	0%	54%	4%
London Midland	61%	67%	5%	66%	5%
Great Northern	43%	40%	-3%	40%	-3%
Thameslink (King's Cross)	75%	62%	-13%	62%	-13%
Thameslink (St Pancras)	88%	77%	-12%	77%	-12%

[1] Load factor is derived from the number of passengers arriving from the north into Euston, St Pancras and King's Cross between 07.00 and 23.00 divided by number of seats available over the same time period. [2] The values given are average daily load factors from the model. Crowding for peak hours will be significantly higher than the values given in this table.

Appendix E. TEE Tables

Package P1 - Central Case

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers				
User Benefits				
Travel Time	2764		130	2633
Vehicle Operating Costs	29		29	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	2792	(1)	159	2633
Business				
User Benefits				
Travel Time	5078		95	4983
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	5078	(2)	95	4983
Private Sector Provider Impacts				
Revenue	5258		0	5258
Operating Costs	-6166		0	-6166
Investment Costs	-3365		0	-3365
Grant/Subsidy	9531		0	9531
Revenue Transfer	-5258		0	-5258
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	5078	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	7871	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	6166		0	6,166
Investment Costs	3365		0	3,365
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-5258		0	-5258
NET IMPACT	4273	*(8)*	0	4,273
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-506	*(9)*	0	-506
TOTALS				
Broad Transport Budget	4273	*(10) = (7) + (8)*		
Wider Public Finances	-506	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	4	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	54	*(16)*
Economic Efficiency: Consumer Users	2792	*(1)*
Economic Efficiency: Business Users and Providers	5078	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	506	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	7423	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	4273	*(10)*
Present Value of Costs (see notes) (PVC)	4273	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	3150	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	1.7	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package P1 - Sensitivity Test 1

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers User Benefits				
Travel Time	2764		130	2633
Vehicle Operating Costs	29		29	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	2792	(1)	159	2633
Business User Benefits				
Travel Time	5078		95	4983
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	5078	(2)	95	4983
Private Sector Provider Impacts				
Revenue	5258		0	5258
Operating Costs	-9269		0	-9269
Investment Costs	-1943		0	-1943
Grant/Subsidy	11211		0	11211
Revenue Transfer	-5258		0	-5258
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	5078	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	7871	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	9269		0	9,269
Investment Costs	1943		0	1,943
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-5258		0	-5258
NET IMPACT	5954	*(8)*	0	5,954
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-506	*(9)*	0	-506
TOTALS				
Broad Transport Budget	5954	*(10) = (7) + (8)*		
Wider Public Finances	-506	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	4	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	54	*(16)*
Economic Efficiency: Consumer Users	2792	*(1)*
Economic Efficiency: Business Users and Providers	5078	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	506	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	7423	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	5954	*(10)*
Present Value of Costs (see notes) (PVC)	5954	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	1469	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	1.2	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package YA - Central Case

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers				
User Benefits				
Travel Time	10257		497	9760
Vehicle Operating Costs	108		108	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	10366	(1)	606	9760
Business				
User Benefits				
Travel Time	16437		361	16076
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	16437	(2)	360	16076
Private Sector Provider Impacts				
Revenue	16892		0	16892
Operating Costs	-11682		0	-11682
Investment Costs	-15006		0	-15006
Grant/Subsidy	26688		0	26688
Revenue Transfer	-16892		0	-16892
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	16437	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	26803	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	11682		0	11,682
Investment Costs	15006		0	15,006
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-16892		0	-16892
NET IMPACT	9796	*(8)*	0	9,796
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-1724	*(9)*	0	-1724
TOTALS				
Broad Transport Budget	9796	*(10) = (7) + (8)*		
Wider Public Finances	-1724	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	18	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	229	*(16)*
Economic Efficiency: Consumer Users	10366	*(1)*
Economic Efficiency: Business Users and Providers	16437	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	1724	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	25326	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	9796	*(10)*
Present Value of Costs (see notes) (PVC)	9796	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	15530	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	2.6	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package YA - Sensitivity Test 1

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers				
User Benefits				
Travel Time	10257		497	9760
Vehicle Operating Costs	108		108	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	10366	(1)	606	9760
Business				
User Benefits				
Travel Time	16437		361	16076
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	16437	(2)	360	16076
Private Sector Provider Impacts				
Revenue	16892		0	16892
Operating Costs	-18530		0	-18530
Investment Costs	-12316		0	-12316
Grant/Subsidy	30846		0	30846
Revenue Transfer	-16892		0	-16892
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	16437	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	26803	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	18530		0	18,530
Investment Costs	12316		0	12,316
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-16892		0	-16892
NET IMPACT	13954	*(8)*	0	13,954
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-1724	*(9)*	0	-1724
TOTALS				
Broad Transport Budget	13954	*(10) = (7) + (8)*		
Wider Public Finances	-1724	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	18	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	229	*(16)*
Economic Efficiency: Consumer Users	10366	*(1)*
Economic Efficiency: Business Users and Providers	16437	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	1724	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	25326	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	13954	*(10)*
Present Value of Costs (see notes) (PVC)	13954	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	11371	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	1.8	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package YB - Central Case

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers				
User Benefits				
Travel Time	9639		421	9218
Vehicle Operating Costs	107		107	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	9746	(1)	528	9218
Business				
User Benefits				
Travel Time	14768		311	14458
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	14768	(2)	310	14458
Private Sector Provider Impacts				
Revenue	16103		0	16103
Operating Costs	-11304		0	-11304
Investment Costs	-13403		0	-13403
Grant/Subsidy	24707		0	24707
Revenue Transfer	-16103		0	-16103
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	14768	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	24514	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	11304		0	11,304
Investment Costs	13403		0	13,403
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-16103		0	-16103
NET IMPACT	8605	*(8)*	0	8,605
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-1642	*(9)*	0	-1642
TOTALS				
Broad Transport Budget	8605	*(10) = (7) + (8)*		
Wider Public Finances	-1642	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	17	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	214	*(16)*
Economic Efficiency: Consumer Users	9746	*(1)*
Economic Efficiency: Business Users and Providers	14768	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	1642	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	23104	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	8605	*(10)*
Present Value of Costs (see notes) (PVC)	8605	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	14499	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	2.7	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package YB - Sensitivity Test 1

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers				
User Benefits				
Travel Time	9639		421	9218
Vehicle Operating Costs	107		107	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	9746	(1)	528	9218
Business				
User Benefits				
Travel Time	14768		311	14458
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	14768	(2)	310	14458
Private Sector Provider Impacts				
Revenue	16103		0	16103
Operating Costs	-17711		0	-17711
Investment Costs	-10692		0	-10692
Grant/Subsidy	28402		0	28402
Revenue Transfer	-16103		0	-16103
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	14768	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	24514	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	17711		0	17,711
Investment Costs	10692		0	10,692
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-16103		0	-16103
NET IMPACT	12300	*(8)*	0	12,300
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-1642	*(9)*	0	-1642
TOTALS				
Broad Transport Budget	12300	*(10) = (7) + (8)*		
Wider Public Finances	-1642	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	17	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	214	*(16)*
Economic Efficiency: Consumer Users	9746	*(1)*
Economic Efficiency: Business Users and Providers	14768	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	1642	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	23104	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	12300	*(10)*
Present Value of Costs (see notes) (PVC)	12300	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	10804	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	1.9	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package P2A - Central Case

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers				
User Benefits				
Travel Time	6930		353	6577
Vehicle Operating Costs	73		73	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	7003	(1)	426	6577
Business				
User Benefits				
Travel Time	12147		253	11893
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	12146	(2)	253	11893
Private Sector Provider Impacts				
Revenue	12043		0	12043
Operating Costs	-8902		0	-8902
Investment Costs	-12172		0	-12172
Grant/Subsidy	21074		0	21074
Revenue Transfer	-12043		0	-12043
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	12146	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	19149	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	8902		0	8,902
Investment Costs	12172		0	12,172
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-12043		0	-12043
NET IMPACT	9030	*(8)*	0	9,030
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-1215	*(9)*	0	-1215
TOTALS				
Broad Transport Budget	9030	*(10) = (7) + (8)*		
Wider Public Finances	-1215	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	13	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	163	*(16)*
Economic Efficiency: Consumer Users	7003	*(1)*
Economic Efficiency: Business Users and Providers	12146	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	1215	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	18111	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	9030	*(10)*
Present Value of Costs (see notes) (PVC)	9030	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	9080	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	2.0	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package P2A - Sensitivity Test 1

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers User Benefits				
Travel Time	6930		353	6577
Vehicle Operating Costs	73		73	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	7003	(1)	426	6577
Business User Benefits				
Travel Time	12147		253	11893
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	12146	(2)	253	11893
Private Sector Provider Impacts				
Revenue	12043		0	12043
Operating Costs	-12278		0	-12278
Investment Costs	-11077		0	-11077
Grant/Subsidy	23355		0	23355
Revenue Transfer	-12043		0	-12043
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	12146	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	19149	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	12278		0	12,278
Investment Costs	11077		0	11,077
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-12043		0	-12043
NET IMPACT	11312	*(8)*	0	11,312
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-1215	*(9)*	0	-1215
TOTALS				
Broad Transport Budget	11312	*(10) = (7) + (8)*		
Wider Public Finances	-1215	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	13	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	163	*(16)*
Economic Efficiency: Consumer Users	7003	*(1)*
Economic Efficiency: Business Users and Providers	12146	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	1215	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	18111	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	11312	*(10)*
Present Value of Costs (see notes) (PVC)	11312	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	6799	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	1.6	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package P2B - Central Case

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers				
User Benefits				
Travel Time	6915		375	6540
Vehicle Operating Costs	72		72	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	6987	(1)	447	6540
Business				
User Benefits				
Travel Time	12022		267	11755
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	12022	(2)	267	11755
Private Sector Provider Impacts				
Revenue	12068		0	12068
Operating Costs	-8319		0	-8319
Investment Costs	-12287		0	-12287
Grant/Subsidy	20606		0	20606
Revenue Transfer	-12068		0	-12068
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	12022	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	19009	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	8319		0	8,319
Investment Costs	12287		0	12,287
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-12068		0	-12068
NET IMPACT	8539	*(8)*	0	8,539
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-1219	*(9)*	0	-1219
TOTALS				
Broad Transport Budget	8539	*(10) = (7) + (8)*		
Wider Public Finances	-1219	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	13	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	164	*(16)*
Economic Efficiency: Consumer Users	6987	*(1)*
Economic Efficiency: Business Users and Providers	12022	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	1219	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	17967	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	8539	*(10)*
Present Value of Costs (see notes) (PVC)	8539	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	9429	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	2.1	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Package P2B - Sensitivity Test 1

Table 1: Transport Economic Efficiency Benefits

	ALL MODES TOTAL		ROAD	RAIL
Consumers				
User Benefits				
Travel Time	6915		375	6540
Vehicle Operating Costs	72		72	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
NET CONSUMER BENEFITS	6987	(1)	447	6540
Business				
User Benefits				
Travel Time	12022		267	11755
Vehicle Operating Costs	0		0	0
User Charges	0		0	0
During Construction & Maintenance	0		0	0
Subtotal	12022	(2)	267	11755
Private Sector Provider Impacts				
Revenue	12068		0	12068
Operating Costs	-12072		0	-12072
Investment Costs	-11059		0	-11059
Grant/Subsidy	23131		0	23131
Revenue Transfer	-12068		0	-12068
Subtotal	0	(3)	0	0
Other Business Impacts				
Developer Contributions	0	(4)	0	0
NET BUSINESS IMPACT	12022	(5) = (2) + (3) + (4)		
TOTAL				
Present Value of Transport Economic Efficiency Benefits	19009	(6) = (1) + (5)		

Notes: **Benefits** appear as **positive** numbers, while **costs** appear as **negative** numbers

Table 2: Public Accounts

	ALL MODES TOTAL		ROAD	RAIL
Local Government Funding				
Revenue	0		0	0
Operating Costs	0		0	0
Investment Costs	0		0	0
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
NET IMPACT	0	*(7)*	0	0
Central Government Funding: Transport				
Revenue	0		0	0
Operating costs	12072		0	12,072
Investment Costs	11059		0	11,059
Developer and Other Contributions	0		0	0
Grant/Subsidy Payments	0		0	0
Revenue Transfer	-12068		0	-12068
NET IMPACT	11063	*(8)*	0	11,063
Central Government Funding: Non-Transport				
Indirect Tax Revenues	-1219	*(9)*	0	-1219
TOTALS				
Broad Transport Budget	11063	*(10) = (7) + (8)*		
Wider Public Finances	-1219	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.
All entries are discounted present values in 2011 prices and values.

Table 3: Analysis of Monetised Costs and Benefits

Noise	13	*(12)*
Local Air Quality	0	*(13)*
Greenhouse Gases	0	*(14)*
Journey Ambience	0	*(15)*
Accidents	164	*(16)*
Economic Efficiency: Consumer Users	6987	*(1)*
Economic Efficiency: Business Users and Providers	12022	*(5)*
Wider Public Finances (Indirect Taxation Revenues)	1219	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*
Option Values	0	*(17)*
Present Value of Benefits (see notes) (PVB)	17967	*(PVB) = (12) + (13) + (14) + (15) + (16) + (1) + (5) + (17) - (11)*
Broad Transport Budget	11063	*(10)*
Present Value of Costs (see notes) (PVC)	11063	*(PVC) = (10)*
OVERALL IMPACTS		
Net Present Value (NPV)	6904	NPV=PVB-PVC
Benefit to Cost Ratio (BCR)	1.6	BCR=PVB/PVC

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.