WEST ANGLIA MAIN LINE MEDIUM-TERM STUDY

Railway investment choices

June 2021

Contents

1 Foreword 2
2 Executive summary 3
2.1 Growth and corridor aspirations 3
2.2 Option development 4
2.3 Next steps 5
3 The West Anglia Main Line 6
3.1 Rail industry planning 6
3.2 Study aims and purpose 6
3.3 Geography and scope 8
3.4 Issues and constraints 10
3.5 Train services 14
3.6 Stations 20
3.7 Performance 25
3.8 Recent and ongoing rail improvements 26
3.9 Committed schemes and rail improvements 29
3.10 Uncommitted schemes and aspirations 30
3.11 Previous studies and development 34
4 Study approach 37
4.1 Strategic questions 37
4.2 Methodology 38
4.3 Governance 38
5 Demand forecasts 39
5.1 Context 39
5.2 Passenger forecast 40
5.3 Expected train loadings 41
5.4 Freight forecast 47
5.5 Impact on stations 48
6 Meeting the medium-term needs 50
6.1 Identified improvement options 50
6.2 Combinations and sequencing of options 61
6.3 Freight improvement opportunities 63
6.4 Summary and preferred phasing strategy 64
6.5 Stations 68
6.6 Important considerations 69
7 Recommendations 73
7.1 Responses to the sub-strategic questions 73
7.2 Individual recommendations and preferred strategy 75
7.3 Next steps 76
7.4 Recommendations for further study 77

1 Foreword

The West Anglia Main Line (WAML) is an important inter-regional route connecting the East of England's two busiest stations – Cambridge and Stansted Airport – to London Liverpool Street in the heart of the City of London. This rail route is the principal public transport mode for the UK Innovation Corridor, connecting the scientific and business hubs of London and Cambridge.[1] It is also a significant commuter railway for west Essex and east Hertfordshire and supports connectivity and growth in north east London.

Train operator Greater Anglia is in the process of replacing its entire fleet of trains which will provide a major improvement in the quality and capacity of services providing over 6,000 extra seats on the WAML in the morning high peak.[2] The trains themselves are expected to have improved performance and reliability over those they will replace, benefitting the whole area. However, aspirations beyond new trains exist, to improve journey times and frequencies for WAML passengers, spearheaded by the West Anglia Taskforce (WATF).

For freight operators, the WAML is an important corridor for construction aggregates, with regular services to terminals such as Harlow Mill. Being able to operate heavier payloads for more efficient path utilisation is a core aim.

Despite the challenges that prevent easy achievement of these aims (primarily different service groups operating on a two-track railway) Network Rail recognises and supports them, and has worked with regional stakeholders, including the County Councils, London Boroughs, the WATF and Stansted Airport to assess the priorities for improving the railway in the years ahead.

The study forms part of Network Rail's modular strategic planning process and assesses expected medium-term growth,[3] taking into account the significant impact upon passenger demand caused

[1] https://innovationcorridor.uk/
[2] Based on the structure of the December 2019 timetable.
[3] Considered to be 10-15 years

by the Coronavirus (Covid-19) pandemic, and identifies a range of different infrastructure and technological solutions which could be deployed to meet the aspirations highlighted above.

This study is medium-term in nature because, although now delayed and with its programme uncertain, Crossrail 2 provides the long-term transformative improvement for the WAML. Crossrail 2 would provide the required infrastructure to meet the above aspirations in full, as well as significant capacity increases to support housing and employment growth in the Lea Valley and wider WAML corridor.

West Anglia Taskforce

The West Anglia Taskforce, established in 2015 and chaired by Lord Haselhurst, is the WAML's leading advocate for change and improvements to unlock faster journeys, improve connectivity and facilitate housing and employment growth. Its membership includes local Members of Parliament, the Department for Transport, Network Rail, Greater Anglia, business leaders, local authorities and Stansted Airport.

2 Executive summary

This study seeks to inform medium-term investment choices for this strategically important rail corridor. It assesses a number of Strategic Questions, the answers and outputs to which will help determine what improvements may be required on this corridor over the next 10-15 years. Any improvements would be relatively small scale and would be intended to be delivered before Crossrail 2, although it is uncertain when this might be.

2.1 Growth and corridor aspirations

This study has been undertaken during the Coronavirus (Covid-19) pandemic, which has resulted in a significant reduction in public transport usage across the country, in line with the Government's 'stay at home' message. Significant proportions of traditional peak hours' commuters have not travelled at all, or significantly reduced the number of trips they make.

As a result of this necessary change to travel patterns, it is possible that there may be a lasting impact on company working policies and individuals' behaviour and working location preferences. Uncertainty about future levels of demand is therefore high. As a result, scenarios to simulate a range of potential outcomes are being developed to inform future investment decisions. Analysis undertaken for this study indicates that demand in 10 years' time could be between 15 % lower and 26 % higher depending on the demand scenario considered. The substantial increase in capacity Greater Anglia's fleet replacement brings means that even under the most optimistic demand scenario there are no forecast passenger crowding issues on any services on this route.

For freight, while the route is a relatively significant corridor for construction materials traffic, future growth is forecast to be small, not necessitating any additional paths to meet expected demand.

It is recognised, however, that the WAML has several other challenges and opportunities. As a result, this study has focussed on providing improvement options in line with meeting stakeholders' medium-term passenger and freight aspirations, as set out below in Table 1.

Passenger Service Aspirations	Freight Service Aspirations
• Faster journey times between London and Stansted Airport* • Faster journey times between London and Cambridge* • More frequent station calls in north London • Improved performance	• Heavier payloads • Faster journeys • Improved performance
* also improving journey times to and from key centres such as Bishop's Stortford and Harlow Town	

Table 1 – Passenger and Freight Aspirations for the WAML.

2.2 Option development

Network Rail and its stakeholders produced a list of options aimed at meeting the objectives listed above. The study assessed various options, including infrastructure and signalling upgrades and targeted line speed improvements. Due to the severe constraints that the WAML suffers from, it was deemed that simple adjustments to the current timetable would have little benefit.

The analysis showed that each of the options tested had relatively limited impact when considered in isolation, however when combined and sequenced correctly, these smaller gains begin to compound into more meaningful benefits.

For passengers, a multi-stage enhancements programme could improve the number of station calls throughout the day in north London, improving the sub-optimal 2-3 trains per hour (tph) many stations currently have to a more passenger-focussed 4tph, including at Meridian Water, where thousands of new homes are planned to be built by the London Borough of Enfield.

Several stages of improvements, primarily aimed at improving journey times to and from Stansted Airport would gradually decrease end-to-end journey times to around 40-41 minutes, down from the 47-49 minutes typical journey time today. This would also bring journey time improvements between stations at which the Stansted Express calls. A summary of the stages to achieve this is shown in Figure 1 below.

Stage	Rec. number	Intervention	Primary Driver	Fastest typical London Liverpool Street-Stansted Airport journey time (mins)	Total off-peak / peak station calls per hour (one way Northumberland Park-Waltham Cross)	Other benefits
0	3	Enhanced renewal of Broxbourne Junction *(timed with planned renewal)*	Performance	47 (current)	15 / 19 (current)	• Performance improvements • Potential small journey time improvements for Hertford East services
1a	4, 5, 7	Dynamic loop + ETCS (2-minute headway)	Station Calls	47 (1tph capable of 45)	22 / 23	• Additional station calls in north London • Performance improvements
1b	1	Line speeds (Bethnal Green North Junction – Coppermill Junction)	Journey Time	45	22 / 23	• Journey time benefits for other services, e.g. Hertford East
2	6	Second Stansted tunnel	Journey Time	41	22 / 23	• Improved journey times for Stansted trains to/from the north • Performance improvements
3	2	Line speeds (various sections north of Cheshunt)	Journey Time	40	22 / 23	• Improvement to Cambridge journey times
4	n/a	Four-tracking south of Broxbourne with Crossrail 2 *(or other similar solution providing terminal capacity)*	Performance Station Calls Journey Time Connectivity	30-35 (estimate)	Likely 60+	• Large journey time benefits for all longer-distance trains • Ultra-frequent station calls • Significant performance improvements • Improved regional connectivity

Figure 1 – Proposed sequencing of recommendations.

These proposals are also likely to have positive implications for performance, as more flexibility is built into the infrastructure.

London Borough of Enfield has achieved funding for a passing loop at Ponders End station in order to deliver 4tph at Meridian Water station and is likely to be delivered. The Phase 1a recommendation above therefore could be a lengthening of this static loop into a longer 'dynamic' loop, which gives greater passenger service benefits.

For freight, trains will still need to be looped so that they don't impede fast passenger services to and from Cambridge and Stansted Airport, meaning that journey time improvements will be unlikely. There are, however, opportunities to improve the network to accommodate longer, and therefore heavier freight trains by lengthening loops along the route.

It remains the case that longer-term aspirations for higher frequency calls in north London and even faster journeys to Stansted Airport and Cambridge will require a major programme such as Crossrail 2 to be delivered. For long-term freight aspirations to run intermodal and automotive trains, longer loops and higher gauge clearance will also be required. These established long-term options have not been reassessed by this study but are set out in the Anglia Route Study and Freight Network Study.[4]

2.3 Next steps

It should be cautioned that, at the time of publication, the Government's ability to fund business case development under the Rail Network Enhancements Pipeline (RNEP) is currently under severe pressure and that proposals which do not present strong business cases are unlikely to receive development funding in the near future.

In this context, it is recommended that the shorter term options identified in this study are investigated in more detail by Network Rail. This is to better understand the feasibility of the options and estimate of potential cost ranges before detailed business case work commences. This would give the programme the greatest chance of being developed further if these assessments are positive.

Subject to positive outcomes of these feasibility studies, separate programmes for passenger benefits and freight benefits should be commenced.

[4] The Anglia Route Study and Freight Network Study can be found here: https://www.networkrail.co.uk/running-the-railway/long-term-planning/

3 The West Anglia Main Line

This section describes the aims of the study, the characteristics of the West Anglia Main Line, as well as current level of service, recent growth trends and upcoming committed rail schemes and significant third-party developments.

3.1 Rail industry planning

Network Rail has a responsibility to plan for the long-term needs of the railway. To be as focussed and targeted in its long-term planning as possible, Network Rail undertakes detailed studies aimed at a defined area of geography under its rolling programme of Continuous Modular Strategic Planning (CMSP). This study forms a part of that process for Network Rail's Anglia Route and Eastern Region.[5]

CMSP replaced the previous planning methodology of producing Route Studies, which provided a high-level overview of the whole route. The last Route Study covering the WAML was published in 2016, and also included assessment of the Great Eastern Main Line, London Orbital routes and Essex Thameside corridor. CMSP is more focussed on a specific area of the rail network, so this study is able to provide a more detailed assessment of the WAML than previous Route Studies.

For this study, Network Rail has worked with its industry partners and stakeholders to:

- determine medium-term passenger and freight growth forecasts for the corridor;
- identify the short- and medium-term enhancement options to support demand growth and aspirational service improvements for passengers and freight, and;
- establish a suitable staging of viable options to meet these needs and aspirations.

The production of a more focused study such as this provides greater ownership by key stakeholders bringing the case for investment to Government and other funders through the Rail Network Enhancements Pipeline (RNEP).[6]

3.2 Study aims and purpose

Through provision of significant new track capacity, it is widely acknowledged that Crossrail 2 would deliver the long-term capacity needed on the southern part of the WAML, also delivering much improved connectivity and journey times. However, the delivery date of Crossrail 2, and the significant benefits it would bring, is currently uncertain with scheme development being paused in 2020.

[5] Further details can be found here: https://www.networkrail.co.uk/running-the-railway/long-term-planning/
[6] For more information on the RNEP, see https://www.gov.uk/government/publications/rail-network-enhancements-pipeline

Crossrail 2

Crossrail 2 is proposed to deliver two additional tracks between Tottenham and Hale and Broxbourne, allowing non-stopping, long-distance trains to and from Cambridge and Stansted Airport and shorter-distance suburban services as far as Broxbourne to be separated, delivering the longstanding twin aims of increased services and journey time improvements.

South of Tottenham Hale station, the slow lines are proposed to enter new tunnels crossing central London, ultimately connecting with the South West Main Line north of Wimbledon. The plan opposite shows the proposed route through central London and onto the WAML at Tottenham Hale.[7]

Note, route map is from 2015, and therefore shows Angel Road instead of Meridian Water.

The main aim of this study, therefore, is to identify the most beneficial medium-term enhancement options, to provide benefits to the WAML in advance of, or complementary to, Crossrail 2 and to address wider aspirations for improving services on this important corridor. Ideally, these improvements will be complementary to the eventual scheme. These options will aim to;

- support any passenger demand growth in peak hours;
- improve connectivity and access to the railway, particularly for north London suburban stations which currently do not share the same high level of service compared with other similar suburban London routes, and;
- improve journey times for longer-distance services between London and Cambridge & Stansted Airport.

The headline Strategic Question this study seeks to answer is, therefore, '***What are the priority enhancements that could provide improved performance, journey times and service offering on the West Anglia Main Line prior to the delivery of Crossrail 2?***'.[8]

[7] More information about Crossrail 2 and a full, high resolution, version of the plan can be found at https://crossrail2.co.uk/

[8] The Strategic Questions are set out in full in section 4.

This study has been identified as a priority for 2020/21 for a number of reasons:

1. The 2016 Anglia Route Study identified the need for an improved fleet (via lengthening or higher density rolling stock) to meet the required forecast growth in the short-term. A fleet of new trains is currently being introduced which will markedly improve the quality and capacity of services. Once in service, any further increases in capacity will need to be provided by improvements to the infrastructure to provide additional train paths. Prioritised next steps need to be identified to continue to meet the strategic requirements of the route.

2. The West Anglia Capacity Enhancements scheme, sometimes referred to as the 'STAR' scheme (see 3.8.4), completed in 2019 added additional infrastructure and changed the timetable structure of some shorter-distance services.

3. Previous studies and developing business cases have or are being completed for key interfacing elements of the WAML, i.e. the Great Eastern Main Line (GEML) Study, and Strategic Outline Business Cases (SOBCs) for London Liverpool Street and Stratford stations. The effect of growth and any required changes to the WAML need to be considered to properly inform these related business cases and funding decisions.

4. The timing, funding and delivery schedule for Crossrail 2 is currently uncertain but as development of the programme has now been paused, it is clear it will not be delivered in the next decade. In the instance that growth in passenger demand needs to be accommodated ahead of the Crossrail 2 timescales, complementary medium-term options need to be considered. Similarly, meeting stakeholder aspirations of improved journey times and connectivity will not be possible without further improvements to the infrastructure.

3.3 Geography and scope

The WAML runs between London Liverpool Street and King's Lynn and carries busy long-distance commuter and leisure traffic from Stansted Airport and Cambridge into the City of London. The route also has a relatively complex suburban train service offering, passing through the densely populated north London areas of Tottenham and Enfield and the commuter belt along the Essex-Hertfordshire border, including the large towns of Harlow and Bishop's Stortford.

Certain areas along the route have the potential for significant housing and employment growth, including south Cambridge and around Harlow. In London, 10,000 homes will be built in Enfield, alongside the new Meridian Water station, and 8,000 homes could be built around the proposed Ruckholt Road station in Waltham Forest.

Figure 2 opposite shows a geographic representation of the WAML (including its Lea Valley, Stratford, Hertford and Stansted branches) in red and pink, and the counties through which it passes. The red area is the part of the corridor which this study will consider. The pink areas of the WAML are out of scope and are described below.

This study focuses on the core parts of the WAML which must deliver the challenging twin requirements of good connectivity and capacity for services from Hertford East and Bishop's Stortford calling at north London stations, and fast journey times for services from Cambridge and Stansted Airport.

The pink, out of scope, areas are;

1. **The north London suburban lines to London Liverpool Street from Chingford, Cheshunt and Enfield Town, known collectively as the Lea Valley Lines, operated by London Overground**. The Class 315 and 317 trains previously operating these routes have recently been replaced with much higher capacity Class 710 rolling stock, which are expected to provide sufficient capacity until at least 2043, as detailed in the 2016

Figure 2 – Extent and scope of the WAML, with the red areas within the study's scope.

Anglia Route Study. Transport planning for these lines is led by Transport for London (TfL).

London Overground and Greater Anglia services share platforms at London Liverpool Street station and operate over the same infrastructure between London Liverpool Street and Bethnal Green (for Cheshunt and Enfield Town services) and Clapton Junction (for Chingford services), meaning the long-term requirements for both service groups must be taken into account in planning and decision-making.

2. **The section north of Cambridge North station, which is predominantly served by Great Northern services to and from London King's Cross**. Short platforms at several intermediate stations between Cambridge North and King's Lynn have recently been extended to allow 8-car operation, improving capacity. Further improvements to be delivered by the Ely Area Capacity Enhancements scheme (see 3.10.5) could deliver further benefits for the King's Lynn route.

3.4 Issues and constraints

Competing demands exist on the WAML for fast journey times and frequent train services, which the current two-track configuration struggles to deliver. Figure 3 below shows the 'level of complexity' along the WAML as far as Cambridge North. The diagram shows where the infrastructure is most constrained, by either total numbers of trains, complex stopping patterns, single-line infrastructure, or a combination of these factors. Green indicates the areas of least concern, rising through yellow and amber to red, indicating the most constrained areas. The main terminus stations are also coloured accordingly, signifying platforming constraints. Table 2 following the diagram explains the main areas of concern (numbered in grey boxes) in more detail.

Notes:

- Chevrons (^ v; ^v) refer to normal directions of train movements on each line.

Level of Complexity – including tph, infrastructure capability, timetable structure, station stops etc.

Low — Very high

For legibility the following simplifications have been made:

- Track layouts have been simplified to core running lines. For example, sidings, depots, freight loops and some crossovers are not shown.
- Complex track layouts on the approach to termini (including Cambridge) are not shown.
- Most (plain line) stations are not shown.
- Some lines (including Great Eastern Main Line, North London Line and Gospel Oak-Barking Line) are not shown.
- The WAML north of Cambridge North station is out of scope and not shown, however the London Overground routes are shown to illustrate network interactions in London.

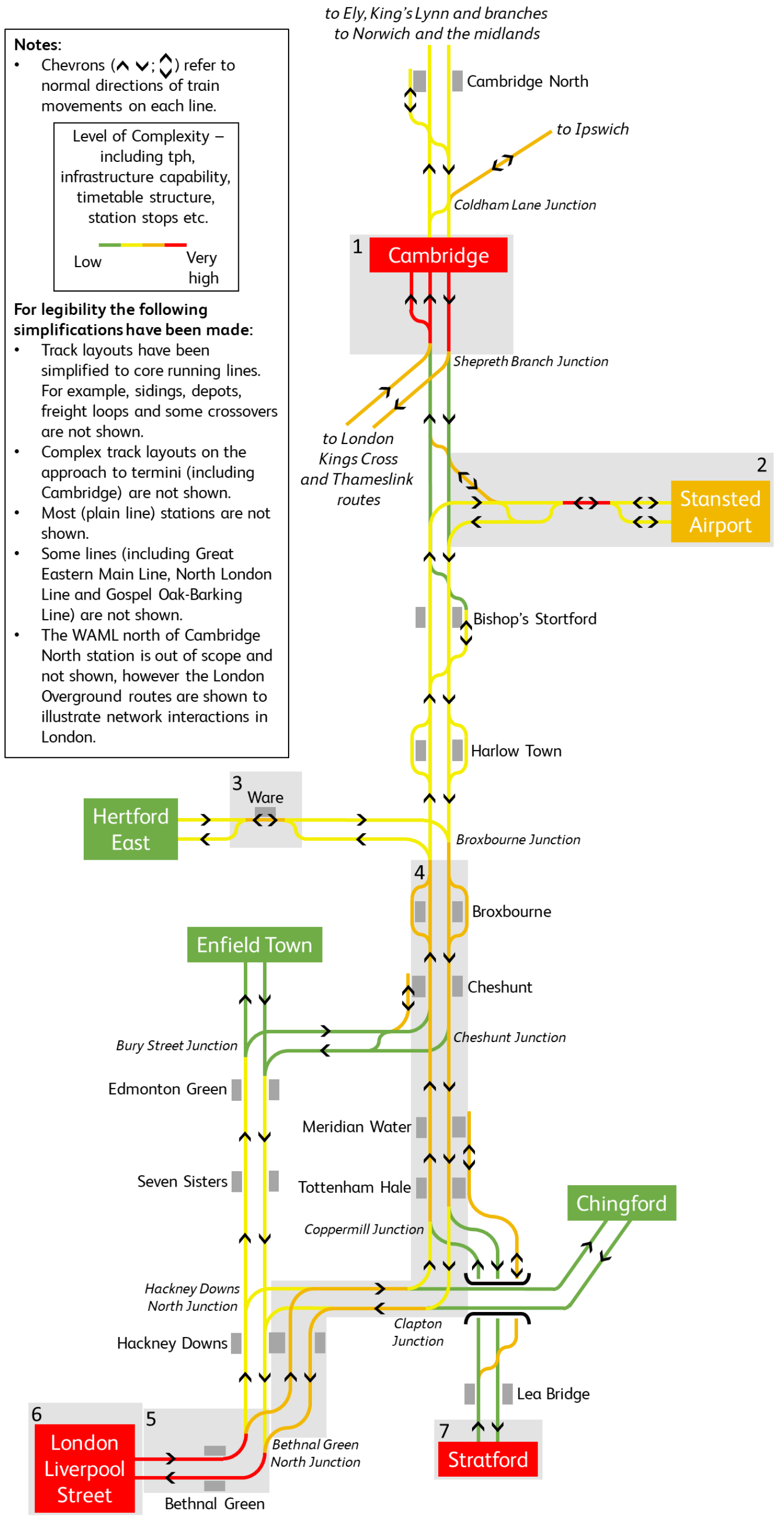


Figure 3 – A simplified diagram of the WAML showing the most constrained areas along the corridor; most severe around Cambridge and London Liverpool Street.

1	Cambridge is the most significant railway hub in East Anglia outside of London. Services from London, Brighton, Birmingham, Norwich, Ipswich, King's Lynn and Stansted Airport currently either call or terminate at the station. The mixture of services passing through or terminating at the station and its complex track layout results in frequent crossing moves, constraining the number of trains which can be run. In the future, East West Rail services from Oxford via Bedford will terminate here, adding further complexity to the train service, and requiring upgrades to track and station infrastructure. Beyond delivery of the Central Section, stakeholders in Norfolk, Suffolk and Essex would like to see the Eastern Section delivered, bringing East West Rail services through to Norwich and Ipswich. Therefore, in the longer term, Cambridge could see more through-services too, subject to successful business case for the Eastern Section.
2	Three separate issues combine to make the Stansted Airport branch somewhat constrained. The single line tunnel under the airport runway acts as a bottleneck, restricting the overall number of services which can run to and from the airport. In the off-peak, the Norwich-Cambridge service is extended to Stansted Airport, resulting in 12 trains per hour (6 in each direction) using this single line section, which is the maximum number of trains that the single line can accommodate. Similarly, the single line chord which provides access to and from Cambridge restricts flexibility in timetabling. Finally, the three platforms are of varying lengths and restrict which services can use which platforms.
3	The single platform at Ware station restricts intensive operation on the Hertford East branch. In both peaks, one train is run after another through the single line section in quick succession (known as 'flighting') to enhance the train service to 3tph in the peak flow direction only. Services are unable to be evenly spaced or sustain this frequency throughout the day due to this single line section (combined with a lack of available capacity on the main line).
4	The 17-mile section between Broxbourne Junction, where the line to Hertford East branches off, and Bethnal Green North Junction, where the main line and the London Overground route via Seven Sisters merge, is the part of the WAML where services to and from Cambridge, Stansted Airport, Bishop's Stortford and Hertford East all share the same two-track infrastructure. No overtaking locations exist south of Broxbourne station, so the timetable must be constructed so that fast services don't get held up behind stopping services. This two-track infrastructure, while only accommodating a maximum of 14tph at the busiest point (between Broxbourne and Cheshunt), is the main reason why the competing aims of fast journey times for long-distance services and frequent station calls for suburban services are difficult to meet. A balance between journey time and service frequency must be made which does not fully meet all aspirations.
5	The 1.3-mile section between Bethnal Green North Junction and London Liverpool Street station is the busiest part of the route. All of the WAML's services to and from London Liverpool Street (including the London Overground) share this two-track infrastructure and current signalling restricts operations to a maximum of 22tph. The maximum train capacity is currently used in the morning high peak hour and is currently divided as 8tph via Seven Sisters, 10tph via Tottenham Hale and 4tph from Chingford converging at Bethnal Green North Junction.
6	Pedestrian capacity at London Liverpool Street station, particularly in the morning peak, is a significant concern. Passengers alighting from the rear carriages arriving at the station often do not exit the platform before the next train arrival on the adjacent island platform, leading to congestion on platforms and at the gatelines. This congestion is caused by a combination of narrow platform widths and bottlenecks at the gateline itself. Options to address these capacity constraints have been developed.
7	Stratford station suffers from similar issues to London Liverpool Street, and Network Rail are developing options to address the short and medium-term pedestrian capacity constraints. Although the number of trains from the WAML that use Stratford is relatively low, only one platform (normally platform 11) is consistently available for use. The adjacent line through platform 12 must be kept clear for freight trains and movements of empty passenger trains to and from the nearby Orient Way depot, so is unavailable for intensive, regular use.

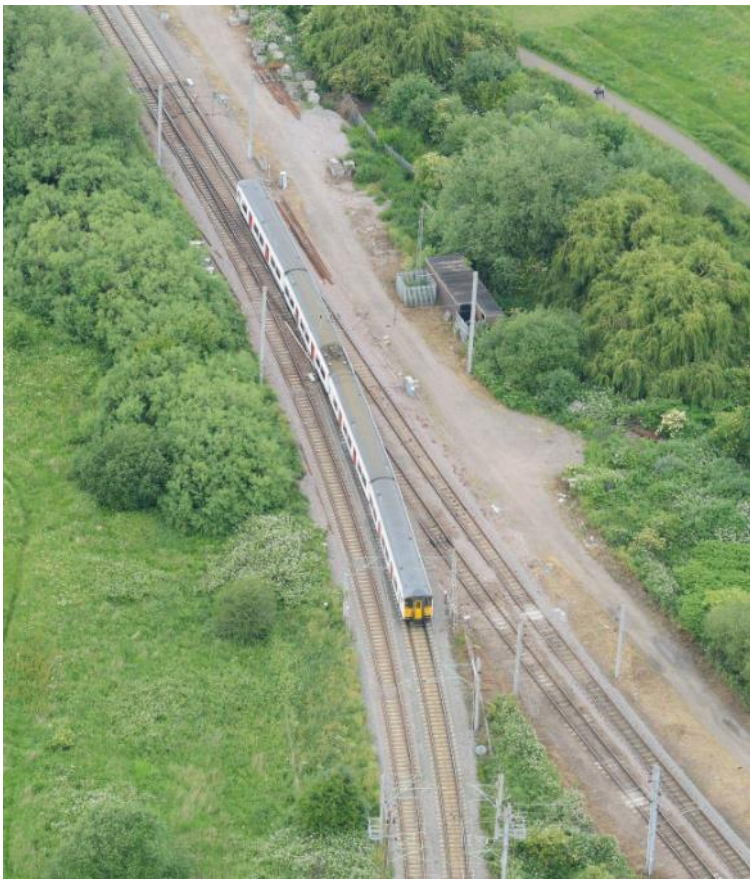
Table 2 – There are seven main geographic areas of constraint on the WAML.

As can be seen from Figure 3 and the corresponding descriptions in Table 2, the biggest constraints exist at either end of the corridor – in London and on the approaches to Cambridge and Stansted Airport. Relatively low numbers of trains operate on the middle part of the route between Broxbourne Junction and Shepreth Branch Junction, but it is important to highlight that these constraints at the extremities of the corridor prevent uplifts of services on the corridor as a whole. The central constraining issue of the WAML is the two-track nature of the corridor, which means that the ambition of frequent station calls for north London suburban services as well as faster journey times, especially for longer-distance services to Cambridge and Stansted Airport are difficult to reconcile.

As well as the geographic issues highlighted in the table above, the following general or multi-locational constraints and issues also exist on the WAML.

1. **Low line speeds**
   The WAML currently has a maximum line speed of 90mph. However, 90mph sections are limited and the speed limit along the line varies significantly, with some sections, such as the majority of the track in the 19 miles between Sawbridgeworth and Great Chesterford limited to 70mph. The section between Tottenham Hale and London Liverpool Street is limited to between 30 and 40mph.

2. **Flat junctions**
   No junctions on the corridor are currently grade separated, meaning that at multiple points along the corridor, some trains must cross the opposite direction running line (therefore restricting capacity). This includes Bethnal Green North, Coppermill, Broxbourne and the three Stansted junctions.



A train bound for London Liverpool Street at Coppermill Junction crosses over the northbound track of the Stratford branch.

3. **Level crossing constraints**
   Proposals to increase train frequency or change timetables may increase risk at several level crossings, meaning upgrades or closures might be required before improvements can be made. Particular crossings to note are: Brimsdown, Enfield Lock, Windmill Lane (next to Cheshunt station) and Wharf Road (between Cheshunt and Broxbourne). Note, Crossrail 2 will require these crossings to be closed.

4. **Congested stations**
   On top of London Liverpool Street and Stratford, station capacity for pedestrians is also a concern at Cambridge; the busiest WAML station outside of London, and at Tottenham Hale due to its popular connection to the London Underground Victoria Line which offers frequent services to London's West End.

5. **Train lengths**
   Most high peak hour services on the Greater Anglia network will be at their longest possible length once its new fleet is fully deployed. It is not deemed feasible to extend trains beyond approximately 240m, meaning an infrastructure enhancement allowing for increased frequency is likely to be required if higher capacity is needed.

6. **Freight infrastructure capability**
   For freight, loading gauge[9] of W8 means that the WAML is not an optimal routing option for 'intermodal' container traffic to and from East Anglian ports such as Felixstowe, London Gateway or Tilbury. Container traffic to and from these ports requires the wider W10 or W12 gauge clearance. It is worth noting that if more freight was to traverse the WAML, this may only be achievable at the expense of passenger services and/or slower journey times without significant investment in infrastructure capability. Simply using the WAML as a conduit for freight travelling to other destinations may not be the optimal use of its limited capacity.

The single most constraining factor of the WAML is the two-track section south of Broxbourne where stopping and non-stopping services share the same infrastructure. It is not expected that there will be many so-called 'quick wins' which will boost capacity and improve journey times significantly as a result of this. More significant infrastructure enhancement will be required to do so.

This study will take a 'blank canvas' approach to assess where the most beneficial gains can be made across the corridor, rather than focus purely on these areas of highest constraint.

3.5 Train services

Like all other London-bound railway lines, the WAML is an important passenger corridor, with services strengthened during peak hours. However, unlike many of its neighbouring lines, such as the GEML or East Coast Main Line (ECML), freight traffic is generally low. This section describes the normal passenger and freight services which operate on the WAML.

[9] Loading gauge relates to the maximum size of the vehicles that may pass over a particular route. This is determined by the physical space available through bridges, tunnels and past other structures. This maximum size is often thought of in terms of an 'envelope', encompassing the space that a vehicle may occupy. This envelope includes not just height and width, but also accounts for vehicle length and the associated 'throw' on curves, as well as the movement brought about by the vehicle's suspension.

3.5.1 Passenger services

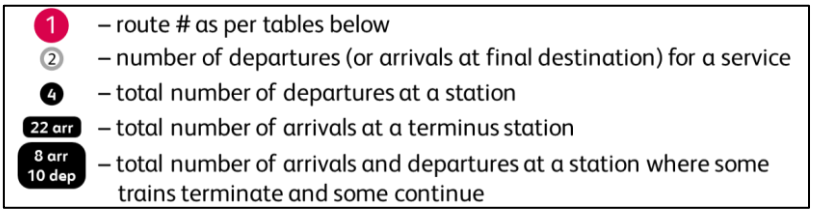
Greater Anglia is the WAML's principal train operator, operating all long- and mid-distance trains to and from London Liverpool Street and Stratford, including the *Stansted Express*.

Thameslink and Great Northern trains operate from Cambridge and King's Lynn to London King's Cross and Brighton[10] (through Central London) via a branch line passing through Royston. Several junctions around Cambridge and Ely connect regional services from Ipswich and Norwich to Cambridge, as well as long-distance CrossCountry trains from Birmingham New Street which terminate at Stansted Airport. Since December 2019, Greater Anglia services from Norwich to Cambridge have been extended to Stansted Airport in the off-peak.[11]

Mid-distance suburban services operate from Hertford East to London Liverpool Street and from Bishop's Stortford to Stratford, calling at north London intermediate stations. Stratford is also the terminus for the half hourly Meridian Water shuttle service, which began in September 2019 to improve frequency in the Lea Valley. Branches to Enfield Town/Cheshunt and Chingford served by London Overground trains also form part of the inner WAML in north London.

London is the primary draw for peak hours commuters, but it is not the only commuter destination on the WAML. Cambridge draws in commuters from towns along the route from both directions, as well as from along several other lines which intersect at this key railway hub. Stansted Airport is also a significant destination for airport-based employees. The WAML therefore has complex train interactions around the three primary destinations of London, Cambridge and Stansted Airport, with multiple service groups, with differing calling patterns, operated by different train operating companies interacting on constrained infrastructure.

Figures 4-7 overleaf, supported by the key below, show the peak and off-peak service patterns of all passenger services on the WAML in both directions, as per the December 2019 timetable.[12] The individual lines show the different services which operate on the WAML, coloured by operator. Tables 3 and 4 beneath them summarise the numbers of services.

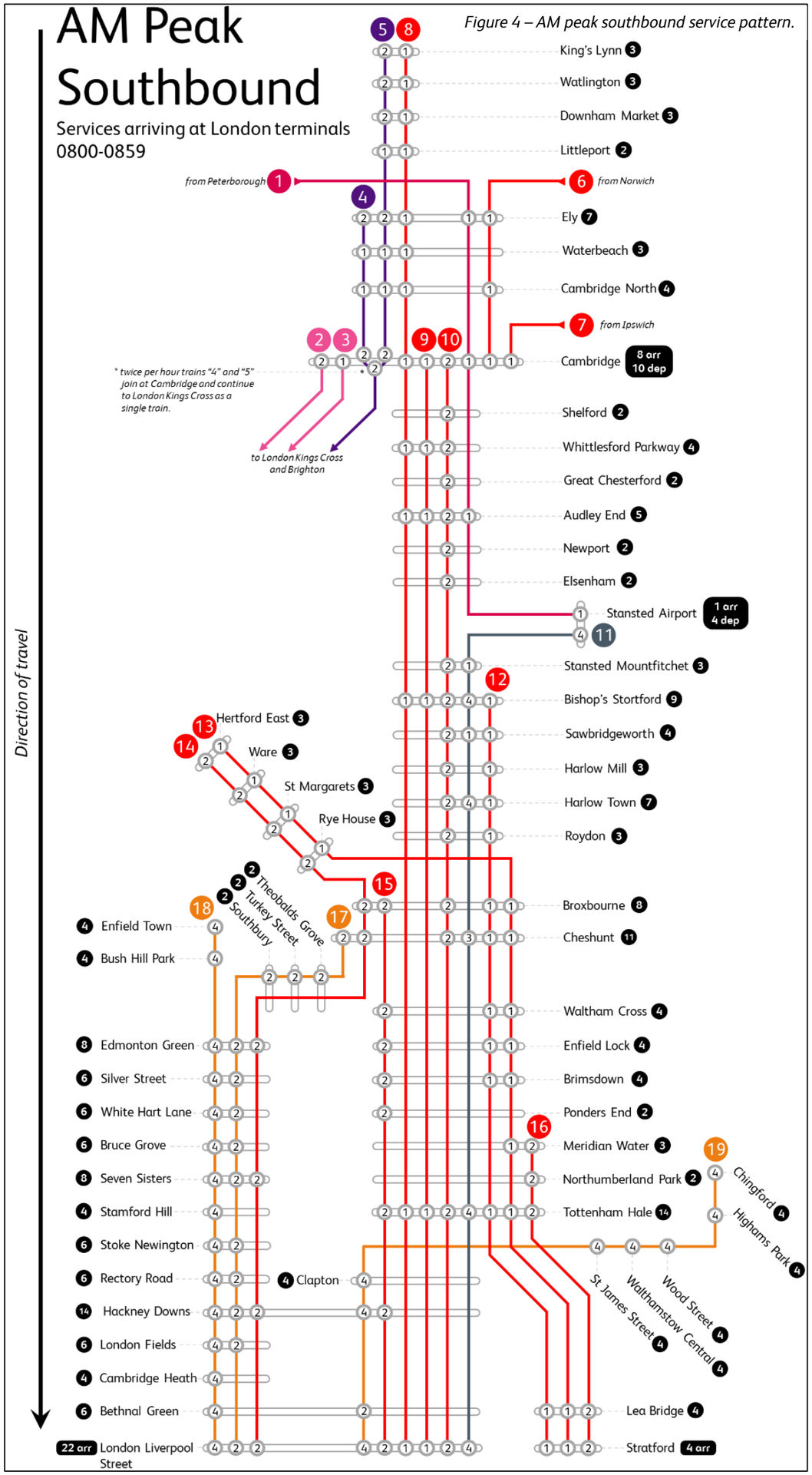


[10] Thameslink services to Maidstone East are also proposed to be introduced as part of the full Thameslink timetable, replacing the Cambridge-London King's Cross services.
[11] It is currently not possible to extend this in the peak due to the higher peak hours service frequency from Cambridge to London Liverpool Street which occupies track capacity required for the service to be extended.
[12] The December 2019 timetable has been chosen due to the amendments made to timetables as a result of the Covid-19 pandemic.

AM Peak Southbound

Services arriving at London terminals
0800-0859

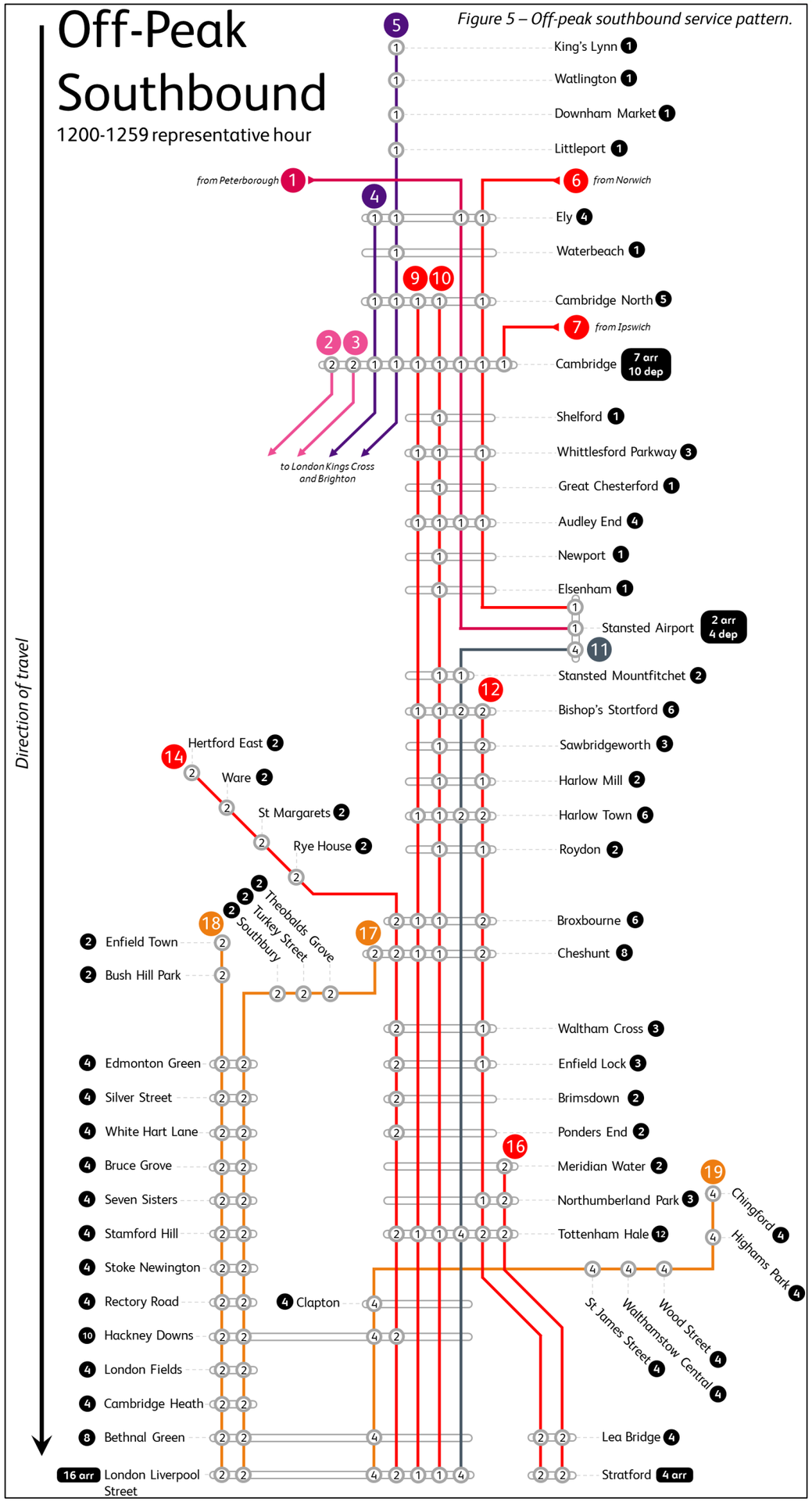
Figure 4 – AM peak southbound service pattern.



Off-Peak Southbound

1200-1259 representative hour

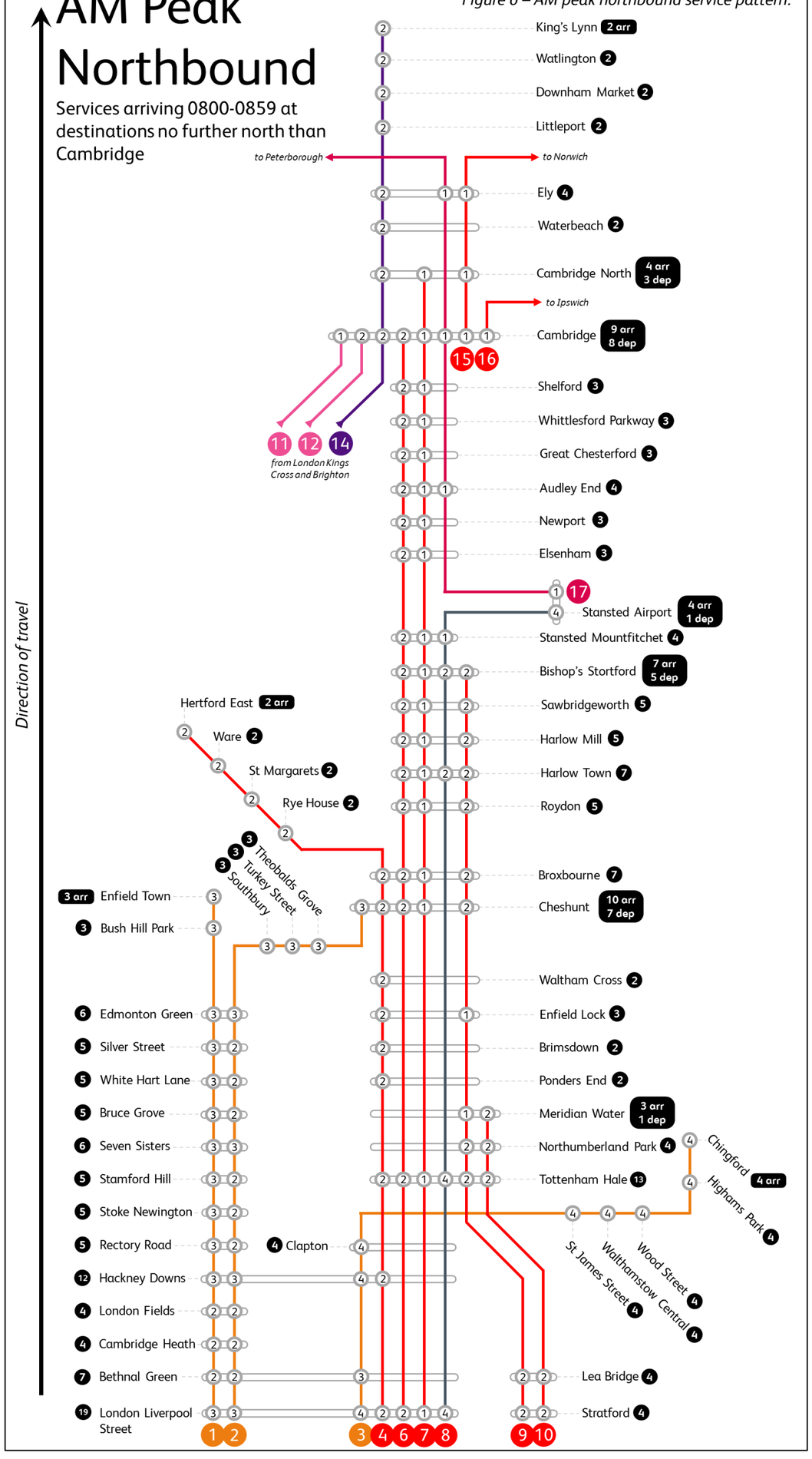
Figure 5 – Off-peak southbound service pattern.



AM Peak Northbound

Services arriving 0800-0859 at destinations no further north than Cambridge

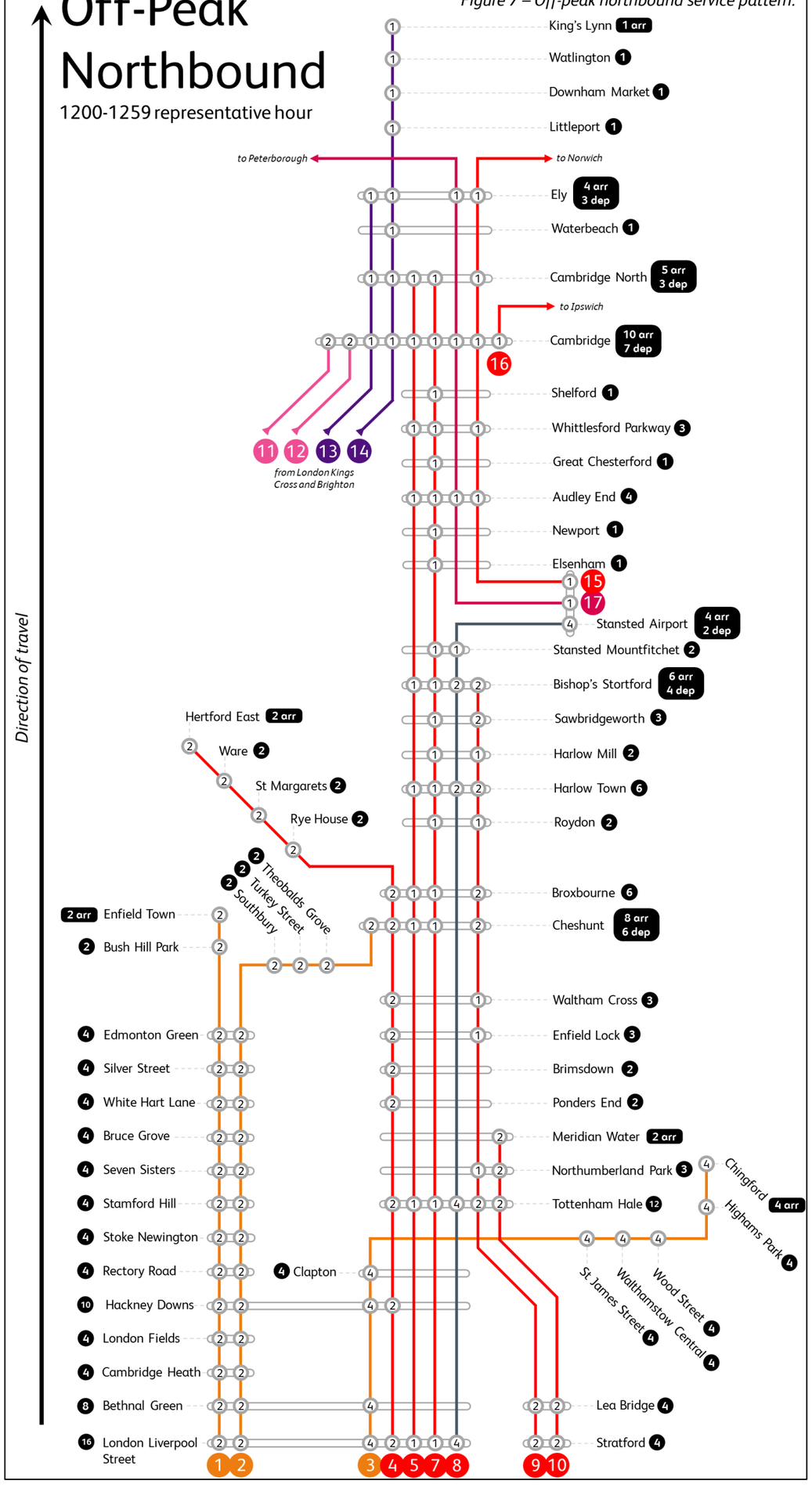
Figure 6 – AM peak northbound service pattern.



Off-Peak Northbound

1200-1259 representative hour

Figure 7 – Off-peak northbound service pattern.



Southbound trains to London, Stansted Airport and Cambridge					
#	Origin	Destination	Operator	Trains per hour	
				AM Peak	Off-peak
1	Birmingham New Street	Stansted Airport	CrossCountry	1	1
2	Cambridge	Brighton	Thameslink	1	2
3	Cambridge	London King's Cross	Thameslink	2	2
4	Ely	London King's Cross	Great Northern	2	1
5	King's Lynn	London King's Cross	Great Northern	2	1
6	Norwich	Cambridge/Stansted Airport	Greater Anglia	1	1
7	Ipswich	Cambridge	Greater Anglia	1	1
8	King's Lynn	London Liverpool Street	Greater Anglia	1	-
9	Cambridge/Cambridge N.	London Liverpool Street (fast)	Greater Anglia	1	1
10	Cambridge/Cambridge N.	London Liverpool Street (slow)	Greater Anglia	2	1
11	Stansted Airport	London Liverpool Street	Greater Anglia	4	4
12	Bishop's Stortford	Stratford	Greater Anglia	1	2
13	Hertford East	Stratford	Greater Anglia	1	-
14	Hertford East	London Liverpool Street	Greater Anglia	2	2
15	Broxbourne	London Liverpool Street	Greater Anglia	2	-
16	Meridian Water	Stratford	Greater Anglia	2	2
17	Cheshunt	London Liverpool Street	London Overground	2	2
18	Enfield Town	London Liverpool Street	London Overground	4	2
19	Chingford	London Liverpool Street	London Overground	4	4

Notes:

- Services 4 & 5 – a train from Ely and a train from King's Lynn join at Cambridge and continue as a single train to London King's Cross. This occurs twice in the high peak hour.
- Service 6 – operates Norwich-Cambridge in peak hours and Norwich-Stansted Airport in off-peak hours.
- Service 8 – operates fast from Cambridge, as per Service 9.
- Services 9 & 10 – operate from Cambridge in the peak, and from Cambridge North off-peak.

Table 3 – Summary of southbound trains.

Northbound trains to destinations including Stansted Airport and Cambridge					
#	Origin	Destination	Operator	Trains per hour	
				AM Peak	Off-peak
1	London Liverpool Street	Enfield Town	London Overground	3	2
2	London Liverpool Street	Cheshunt	London Overground	3	2
3	London Liverpool Street	Chingford	London Overground	4	4
4	London Liverpool Street	Hertford East	Greater Anglia	2	2
5	London Liverpool Street	Cambridge North (semi-fast)	Greater Anglia	-	1
6	London Liverpool Street	Cambridge (slow)	Greater Anglia	2	-
7	London Liverpool Street	Cambridge North (slow)	Greater Anglia	1	1
8	London Liverpool Street	Stansted Airport	Greater Anglia	4	4
9	Stratford	Bishop's Stortford	Greater Anglia	2	2
10	Stratford	Meridian Water	Greater Anglia	2	2
11	Brighton	Cambridge	Thameslink	1	2
12	London King's Cross	Cambridge	Thameslink	2	2
13	London King's Cross	Ely	Great Northern	-	1
14	London King's Cross	King's Lynn	Great Northern	2	1
15	Cambridge/Stansted Airport	Norwich	Greater Anglia	1	1
16	Cambridge	Ipswich	Greater Anglia	1	1
17	Stansted Airport	Birmingham New Street	CrossCountry	1	1

Notes:

- Service 15 – operates Cambridge-Norwich in peak hours and Stansted Airport-Norwich in off-peak hours.

Table 4 – Summary of northbound trains.

The number of different services operating on the WAML illustrated in the tables above leads to high track usage, especially in peak hours, around the key destinations of London and Cambridge, as described in section 3.4. As can be seen from the service group diagrams above, several north London stations suffer from poor service frequency even in peak hours, at 2 or 3tph. This is below the 10-15 minute service frequency required to be considered as 'turn-up-and-go', offered on many neighbouring suburban routes to and from London. As explained above in section 3.4 increasing this service frequency is not possible without impacting on the journey times of the longer-distance Cambridge and Stansted Airport services.

3.5.2 Freight services

Although the WAML is not one of the region's principal freight routes outlined in the 2017 Freight Network Study, there are several important freight flows that interact with the corridor. Most of the existing flows carry construction materials and there are several terminals sited on or accessed via the WAML. These terminals include:

- Bow Yard, south of Stratford;
- Harlow Mill;
- Chesterton, adjacent to Cambridge North station,
- Ely Freight Terminal,
- Middleton Towers quarry, near King's Lynn, and;
- Whitemoor Yard, near March on the Ely-Peterborough line.

All these sites are involved with the processing or onward distribution of aggregates materials for the construction industry. Whitemoor Yard also acts as a distribution point for Network Rail's infrastructure maintenance and renewals programme.

Most freight traffic on the WAML travels through Cambridge, however very few of these freight journeys traverse a significant portion of the corridor. Instead, freight flows interact with the corridor at three separate key locations.

The first location is Shepreth Branch Junction, where freight flows to and from the ECML via Royston cross the WAML to join up with the nationally important cross-country freight corridor at Ely.

The second location is at Harlow Mill where aggregates traffic enters and exits the yard. This site primarily handles flows of construction materials to and from the Leicestershire quarries.

The final and most important intersection on the corridor is between Coppermill Junction and Tottenham South Junction. This is where freight traffic to and from Bow Yard, as well as some container traffic from Felixstowe routed on the GEML via Stratford, crosses the WAML creating conflicting moves with passenger services.

Due to its restrictive gauge clearance, explained above in 3.4, the WAML is not an optimal routing option for intermodal container flows (except for the short crossing manoeuvre described above).

However, if the corridor was gauge cleared to W10 or W12, it could be used as a more robust diversionary route for intermodal traffic to and from the region's ports, including Felixstowe, Tilbury and London Gateway, or even offer regular timetabled services. W12 gauge was highlighted as long-term aspiration for the corridor in the 2017 Freight Network Study (FNS), however at present enhanced gauge clearance is not being pursued, as other higher priority routes for gauge clearance currently exist. It is important to highlight that if the WAML was to be cleared to W12 gauge and convey additional freight services beyond what is analysed in this study, further capacity analysis work would be required to assess the impact on capacity for all rail users, which may necessitate additional infrastructure enhancements.

In 2019, national freight forecasts were produced, a summary of which is given below in section 5.

3.6 Stations

There are 60 stations on the WAML and its branches. Within the scope of this study, defined above in 3.3, there are 31 stations which serve the medium- and long-distance services which are the focus of this study, plus another three where there is a limited service.[13] Types and sizes of station on the WAML vary enormously, including;

- the busy southern termini of London Liverpool Street and Stratford, which also act as significant interchange hubs with other services, including several London Underground lines;
- interchange stations, such as Tottenham Hale and Cambridge, also serving large local populations;
- north London stations serving dense urban areas, such as Ponders End and Enfield Lock;
- large stations with a high service frequency serving key towns, such as Harlow Town and Bishop's Stortford;
- smaller stations with a more limited service frequency serving small towns or villages, such as Roydon, Sawbridgeworth and Elsenham, and;
- Stansted Airport station, which serves passengers and employees travelling to and from the airport.

[13] Two trains in the high peak hour on the Hertford East to London Liverpool Street route call at Edmonton Green and Seven Sisters, which are primarily served by London Overground services. Hackney Downs also enjoys a half hourly stop on the Hertford East service throughout the day.

Table 5 opposite shows the top five busiest stations on the WAML, by total footfall in 2019/20, and Table 6 below shows the five fastest growing stations between 2010/11 and 2019/20.

Station	Entries and exits (millions)
London Liverpool Street	65.98
Stratford	41.91
Cambridge	11.59
Tottenham Hale	9.25
Stansted Airport	8.47

Table 5 – The five busiest WAML stations, 2019/20.

Station	2010/11 entries and exits (millions)	2019/20 entries and exits (millions)	2010/11 to 2019/20 growth rate
Northumberland Park	0.18	0.72	307 %
Ponders End	0.26	0.66	156 %
Tottenham Hale	3.83	9.25	141 %
Stratford	17.48	41.91	140 %
Brimsdown	0.47	1.06	127 %

Table 6 – The five stations with the highest growth rates over the last decade.

Notes for Tables 5 and 6:

- The tables only include those stations in the scope of the study, so they exclude London Overground stations, for example.
- All figures taken from ORR Estimates of Station Usage[14] and do not include usage estimates for London Underground or Docklands Light Railway.
- London Liverpool Street, Stratford and Cambridge serve other lines, so the figures quoted will include users on other routes.
- More than half of Northumberland Park's 307 % growth occurred between 2018/19 and 2019/20, attributed to improved service frequency following the West Anglia Capacity Enhancements scheme, as well as the opening of Tottenham Hotspur FC's new stadium nearby in April 2019.

The usage of Stansted Airport station has also more than doubled over the period, with the figures changing broadly in line with the total number of air passengers. The new stations of Lea Bridge and Cambridge North have both seen high growth since their opening years, with 63 % and 94 % growth respectively.

The figures quoted above in Tables 5 and 6 are the total entries and exits from all National Rail services, not just WAML trains in the scope of this study. High level analysis of station usage shows that approximately 20 % of users at London Liverpool Street, 4.5 % of users at Stratford and 13.5 % of users at Cambridge were passengers making trips on the WAML (excluding London Overground), highlighting the interchange roles these stations play in serving multiple routes.

Over the last decade most stations on the route have recorded strong growth rates in the numbers of users, especially in north London, where footfall has more than doubled at many stations (albeit from a relatively low base at some). The train service at these stations has often remained the same despite these increases.

Usage at stations in the middle and northern parts of the route have grown at a slower rate, generally between 20 and 50 %, although the station registering the lowest rate of growth – Roydon – was still 18 %. Only two

[14] https://dataportal.orr.gov.uk/statistics/usage/estimates-of-station-usage/

stations registered declines in the period – Great Chesterford and Newport – with 5% and 11% reductions respectively. These two stations are two of the lowest used stations on the corridor, so the real terms decline in passengers was small; approximately 6,000 at Great Chesterford and 25,000 at Newport. The reasons for these declines are not immediately obvious, however the adjacent stations of Audley End and Whittlesford Parkway (both of which recorded strong growth in the period) both have large car parks and a more frequent train service to both London Liverpool Street and Cambridge, which could have encouraged drivers from these stations where train service and car parking is more limited.

The high rates of growth on the corridor have led to growing pedestrian capacity pressures at several key stations along the corridor. The stations most likely in need of future investment to accommodate passenger numbers and facilitate safe and efficient passenger movements throughout the stations are:

London Liverpool Street (2019/20 National Rail footfall – 65.9m; 2019 LU footfall – 67.2m)

Being the City of London terminus of both the WAML and the GEML, as well as being an interchange with London Underground's Central, Circle, Hammersmith & City and Metropolitan Lines and 14 London bus routes makes this the busiest station in Network Rail's Eastern Region and the third busiest nationally. The four Underground lines makes it London Underground's sixth busiest station. The future addition of Elizabeth Line services to/from west London, including Heathrow Airport, and south-east London and Canary Wharf using new subsurface platforms will increase the potential interchange opportunities. A subsurface link to Moorgate will also create a new direct link to London Underground's Northern Line and national rail services to Hertford North and Stevenage.

Short-term improvements to the station are currently being assessed, mostly focussed on the gatelines with the aim of speeding up the exiting of platforms in the morning peak. See 3.10.1 below for more details on these proposals.

Cambridge

(2019/20 National Rail footfall – 11.6m)

Cambridge station is the WAML's third busiest station in terms of entries and exits. Assessments carried out and summarised in Network Rail's Cambridgeshire Corridor Study, published in 2019,[15] indicate that the station's main through platform, which also acts as access to its six other platforms, regularly experiences congestion, particularly in peak hours. The expected arrival of East West Rail (see 3.10.3 below for details) will necessitate additional platforms and improved access, most likely with an additional platform interchange towards the south end of the station. Access from the east side of the railway has also been highlighted as a potential solution to improve access from that side of the city and reduce numbers of passengers at the existing single entrance. Growth since 2010 has been strong, with 3.5m more users per year (an increase of 41 %), despite the opening of nearby Cambridge North station in 2017.

Tottenham Hale

(2019/20 National Rail footfall – 9.2m; 2019 LU footfall – 14.0m)

Tottenham Hale is an important interchange with the London Underground Victoria Line, providing passengers with an alternative route to central and south-west London to travelling via London Liverpool Street. Growth in National Rail entries and exits has increased by 5.4m (141 %) between 2010/11 and 2019/20, with 5.8m more users on the Underground in the same period. The station is of particular importance for the Stansted Express, with all four trains per hour stopping here throughout the day.

A new platform and accessible bridge were installed by Network Rail in 2018 as part of the wider West Anglia Capacity Enhancement scheme (see 3.8.4 below for more details). TfL is currently enlarging the station entrance building, which will provide much improved access between main line and London Underground services. The delivery of Crossrail 2 is expected to necessitate a further redevelopment of the station.

[15] https://cdn.networkrail.co.uk/wp-content/uploads/2016/12/Cambridgeshire-Corridor-Study-2019.pdf

Stratford (2019/20 National Rail footfall – 41.9m; 2019 LU footfall – 64.8m; 2016 DLR footfall – 19.7m)

The number of WAML services which terminate at Stratford is limited, so the majority of Stratford's high footfall and rapid growth over the last decade is generated by passengers using GEML or London Overground services on the North London Line. The station is a key interchange hub providing access to the Central and Jubilee Lines, TfL Rail (to become the Elizabeth Line), London Overground, two DLR routes and other national rail services on the GEML. The station is also an interchange with two bus stations, with 18 routes between them. The rapid regeneration of the area, beginning with the Jubilee Line extension, delivery of HS1, then accelerated by the London 2012 Olympic Games, has led to high demand growth on both National Rail and TfL services. Entries and exits estimated for National Rail services and London Underground services grew by 24.4m (140%) and 35.0m (117%) respectively over the period 2010-2019. This growth is expected to continue, driven by continued residential, commercial and leisure developments in the area.

Like London Liverpool Street, development work is ongoing to establish a phased investment strategy, primarily focussed on future pedestrian capacity needs (see 3.10.2 below for further details). The expected development of the Lea Valley, for example around Meridian Water station, is expected to increase the demand for rail services to Stratford from the WAML alongside wider rail growth from Crossrail and the Great Eastern Main Line.

The above four stations have been recognised as having pedestrian capacity challenges which are likely to worsen as demand (including from other interfacing lines, such as the GEML and future East West Rail) increases. Although other stations have experienced high growth over the last decade, such as Stansted Airport and several north London stations, these are not identified as having any capacity enhancement needs, nor do any of the major town centre stations, such as Bishop's Stortford or Harlow Town.

Stansted Airport station is an important terminus in the middle of the route, with the 4tph Stansted Express from London Liverpool Street terminating here as well as 2tph from the Cambridge direction. The station has three platforms of varying lengths, with platform 2 much shorter and only able to accommodate the shorter trains to/from the north. This lack of platforming flexibility at Stansted Airport is noted, and would need to be addressed if higher train frequency to the airport was aspired.

3.7 Performance

The traditional method of presenting train punctuality is the Public Performance Measure (PPM), which shows the percentage of trains which arrive at their scheduled destination within five or ten minutes of their planned arrival time, depending on service type. Performance reporting is currently being overhauled to be more representative of a train's full journey, recording punctuality at every station call. As this is a new method of reporting, it is not possible to track historical trends, and PPM must be relied upon for this.

Greater Anglia's PPM target is currently to ensure at least 88.8 % of trains arrive at their destination within five minutes of their scheduled arrival time. Network Rail data shows that since 2010 performance on the WAML has been relatively steady, averaging around 90-92 %, as shown by the grey line in Figure 8 below. This shows the annual average of all WAML service groups, including London Overground, over the period 2010-2019. The grey line shows the daily percentage, with the shades of blue indicating the levels of performance in the peak and off-peak periods.

The data shows that in the off-peak period, when fewer trains and passengers are using the network, performance is consistently better than either the AM or PM peak, sometimes by as much as 5 %.

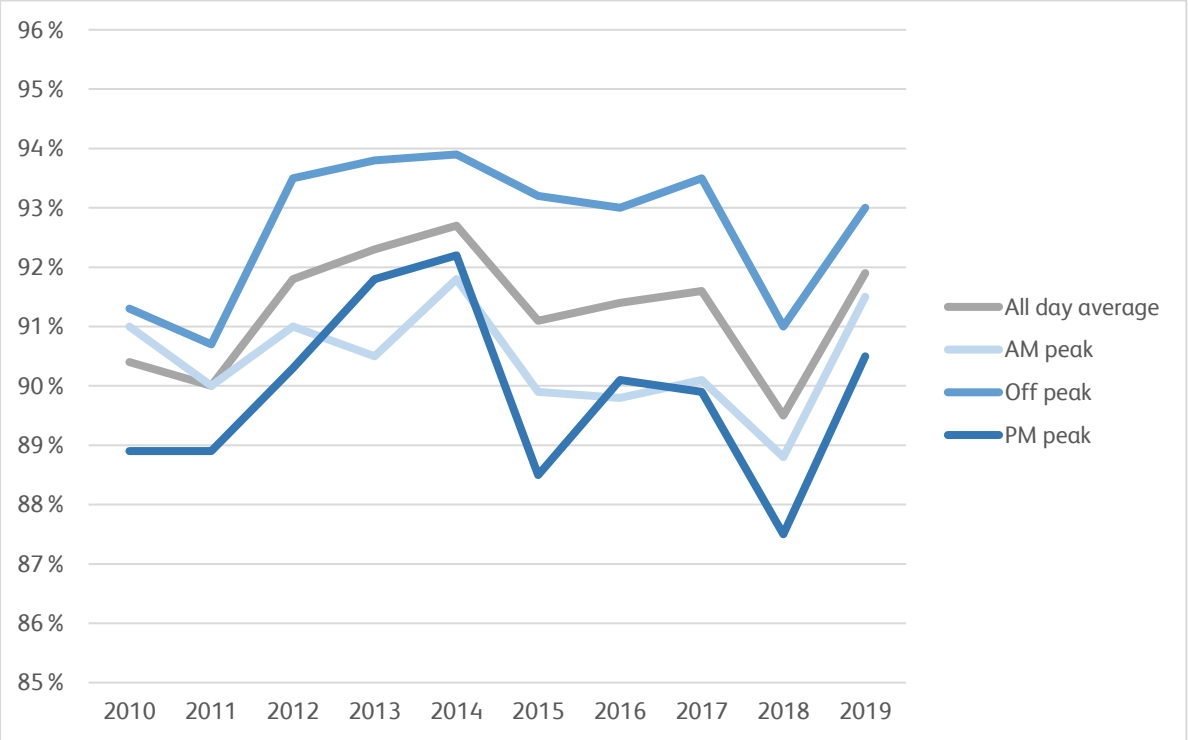


Figure 8 – The off-peak annual PPM averages are consistently better than either of the peaks.

When the average PPM figures are interrogated in more detail and broken down by service group, disparities begin to emerge. Figure 9 below shows a comparison of the annual average PPM between the short and longer-distance WAML routes.

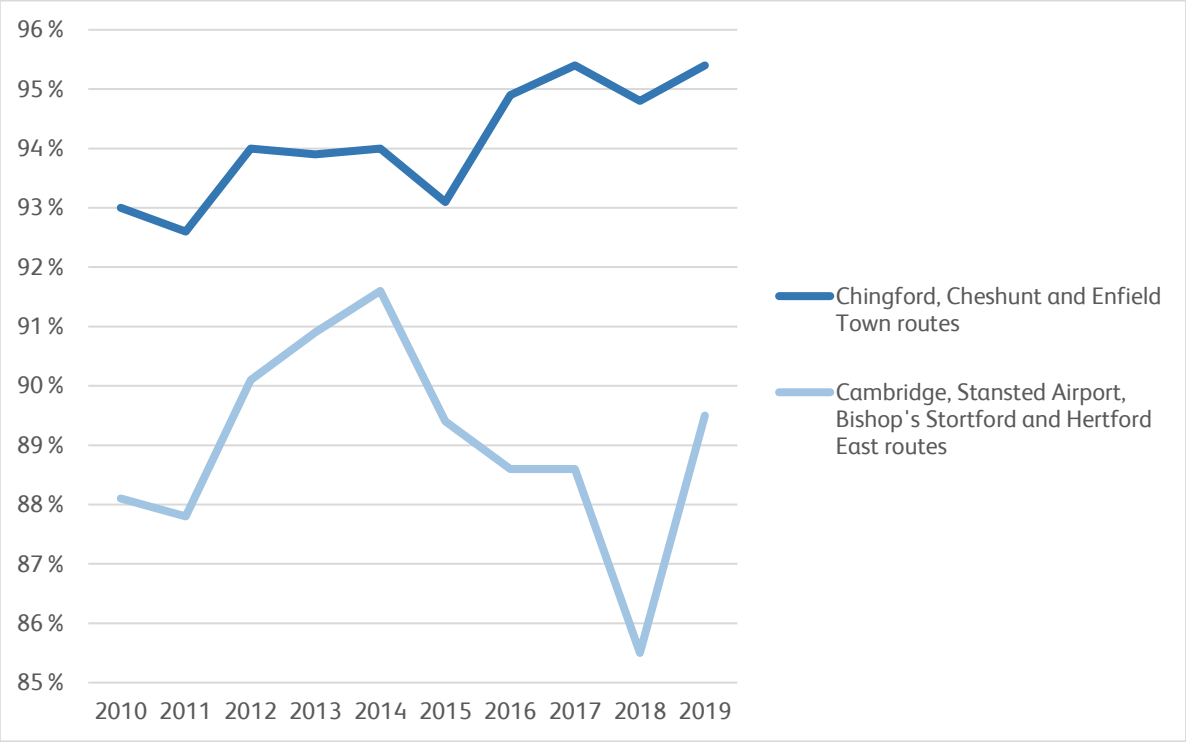


Figure 9 – Analysis of PPM data shows the short-distance services consistently outperform longer-distance services by an increasing margin.

The annual average PPM illustrated above shows large differences between PPM achieved over the last decade between the London Overground routes to Enfield Town, Cheshunt and Chingford,[16] and the longer-distance services to Hertford East, Bishop's Stortford, Stansted Airport and Cambridge. While performance for the London Overground routes has improved over the last decade, reaching averages above 95 % in recent years, performance of the longer-distance Greater Anglia services has been declining from a peak in 2014, although in 2019 a significant improvement was observed.

While this performance situation of the short-distance services outperforming the longer-distance ones is not unique to the WAML, this further highlights the challenges of operating multiple long-distance services on a two-track railway with constrained infrastructure at either end of the route. Adding more services in peak or off-peak hours without corresponding capacity improvements is likely to cause performance to decline.

3.8 Recent and ongoing rail improvements

Since the 2016 Anglia Route Study was published, some significant improvements have been made to the WAML, which are listed below in chronological order of delivery.

[16] Operated by Greater Anglia until May 2015.

3.8.1 Lea Bridge station

Lea Bridge station in the London Borough of Waltham Forest reopened in May 2016 after a 31 year closure, providing improved public transport connectivity for local communities to the nearby hubs of Stratford to the south and Tottenham Hale to the north. Before the station reopened the area was poorly supported by public transport except for indirect bus connections. Usage has increased from 315,000 in 2016/17 to 512,000 in 2019/20.[17]

3.8.2 Cambridge North station

In May 2017 Cambridge North station opened, situated between Cambridge and Waterbeach stations in the suburb of Chesterton close to Cambridge Science Park, offering an alternative to the city centre station and an interchange with the Cambridgeshire Guided Busway. The first three years of operations have shown strong passenger growth, with 949,000 entries and exits in 2019/20; 94% more than 2017/18.[18] Further growth is likely to be facilitated by the development of offices and housing on adjacent Network Rail land.

[17] ORR Estimates of Station Usage. Note, the 2017/18 figure is only for the 11 months May-March.
[18] ORR Estimates of Station Usage. Note, the 2017/18 figure is only for the 11 months May-March.

3.8.3 Meridian Water station

In June 2019 Meridian Water station opened, replacing the nearby Angel Road station. The station was funded by the London Borough of Enfield ahead of a major regeneration of the surrounding area. The bridge over the railway also acts as a public thoroughfare between the established communities to the west and the existing industrial and retail areas to the east. The station served 137,000 users in 2019/20.[19]

3.8.4 West Anglia Capacity Enhancements

The West Anglia Capacity Enhancements scheme (also known as the Stratford-Angel Road 'STAR' scheme) was completed in September 2019, constructing a third track (known as the Lea Valley reversible) between Lea Bridge and the new Meridian Water station, along with third platforms at Tottenham Hale and Northumberland Park. The third track allowed for an improved service to Stratford from Meridian Water, Northumberland Park, Tottenham Hale and Lea Bridge. Northumberland Park and Tottenham Hale stations were also made step-free by this programme.

3.8.5 Greater Anglia and London Overground fleet replacements

Greater Anglia is currently introducing a full new fleet of high density, high quality rolling stock across its network. On the WAML, Greater Anglia is replacing its Class 317 and 379 units currently in operation. This will consist of two train types; Class 745s (pictured opposite) for Stansted Airport services and Class 720s for all other routes. The Class 745s are now in operation and the Class 720 fleet is currently undergoing testing and beginning deployment. The full Class 720 fleet is expected to be complete by mid-2022.

One of Greater Anglia's new Class 745 trains at London Liverpool Street.

[19] ORR Estimates of Station Usage. Note, the 2019/20 figure is only for the 10 months June-March

TfL has also carried out a whole fleet replacement on its West Anglia routes, introducing new high capacity Class 710 rolling stock on the London Overground routes to Chingford, Cheshunt and Enfield Town. These new trains have provided a much-needed capacity improvement on these suburban routes, expected to provide sufficient capacity into the 2040s. The full fleet rollout, replacing its Class 315 and 317 units, was completed in October 2020.

One of London Overground's new Class 710s.

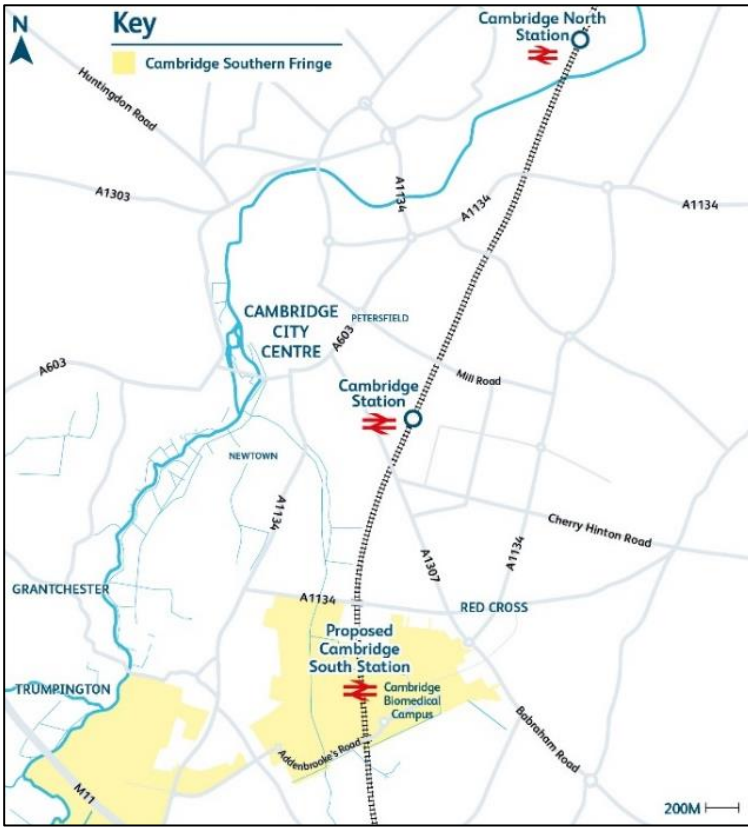
3.9 Committed schemes and rail improvements

In addition to the recent and ongoing enhancements mentioned above, there are a number of rail and non-rail schemes committed for delivery which will either improve the railway itself, or introduce more passengers to the railway, through housing and regeneration proposals, for example.

3.9.1 Cambridge South station

Cambridge South station (previously referred to as Addenbrookes) will be situated on the West Anglia Main Line between Cambridge station and Shepreth Branch Junction.

Development work is currently ongoing and the scheme has been committed to delivery as part of Government's March 2020 budget. The development of the scheme has demonstrated it will require four platforms and an extent of four tracks between Cambridge South and Cambridge station to ensure the station location and layout will not impair the existing and future timetable proposals. The station is expected to be completed by 2025. Further details can be found on Network Rail's website.[20]



[20] https://www.networkrail.co.uk/running-the-railway/our-routes/anglia/cambridge-south-station/

3.9.2 Meridian Water development and service improvements

Meridian Water is a major regeneration programme led by the London Borough of Enfield. 10,000 homes and thousands of jobs are to be created as part of the proposal. Construction of the first homes is already underway, and is expected to phased over the next 20 years. The development follows the delivery of Meridian Water station and subsequent train service improvements in 2019.

To support the new housing, further improvements to the train service are proposed. The Lea Valley Rail Programme Phase 2 being developed by the London Borough of Enfield is identifying methodologies (through physical infrastructure works and timetable changes) to increase the service frequency to the new Meridian Water Station. The works will be funded by the Housing Infrastructure Fund (subject to relevant conditions being met). A frequency of at least 4tph throughout the day is aspired.
This study will also test the infrastructure proposed by this programme in the context of wider WAML requirements and aspirations.

3.10 Uncommitted schemes and aspirations

As well as the committed schemes listed above, there are a number of proposed rail enhancements and non-rail schemes, which may impact upon the level of demand and types of train services required on the WAML should they proceed.

3.10.1 London Liverpool Street station improvements

London Liverpool Street last had a major upgrade in the 1980s when the concourse was enlarged and platforms were extended. Rising passenger numbers means that the station is now experiencing passenger congestion issues, and further improvements are required.

Options to improve the pedestrian capacity and customer experience at the station have been developed. These would speed up platform clearance times and provide more space for passengers to pass through the concourse and wait for departures.

Longer-term aspirations, involving adjacent commercial landowners, seek to implement a more significant station improvement to enhance station entrances and platform access alongside new commercial developments. This scheme is not currently in active development but could involve a combination of;

- more entrances;
- more platforms;
- enlarged concourse sizes;
- more entry points to platforms, and;
- more lifts, improving accessibility.

3.10.2 Stratford station improvements

A phased investment programme is also being developed with similar overall aims of improving circulation space and user experience at Stratford station.

The catalyst of the 2012 London Olympic Games has meant that over the last decade, rapid redevelopment of the local area has increased passenger demand at the station from both increased numbers of nearby residents using it as their local station, and as a destination station for passengers from further afield. As a result, the station does not conform to the norms of many other busy stations. Its flows are not overwhelmingly one-way in either peak, as is generally the case with central London stations. And unusually, Stratford's evening peak is busier than its morning peak, due to the mixture of commuters (either arriving, departing or interchanging at the station) and leisure passengers going to or from the nearby shopping centre and Olympic Park. Weekends are also busy due to the nearby shopping and leisure destinations.

Even before the Olympics, the service offering was changing, with the Jubilee Line starting in 1999, and the historic North London Line to North Woolwich being reconfigured and divided between the London Overground and Docklands Light Railway (DLR) between 2009 and 2011. On top of established services on the GEML and the Central Line, these connections have made Stratford an extremely important interchange hub.

In the short-term it is proposed to improve pedestrian capacity with small targeted projects to remove bottlenecks and provide more space on platforms. In the long-term a much more significant intervention is needed to provide;

- enlarged entrances and gatelines;
- more entrances, and;
- better interchange between all platforms.

3.10.3 East West Rail Central Section

East West Rail (EWR) is a major project to establish a strategic railway connecting East Anglia with central, southern and western England. In February 2020 a Transport and Works Act Order was issued for the Western Section, allowing works to begin to re-introduce passenger and freight services between Bedford and Oxford, Milton Keynes Central and Aylesbury by the end of 2023.

There is currently little infrastructure on the proposed route for the Central Section, linking the Western Section with East Anglia between Bedford and Cambridge. Following a public consultation, the preferred corridor for the Central Section was announced in February 2020. Figure 10 below shows the preferred route corridor. Delivery of the Central Section is expected to commence in 2025, pending successful business case progression.

The Central Section of the EWR route will connect into the Thameslink branch via Royston between Foxton and the

junction with the WAML, with trains approaching Cambridge from the south. The existing track and signalling infrastructure, as well as Cambridge station, will need to be upgraded to accommodate EWR services.

Ongoing work by Network Rail and the East West Rail Company will determine the extent of work required. Further eastward extension of EWR services to Ipswich via Bury St Edmunds and Norwich via Ely and Thetford will be subject to separate successful business cases.

The delivery of EWR's Central Section will transform rail connectivity to and from the Cambridge area, opening up more direct and faster connections with the midlands, without the need to travel via London. More information on the project can be found on the EWR website.[21]

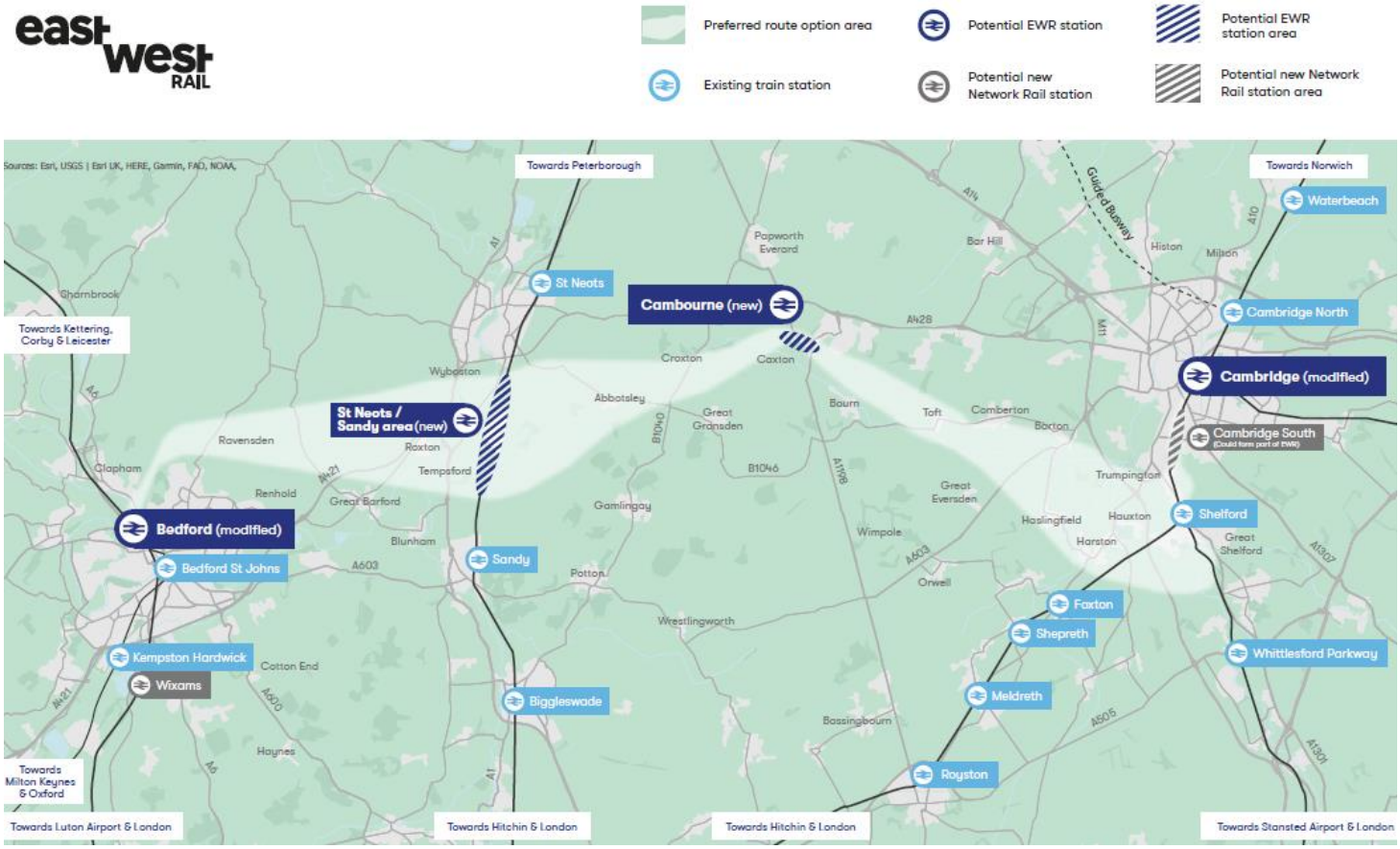


Figure 10 – The proposed route of EWR's Central Section via St. Neots/Sandy and Cambourne, announced in February 2020.

[21] https://eastwestrail.co.uk/. A full high resolution image of the plan can also be found on the EWR website.

3.10.4 New station proposals

Several proposals for new stations have been included in recent Local Plans.

Broxbourne Borough Council has proposed two new stations in its 2018-2033 Local Plan. The first is in Turnford, between Cheshunt and Broxbourne, and the second is Park Plaza in Waltham Cross, south of Theobalds Grove station on the Southbury Loop of the London Overground.

The London Borough of Waltham Forest has promoted the idea of a station at Ruckholt Road, between Lea Bridge and Stratford stations, in its Draft 2020-2035 Local Plan.

A proposal for a new station at Sawston, between Whittlesford Parkway and Shelford, has recently been submitted under the Government's Restoring Your Railways scheme.[22] A much more significant proposal to reopen the branch line from Cambridge to Haverhill has also been proposed.

These proposed railway improvements are intended to support established communities which currently lack a nearby rail connection and/or support further local growth and development potential. Careful consideration would need to be given by promotors as to how additional station calls and/or additional services at these stations would affect journey times and capacity along the WAML, especially when these are known key issues. New stations and railway branch proposals should also be evaluated against other transport options to establish the optimal solution, which may not always be heavy rail.

3.10.5 Ely Area Capacity Enhancements

Although located outside of the scope of this study, the Ely Area Capacity Enhancements will increase the capacity of the railway through Ely station and Ely North Junction. This part of the rail network is critical for freight movements between the Port of Felixstowe and the Midlands, as well as inter-regional, inter-city and local passenger services. The improvements in this area are also expected to provide additional train paths for passenger trains to Cambridge via Ely alongside performance gains.

Further details can be found on Network Rail's website.[23]

[22] https://www.gov.uk/government/publications/re-opening-beeching-era-lines-and-stations/re-opening-beeching-era-lines-and-stations
[23] https://www.networkrail.co.uk/running-the-railway/our-routes/anglia/ely-area-capacity-enhancement-scheme/

3.10.6 Harlow and Gilston Garden Town

The Harlow and Gilston Garden Town is a proposed development of 16,500 homes, as well as associated community assets across four separate areas around Harlow. The largest of these areas, Gilston, is itself made up of seven individual villages and is expected to accommodate 10,000 homes to the north of the town, close to Harlow Town station. The station is proposed to be enhanced with an additional entrance to provide improved access to the north. Proposals for these communities are at various stages of the planning process, and, if approved, are expected to be built from 2022 over a period of at least 10 years.

3.10.7 Madison Square Garden, Stratford

A 21,500 capacity entertainment venue, known as the MSG Sphere is proposed to be located adjacent to Stratford station. The venue would be centred around an auditorium for live events, but would also house a nightclub, retail and bars & restaurants. Set to be on the doorstep of Stratford station, it is expected to increase demand at the station, particularly either side of scheduled auditorium events.

Network Rail, TfL and train operators are currently working with MSG to ensure that station operations would not be adversely affected if the project goes ahead. Investment in the station as part of the MSG project is expected to include a new station entrance/exit to accommodate additional rail demand generated by the venue.

3.11 Previous studies and development

The last major study of the WAML took place in 2015/2016, as part of the Anglia Route Study. The Route Study recommended Crossrail 2 as the end state configuration, as well as a number of intermediate options to accommodate growth, improve connectivity and speed up journey times, some of which will be reconsidered and updated by this study.

3.11.1 2016 Anglia Route Study

Short- and medium-term proposals to improve the train service on the route proposed by Network Rail's 2016 Anglia Route Study included improving line speeds and lengthening trains. Doubling of the tunnel to Stansted Airport, highlighted above as one of the corridor's key constraints, was also highlighted as a barrier to improved connectivity and journey times to the airport. This study will reassess the viability of these opportunities, in conjunction with other options, such as passing loops and signalling upgrades. Full details of all the options considered and their suitability are set out in section 6.

3.11.2 Explored Crossrail 2 alternatives

The delivery of the Crossrail 2 programme remains the rail industry's target end state network configuration, which will cater for growing demand, deliver enhanced frequency and faster long-distance journey times, as well as enable housing growth along the corridor, particularly along the Lea Valley in north London.

It is, however, accepted that other improvements may be required sooner to deliver required capacity and meet stakeholder aspirations. The Crossrail 2 development team and the 2016 Anglia Route Study previously assessed whether alternative options for increasing capacity and improving journey times on the WAML exist without providing tunnels through central London.

The options assessed included constructing one or two additional tracks from Broxbourne to either Tottenham Hale or Bethnal Green. While this would be possible and could deliver an improvement in journey times and provide an improvement in frequency, without another destination to terminate trains no uplift in capacity would be possible, severely devaluing the business case of additional infrastructure without Crossrail 2's cross-London connectivity. All the options assessed to provide additional tracks without cross-London connectivity have severe feasibility issues, including;

1. Construction of additional tracks south of Tottenham Hale above ground will be extremely disruptive, requiring the acquisition and demolition of hundreds of residential, commercial and industrial properties. Dozens of structures, such as road bridges, would also be affected.
2. Platform usage at London Liverpool Street is highly utilised during peak hours. More platforms would be required to accommodate additional trains and maintain high levels of performance. Two possible places to provide more platforms have been identified; next to platform 1 or between platforms 10 and 11. Both options are deemed extremely challenging due to the level of impact on adjacent property and station operations. New platforms would also require modification or total remodelling of the throat of the station, which is challenging in itself as tracks must avoid structural supports of high-rise buildings.
3. Similarly, space to terminate trains at Stratford is limited. Generally, trains from the WAML terminate in platform 11, leaving the track through platform 12 available for freight and empty coaching stock manoeuvres to and from Orient Way depot. There is no vacant Network Rail or third-party land to build additional platforms. Adjacent third-party land on the approach to the station has recently been developed for housing and the remaining land between platforms 10A and 11 is currently subject to a planning application for development as an entertainment venue, described in 3.10.7.
4. Consideration has also been given to tunnelling from the proposed Crossrail 2 tunnel portal south of Tottenham Hale station to London Liverpool Street, instead of the full Crossrail 2 scheme across central London and beyond. In this proposal, subsurface platforms directly underneath the existing trainshed would link into the existing concourse. The existence of several underground railways in this location as well as piling for high rise commercial premises around the station has resulted in this option not being progressed further.

All options have affordability issues as well as lower overall benefits than Crossrail 2. All would be extremely expensive and disruptive to deliver, both in terms of disruption to the operation of the railway and lineside neighbours, especially in the case of a pair of additional tracks elevated alongside the existing viaduct.

This study will not re-assess these options to three- or four-track the WAML in advance of Crossrail 2, as these have previously been proven as highly unlikely to deliver a robust business case. Instead, this study will identify meaningful options to provide capacity and journey time improvements in the medium-term in the context of the delivery of Crossrail 2. This means options which do not prohibit efficient delivery of Crossrail 2 will be prioritised.

3.11.3 2020 Arup West Anglia Main Line Rail Improvements Study

In January 2020, Arup published a study, commissioned by IFM Investors, shareholders in MAG, the owning group of Stansted Airport. This study identified potential WAML improvements primarily aimed at improving journey times to and from Stansted Airport. The study's principal medium-term recommendations were to increase the line speed between London Liverpool Street and Tottenham Hale and to double the single-track tunnel into Stansted Airport station.

This study will also assess line speed improvements south of Tottenham Hale along with line speed improvements north of Broxbourne. Previously, the 2016 Anglia Route Study cautioned the ability of improved line speeds to give benefits without negative impacts on calling frequency of other services, such as those in north London served by Hertford East trains, without new higher performing trains and unlocking other constraints.

This study assesses the potential for line speed improvements in this area in conjunction with other options, such as track loops, improved signalling, or doubling the tunnel to Stansted Airport

4 Study approach

The study commenced in mid-2020 with the aim of advising the most worthwhile enhancement options to allow for any increases in demand and support medium-term stakeholder aspirations of shorter journey times and increased frequency.

4.1 Strategic questions

The study has been carried out with the aim of answering the following overarching question:

What are the priority enhancements that could provide improved performance, journey times and service offering on the West Anglia Main Line prior to the delivery of Crossrail 2?

This question has been supported by six sub-questions, agreed with the study steering group before the study commenced.

SQ1: What are the current proposals to improve the capacity and journey times on the West Anglia Main Line?

SQ2: What is the expected growth in passenger and freight demand on the route over the medium-term?

SQ3: What additional passenger stops and/or services are expected to be required to meet the forecasted demand?

SQ4: What opportunities exist to improve journey times and service frequencies on the route?

SQ5: What are the likely infrastructure and technology options to improve the rail network that would support the additional stops and/or services that are expected?

SQ6: What is the most efficient phasing of options to meet the medium-term needs of the route?

These questions will be answered by the following sections of this document and will be summarised in the final section.

4.2 Methodology

As outlined above, the introduction of longer, higher capacity trains on the WAML means that any future capacity improvements will need to be provided by increasing the number of services which operate. Due to the current constraints on operating additional services, improvements to the railway infrastructure will be required to do this. Demand forecasting has been carried out to establish whether additional capacity is likely to be required prior to the delivery of Crossrail 2.

The existing timetable has been assessed to understand whether it could be assembled more efficiently, as well as determining what could be delivered by implementing one or more enhancements to the railway in order to meet any capacity needs and the aspirations of improved journey times and calling frequencies. This technical analysis was carried out using the latest version of the Timetable Planning Rules, modelled in Railsys simulation software. Figure 11 below gives an overview of the methodology employed.

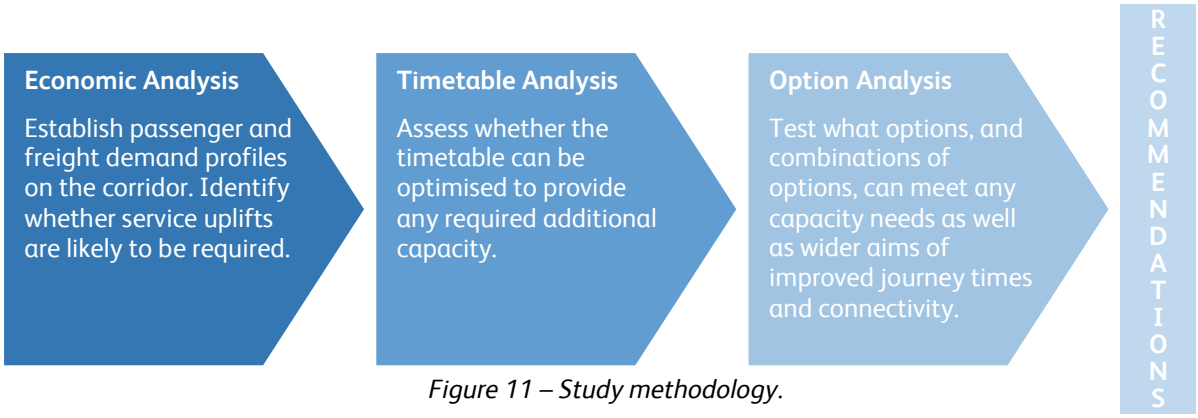


Figure 11 – Study methodology.

4.3 Governance

Network Rail has responsibility for the long-term planning of the railway and does so using a programme of studies, as explained in section 3.1. This study was proposed to and endorsed for development by the Anglia Route Investment Review Group and the Department for Transport. The study has been led by Network Rail and supported and shaped by a stakeholder steering group. Steering group membership was made up from train operators, local government, the airport operator MAG, Transport for London, the Department for Transport and the West Anglia Taskforce, itself representing the interests of local authorities, business groups and MAG. The steering group shaped the study's initial remit, agreed the scope of the strategic questions set out above and endorsed the study's overall recommendations.

Steering Group Members		
Network Rail	Transport for London	Hertfordshire County Council
Department for Transport	Rail Delivery Group	Cambridgeshire County Council
Greater Anglia	West Anglia Taskforce	London Borough of Enfield
DB Cargo	MAG (Stansted Airport)	London Borough of Haringey
GB Railfreight	Essex County Council	

5 Demand forecasts

This section outlines the expected changes in passenger and freight demand along the corridor in the medium-term. Greater Anglia's new fleet of intercity and suburban trains, due to be fully in service by mid-2022, operating as per the December 2019 timetable have been used as the baseline in determining whether shortfalls in passenger capacity exist.

National freight forecasts conducted in 2019 have been used to assess future levels of freight traffic expected on the WAML.

5.1 Context

This study commenced in summer 2020, during the onset of the Coronavirus (Covid-19) pandemic. Government advice to limit travel for work and leisure has significantly impacted the level of demand on the West Anglia Main Line, as large numbers of commuters ceased or reduced their daily travel to the line's key hubs of London and Cambridge. The fall of global business and leisure travel has reduced demand for travel to and from Stansted Airport. Passenger levels remain supressed as office workers remain either partially or wholly based at home. The train service level has at various points been reduced to reflect this fall in demand.

To some extent, the pandemic may have accelerated home working trends which have been developing in recent years. However, this trend of increased home working or flexible four-day working weeks largely effected Fridays and to a lesser extent Mondays, as people elected to make the most of flexible working arrangements increasingly being offered by employers by adding days onto their weekends. Mid-week demand levels continued to increase, as fewer people used these days for home or flexible working.

Before the start of the pandemic, in 2019, a review of the rail market forecasts for London and the south east was conducted considering the expected growth in rail passengers over the next generation (up to 2050). This was carried out to inform a Rail Strategy for London. The review suggested that, over all rail corridors into London, it is expected that passenger numbers would grow by approximately 70 %. Such an increase on an already congested railway was considered a significant long-term challenge for the industry and its funders to address.

It is possible that the pandemic will have a long-term impact on passenger demand due to behavioural changes, namely an increased number of employees choosing to work from home, which will affect the previously assessed passenger growth forecasts. However, there is a lot of uncertainty around both the short- and long-term changes in passenger behaviours and their impact on travel patterns affecting commuting, business, and leisure travel.

Current industry research looking at the impact of the pandemic on travel patterns has been used to test a number of high-level scenarios to understand the potential impact on rail demand. More detail on this will be provided in the passenger forecast section below.

Nationally, rail freight haulage has been much less impacted than passenger services, with numbers of trains running retuning to near-normal levels after a dip in volumes in spring and summer 2020.

5.2 Passenger forecast

Transport for London's Railplan model was used to forecast future southbound demand on the WAML in the high peak hour[24] across all Greater Anglia services in order to compare forecast demand with available capacity.

Northbound demand towards Cambridge, including any demand which may be generated by the delivery of East West Rail's Central Section, has not been assessed by this study as this was considered by the 2019 Cambridgeshire Corridor Study.

The likely demand generated by Cambridge South station, due to be delivered in 2025 has been included following consultation with the project development team. The forecast excludes Crossrail 2 demand and capacity as well as demand which may be generated by Greater Anglia's new rolling stock, though the assessments take into account the capacity increase these new trains provide.

To reflect the potential economic and behavioural impacts as a result of the Covid-19 pandemic, high-level industry scenarios have been tested to dampen long-term pre-pandemic forecasts as described in 5.1. The scenarios include:

- '**Covid – Low Rail Demand**': Forecast demand is reduced by approximately 35 %;
- '**Covid – Medium Rail Demand**': Forecast demand is reduced by approximately 20 %, and;
- '**Covid – High Rail Demand**': Forecast demand is reduced by approximately 5 %.

Forecast demand arriving at London Liverpool Street and Stratford in the high peak hour is expected to be between 15 % lower (based on the 'Covid – Low Rail Demand' scenario) and 26 % higher (based on the 'Covid – High Rail Demand' scenario) in 2031 when compared with 2016 levels of demand.[25]

[24] Arrivals into London Liverpool Street or Stratford between 08:00 and 08:59.
[25] Note, 2016 is used to align with the Railplan base year and Autumn 2016 count data. Growth rate calculations with a base year between 2016 and 2026 are not able to be accurately determined due to the additional Meridian Water–Stratford services being included in the timetable after the completion of the West Anglia Capacity Enhancements scheme in 2019. These additional services are not included in the 2016 base year but are in the next base year of 2026. Interpolating 2020-based growth will be misrepresented due to this mismatch.

What is Railplan?

Railplan is a Transport for London model that assigns public transport demand to various transport modes, including National Rail, London Underground, DLR, and buses. Railplan predicts the mode of public transport that passengers choose, and the routes they take on that mode. It also considers the impact of crowding in assigning passengers to services. Railplan uses input from another Transport for London model, the London Transportation Studies (LTS) model, which uses demographic, economic, transport, policy and planning information to forecast future trip numbers, origins, destinations, and use of public transport.

Both Railplan and LTS models are compliant with TAG (DfT's Transport Appraisal Guidance) and are considered more suitable for modelling peak travel on the WAML than traditional EDGE/PDFH/MOIRA method because they are stronger in the following areas particularly relevant to the WAML;

- they use planning data from the Mayor's spatial strategy for areas in Greater London, e.g. for Stratford, and planned housing developments in London Boroughs along the WAML, including Meridian Water, and;

- they can model multi-modal journeys and interchanges, such as National Rail to London Underground at Tottenham Hale and Stratford.

Outside Greater London, Railplan reverts to EDGE/PDFH/MOIRA data.

5.3 Expected train loadings

Services were classified as 'Inner' or 'Outer' to assess expected average train loadings for both the shorter distance and longer distance service groups. The services were classified as follows;

- **Inner:** services from Hertford East, Broxbourne or Meridian Water, calling in varying patterns at North London suburban stations;

- **Outer:** services from Cambridge (including the single high peak hour service which starts in King's Lynn), Stansted Airport and Bishop's Stortford, again with varying calling patterns at stations predominantly outside of London.

Future forecasted demand was allocated to future capacity[26] using calibrated passenger count data in order to assess whether any part of the WAML is expected to be over-capacity in the medium-term.

Figure 12 below shows the average seat utilisation or standing density forecast between each pair of stations in the morning high peak hour, split between the Inner and Outer service groups in 2031 using the 'Covid – High Rail Demand' scenario. Green shading shows the proportion of seats forecasted to be occupied on average, with lighter shades showing higher availability. Passengers are forecasted to be standing when pink shades appear, as per the key.

[26] The total expected capacity to be available once Greater Anglia's new fleet is fully introduced.

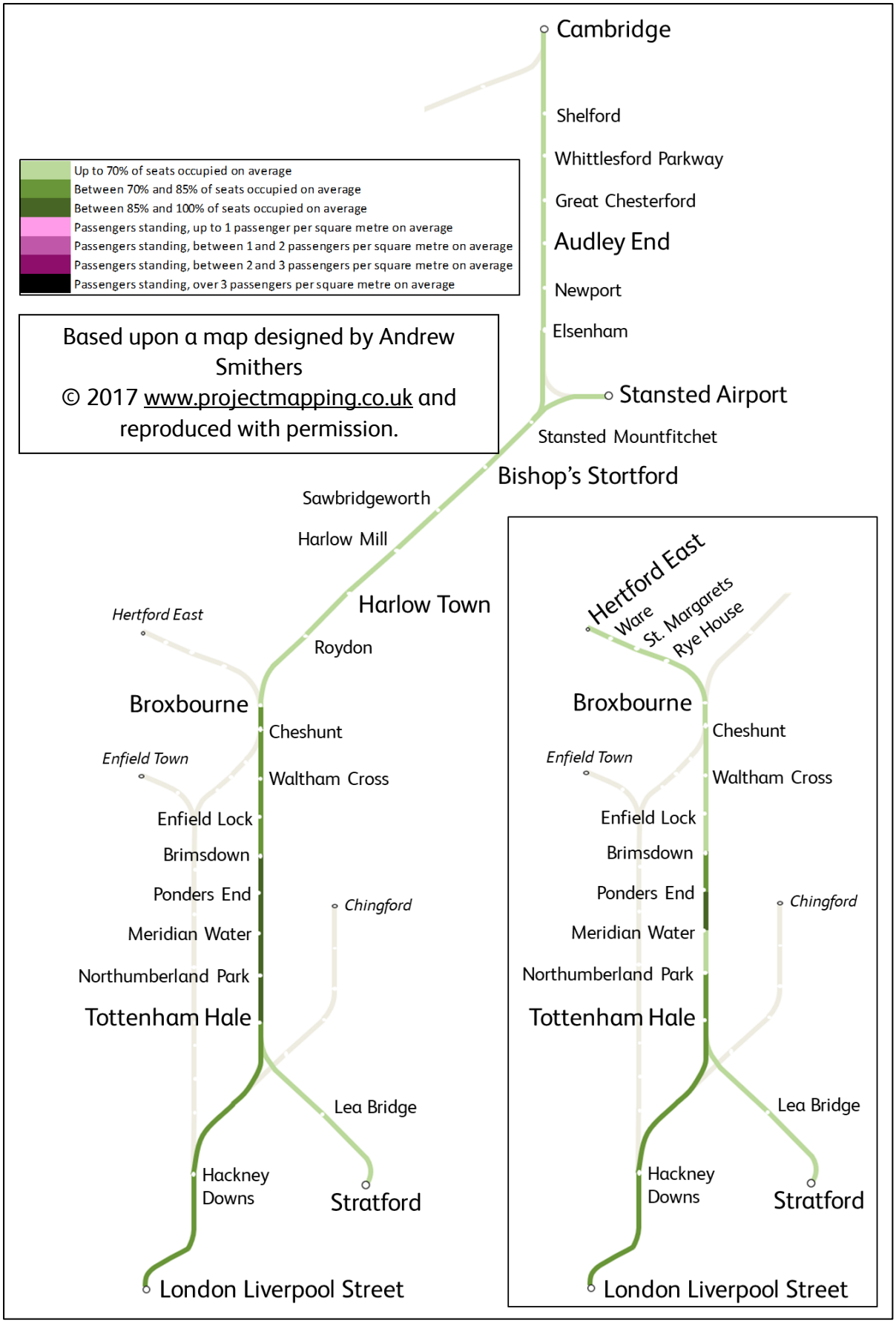


Figure 12 – Outer and Inner (inset) forecast medium-term (2031) average train utilisation ('Covid – High Rail Demand' scenario) using Greater Anglia's new fleet.

As can be seen from both heat maps, no capacity or overcrowding issues are expected in the medium-term on any part of the WAML even when applying the 'Covid – High Rail Demand' scenario, which has the lowest level of pandemic-related demand suppression of the scenarios tested. The 'Covid – Medium Rail Demand' and 'Covid – Low Rail Demand' scenarios therefore also show no crowding issues. This assessment has been carried out using assumptions for the new rolling stock.

In response to stakeholders advising the strong potential for high growth in certain areas, particularly Cambridge and Harlow, a sensitivity, 'Covid – High Rail Demand +10 % ' was also assessed to capture any aspirational demand above the 'Covid – High Rail Demand' scenario. Planned capacity is also expected to be sufficient in this scenario, with no standing passengers projected on any Outer services in the medium-term, and only limited standing up to one passenger per square metre on Inner services between Ponders End and Meridian Water.

It is important to note that these heat maps indicate average passenger loadings across the high peak hour (08:00-08:59 arrivals at London Liverpool Street or Stratford). Therefore, some trains may be busier (or quieter) than these averages suggest.

For example, average seat utilisation on the Inner services reduces south of Meridian Water due to the 2tph between Meridian Water and Stratford also being included in the model from this point. Trains passing through Meridian Water from Broxbourne or Hertford East are likely to remain, on average, busier than those entering service at Meridian Water, and perhaps busier than the heat map suggests. The heat maps also assume that passengers are spread equally throughout a train and make no allowances for whether certain sections of a train are busier than others.

5.3.1 Comparison with current/old rolling stock

Before its new fleet began to be introduced on the WAML in mid-2020, Greater Anglia operated Class 379s and two variants of Class 317, all of which are due to be replaced by mid-2022. The types of rolling stock used before the fleet renewal, their capacity, and usual routes are listed in Table 7 below.

Class	Capacity			Routes Normally Operated
	Seats	Standing	Total	
317/5 (4-car)	292	129	421	Bishop's Stortford, Hertford East, Broxbourne, Meridian Water,
317/6 (4-car)	258	116	374	Cambridge
379 (4-car)	209	136	345	Stansted Airport (limited numbers for Cambridge and King's Lynn)

Table 7 – Previous Greater Anglia fleet.

Each of these units can be operated in 4-, 8-, or 12-car formations, with the seated, standing and total capacity doubling or trebling as a result. The new Class 720 and 745 units have greater capacity than those they will replace, as detailed below in Table 8. Note, that the Class 720 units have an extra carriage than the Class 317s they are replacing, but still offer more capacity per carriage than the older 317s. The Class 745, due to serve Stansted Airport, can only be operated as a 12-car train, and again offers more capacity per carriage than the Class 379s they are replacing.

Two of Greater Anglia's Class 317 units, being phased out of service.

Class	Capacity			Routes Normally Operated
	Seats	Standing	Total	
720/5 (5-car)	544	145	689	Cambridge, King's Lynn, Bishop's Stortford, Hertford East, Broxbourne, Meridian Water
745/1 (12-car)	748	381	1129	Stansted Airport

Table 8 – New Greater Anglia fleet capacity.

The interior of one of Greater Anglia's new Class 720s, to be used on non-airport routes.

The interior of one of Greater Anglia's new Class 745 Stansted Expresses.

With assistance from Greater Anglia to determine what rolling stock would operate what services and in what formation during the high peak hour the capacity change that can be expected on each service can be estimated. With a combination of higher capacity trains and longer trains, the capacity of services in the high peak hour will increase dramatically once all new trains are in service. For conciseness, services have again been grouped into Inners and

Outers to show this. As shown below in Table 9, the total number of seats across all Greater Anglia services arriving into London Liverpool Street or Stratford in the high peak hour will increase by 71 %.

	Inner Services	Outer Services	Total
Old Rolling Stock Total Seats	4,020	4,751	8,771
New Rolling Stock Total Seats	7,072	7,888	14,960
% change	76 %	66 %	71 %

Table 9 – Fleet capacity comparison.

A slight increase in the number of standing passenger capacity means that overall capacity will increase by approximately 48 %. To test the impact that this entire fleet replacement is expected to have on the level of capacity and crowding in the medium-term, the same forecasts were applied to the old rolling stock, and are illustrated in Figure 13 for both the Inner and Outer service groups.

Old and new – a new Class 720 alongside a Class 317, being phased out.

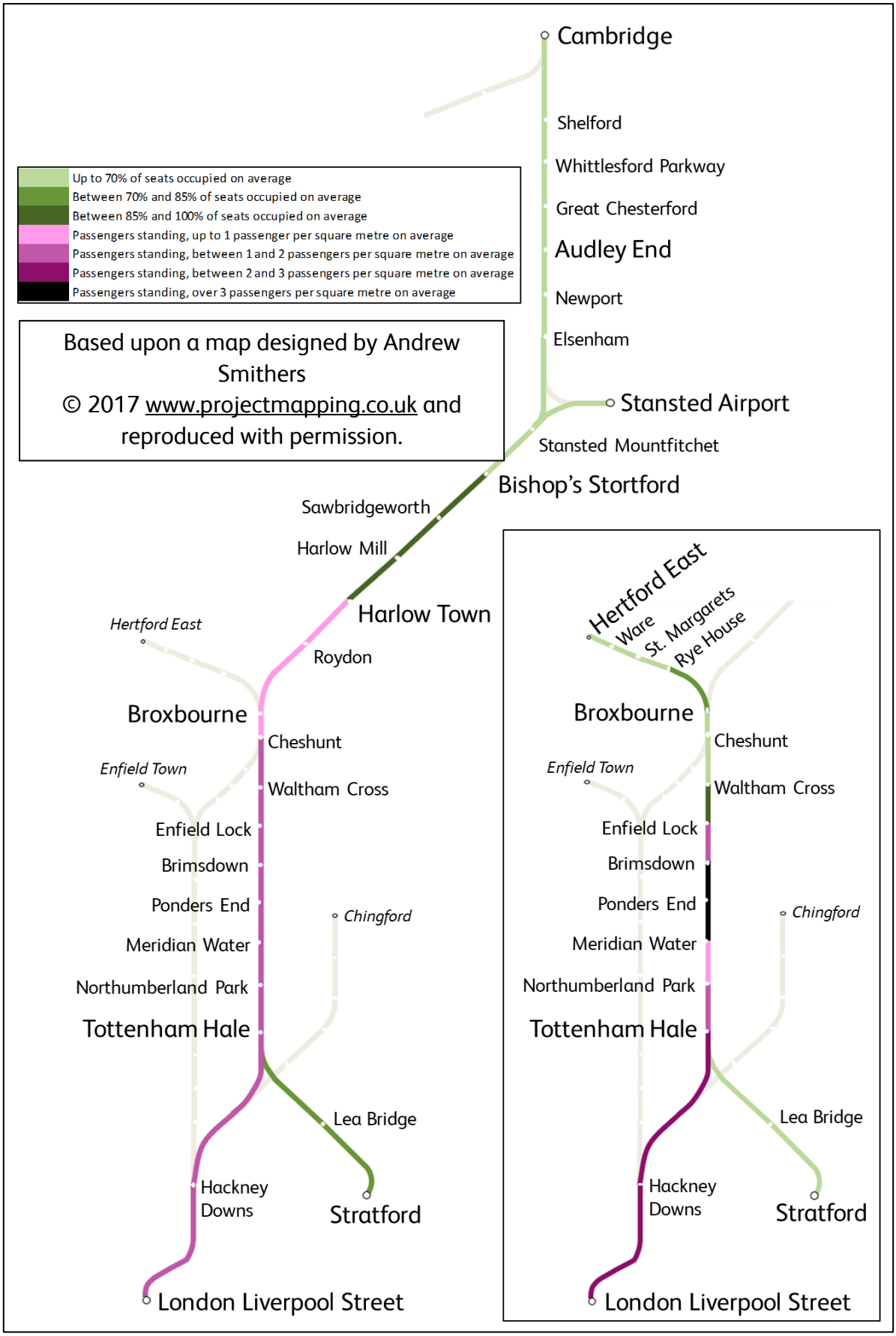


Figure 13 – Outer and Inner (inset) forecast medium-term (2031) average train utilisation ('Covid – High Rail Demand' scenario) using Greater Anglia's old fleet.

The results of this test are stark when compared with the same forecast applied to the new fleet. Without the new fleet, more capacity would be needed across all service groups to reduce the numbers of standing passengers, including from as far north as Harlow Town on Outer services and some severe crowding above three passengers per square metre on the Inner services between Brimsdown and Meridian Water.

The significant capacity increase the new rolling stock brings will benefit passengers on the WAML over the medium-term, in terms of providing a modern, spacious and comfortable travelling environment, especially if demand as a result of the Covid-19 pandemic continues to be reduced in the medium-term.

However, additional capacity does not provide any solutions to the aspirations for improved journey times or stopping frequency, and this study will therefore focus on providing suitable options to address these matters in the medium-term.

Crossrail 2 remains the overarching aim for transforming the WAML, necessary to bring about more significant improvements in journey times, frequencies and onward connectivity to central London and beyond, as well as enabling greater regeneration of local areas, especially in the Lea Valley.

5.4 Freight forecast

As established above, the WAML is not a major freight route when compared with other surrounding rail corridors, such as the GEML or the cross-country corridor via Ely, which share the distribution of rail freight to and from the Port of Felixstowe.

In 2019, Network Rail commissioned a network-wide rail freight forecast study. The study forecast tonnage of rail freight commodities for 2033/34 and 2043/44 under a range of scenarios.[27] The forecast scenarios were developed in 2018 and 2019 and therefore do not take account of Covid-19 or the Government's legal commitment to net zero greenhouse gas emissions by 2050. In addition, it is important to note that

these forecasts are unconstrained forecasts of market demand, not predictions of actual traffic volumes. The forecasts do not take account of the capacity of the network to accommodate these volumes. For the WAML, these forecast scenarios depict very little change compared to the baseline year.

[27] https://www.networkrail.co.uk/wp-content/uploads/2020/08/Rail-freight-forecasts-Scenarios-for-2033-34-and-2043-44.pdf

However, it is recognised that the market for aggregates is highly sensitive to the level of demand in the wider construction industry. Several rail infrastructure projects are set to take place in the area around Cambridge which could therefore boost demand for construction materials whilst these projects are ongoing, the most significant of which is East West Rail's Central Section.

Freight operators have also pointed out that high payload paths are not currently available throughout the day. This study will consider the possibility of securing an hourly 2600 tonne path in the off-peak hours. Higher trailing weights may require structures to be strengthened, however it is worth noting that the WAML has a published Route Availability of RA8, with RA10 (the maximum possible) available with dispensation.

5.5 Impact on stations

It is recognised that several stations along the WAML regularly experienced pedestrian crowding in the morning and evening peaks, pre-pandemic. As discussed above, passenger demand has fallen dramatically during the pandemic, but as passenger numbers are expected to rise again, these issues with crowding (as detailed more widely in 3.6) are likely to re-emerge.

5.5.1 London Liverpool Street and Stratford

As mentioned above, business cases for improvements to the busy station hubs of London Liverpool Street and Stratford are in development within the early stages of the RNEP. Successful progression of these business cases through the RNEP is critical to ensuring that these key London stations are fit for purpose for the next generation of passengers. No further analysis of either station is required by this study, as work at a more advanced stage is already taking place.

5.5.2 Cambridge

Cambridge station is the only station on the route outside of London which is recognised as regularly experiencing passenger congestion, with passenger numbers rising steadily year-on-year. The Cambridgeshire Corridor Study, published in 2019, highlighted some of these issues as well as expressing that new additional EWR trains will require enlargement of the station to accommodate all services and passengers.

Ongoing assessments are beginning to define the track and station modifications required to accommodate EWR trains, based on several potential scenarios. Depending on whether trains are intended to terminate or continue beyond Cambridge to other destinations such as Norwich and Ipswich, as well as the desired service frequency, will determine the overall scope of works required at and around Cambridge station, including how platforms will

need to be laid out, and which services will use which platforms.

Whichever service specification is taken, new platforms and enhanced access, most likely with a second platform interchange at the southern end of the station, will be needed, but the extent of this will depend the EWR service selected. Modelling of future pedestrian demand at Cambridge station is, therefore, not possible until this is known. Network Rail will continue to work with the East West Rail Company to undertake this modelling once the service specification has been decided upon. Local aspirations for a second station entrance on the east side of the station, improving accessibility from this side of the city and potentially reducing the growing pressure on the existing single station entrance should also be considered as part of this.

5.5.3 Tottenham Hale

Works have recently been carried out at Tottenham Hale station by Network Rail, as part of the West Anglia Capacity Enhancements scheme which enhanced frequency between Stratford and Meridian Water using a new third platform. A new bridge and step-free access to allow passengers to exit the platforms faster and speed up interchange was also provided. Interfacing works carried out by TfL will provide a larger entrance hall and improve access the London Underground Victoria Line. Despite these works, it is possible that further improvements may be required to cater for any increases in demand in the medium-term, in no small part due to the popularity of the connection with the Victoria Line for WAML passengers.

This study will therefore reassess the impacts of demand on Tottenham Hale station, using the updated demand forecast undertaken for this study and will advise whether improvements are likely to be required.

5.5.4 Other stations

As mentioned in 3.6 above, there is a wide variety of station types on the WAML. Network Rail has assessed available information and consulted with Greater Anglia and Stansted Airport to ascertain whether any other assessments of pedestrian flows to advise capacity-based improvements are likely to be required. It has been concluded that modelling is not required at any other stations along the route.

This does not mean that no stations require improvement to make them more accessible and user-friendly. Many of the stations on the route suffer from a lack of full step-free access, although all of the major stations now have lifts, since Tottenham Hale was equipped with these in 2019. It is recommended that Greater Anglia and local authorities bid for stations enhancements funding, such as Access for All funding, as and when this becomes available in order to improve stations, on a priority basis.

6 Meeting the medium-term needs

As established above, there is no requirement to improve capacity in the medium-term to cater for increasing levels of passenger demand. Any rises in demand are expected to be accommodated by the new train fleet.

This section describes the options which have been selected to undergo timetable feasibility testing, and how effective they are likely to be in delivering an improvement to one or more of the aspirations for improved passenger or freight services, which are;

- faster journey times between London and Stansted Airport/Cambridge;
- more station calls for suburban north London stations;
- faster and higher payload freight paths, and;
- improved performance for all services.

6.1 Identified improvement options

As explained above, it is not deemed possible to make small timetable tweaks and deliver meaningful train service improvements. The timetable is finely balanced between delivering station calls and reasonable journey times (and therefore does not meet all aspirations). Without improvements to the railway infrastructure, adding in station calls will slow some trains down, including the Stansted Express, and the desire to speed up journeys requires removal of some station calls, potentially leaving some stations in north London with just 1tph.

Network Rail identified four broad option areas which have the potential to deliver one or more of these aspirations on the WAML. This section explains these proposals and gives an indication of what benefits they are expected to be able to deliver, including the key benefits and issues, and a likely cost range.[28]

Each of the options below were assessed using Railsys timetable modelling software to determine their suitability in meeting the medium-term aspirations for the route, primarily for off-peak hours. Section 6.2 will consider combining and sequencing these options to optimise benefits and will set out how they could be applied in peak hours.

6.1.1 Option group 1 – line speed improvements

Most of the WAML has a maximum permitted speed of between 70 and 80mph, with some limited sections of 90mph track. Areas of relatively low line speed are indicated on Figure 14 below.

[28] Note, these proposed schemes have not been formally cost estimated by this study. A likely Low (£0-20m), Medium (£21-99m) or High (£100m+) cost range is shown based on similar schemes where possible. More detailed cost estimates will be undertaken when schemes enter further development.

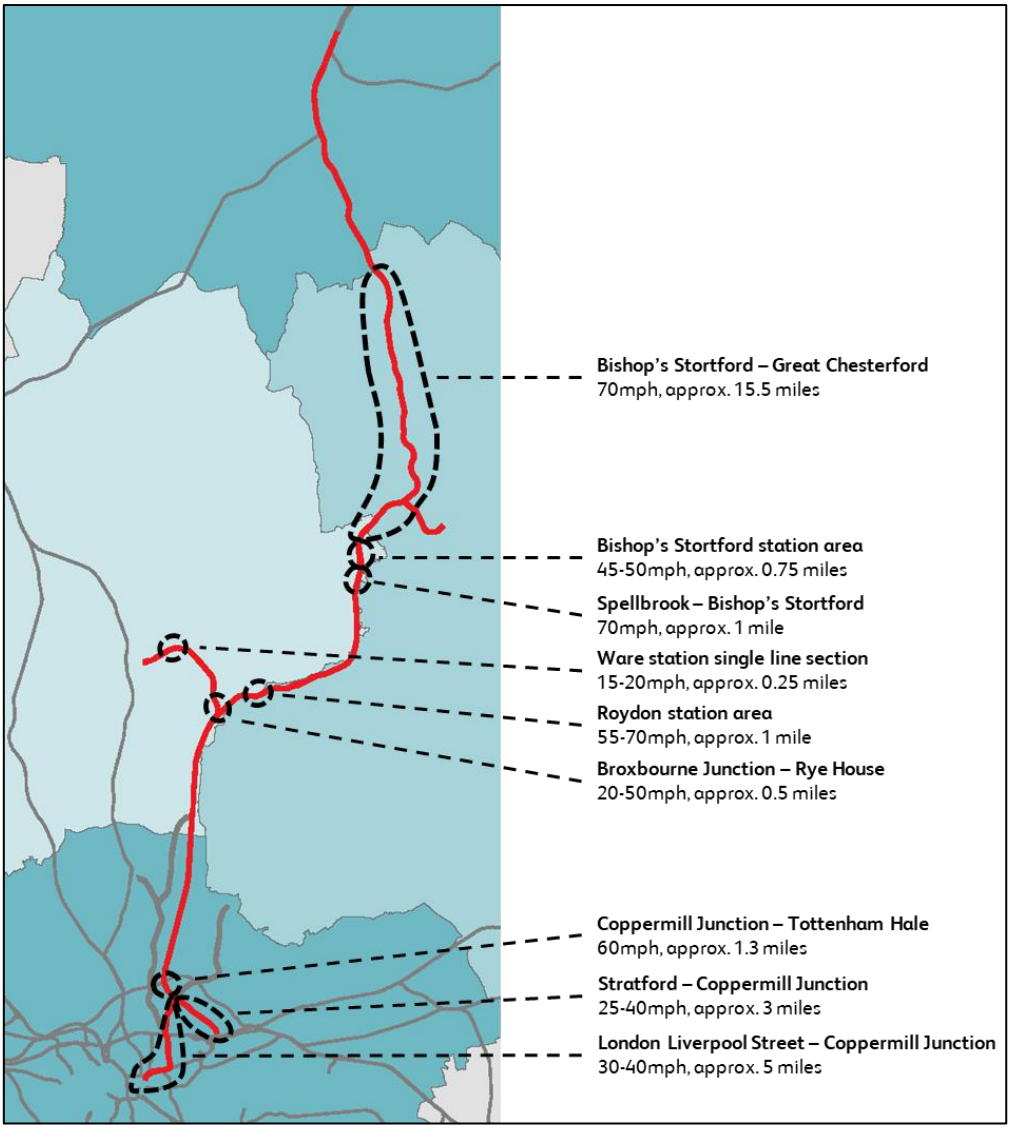


Figure 14 – Areas of relatively low line speed along the route.

Analysis undertaken for the 2016 Anglia Route Study established that improvements to line speeds up to 100mph could theoretically improve journey times between London and Cambridge/Stansted Airport. However, it was concluded that few services could benefit as faster permitted speeds would likely mean that faster trains simply catch up with slower trains more quickly. This is caused by a lack of overtaking places south of Broxbourne and fixed constraints at the ends of the routes, for example the single-track tunnel into Stansted Airport and the need to align timetables with services on other routes around Cambridge and London.

Line speed improvements could feasibly form part of a series of improvements if other constraints are resolved. This opportunity, including assessments of other areas of potential line speed improvement not included in previous work has been assessed by this study.

Medium-term line speed improvement recommendations

Recommendation 1: Line speed improvements south of Tottenham Hale
Recommendation 2: Line speed improvements north of Cheshunt

Out of the areas of low line speed indicated above, several geographic areas of potential line speed improvements, to be delivered in two stages, have been identified:

1. Stage 1 improvements between Bethnal Green North Junction and Coppermill Junction, with the maximum permissible speed raised to 50mph.

2. Stage 2 improvements in various sections north of Cheshunt, raised up to 100mph (exact appropriate speeds to be determined), combined to give an overall journey time improvement:
    - Spellbrook to Bishop's Stortford
    - Elsenham to Newport
    - Audley End to Great Chesterford

Increasing speeds on the section between Bethnal Green North Junction and Coppermill Junction up to 50mph would benefit all WAML trains (plus London Overground trains to/from Chingford) and could speed up all journeys on this section by up to 1 minute 30 seconds.

The second area will not be of benefit until other enhancements to build more capacity into the WAML have been made, but speed improvements here could deliver journey time improvements of around 1 minute to services to/from Stansted Airport and 2 minutes to/from Cambridge once these works have been carried out. Details of recommended sequencing are set out in section 6.2 below.

Further investigations need to be carried out to determine whether these line speed improvements would be viable from an engineering perspective.

Line speed improvements in the intensively used area between Tottenham Hale and Cheshunt are not likely to be beneficial due to the mix of services which use this section.

In addition to longer sections of plain line improvements, increasing line speeds at junctions, while not major enough to be able to offer significantly faster journey times, are likely to be able to improve performance. With trains able to clear junctions quicker, they will be less likely to delay other trains if they are running late. These smaller improvements are best targeted to take place at the same time as planned renewals for cost efficiency.

Broxbourne Junction has been identified as the location most likely to benefit from such an improvement and is planned to be renewed in the next funding period, CP7 (2024-2029). The speed across the junction is only 20mph, however the main line here has a speed of 85/90mph. Trains must, therefore, undertake a significant amount of braking on the main line in order to cross the junction at 20mph.

Short-term line speed improvement recommendations

Recommendation 3: Increase line speed at Broxbourne Junction

It is recommended that the feasibility of renewing Broxbourne Junction with a higher line speed is undertaken to assess whether an enhancement can take place in line with the planned renewal.

Option group 1 – Line speed improvements		
Benefits	**Issues**	**Cost Estimates**
• Small improvement to journey times for all services. • Improved performance.	• Line speeds north of Tottenham Hale not beneficial until other schemes have been delivered. • Long sections likely to be costly, dependent on scope.	Rec. 1 – Med Rec. 2 – Med/High Rec. 3 – Low

6.1.2 Option group 2 – signalling improvements

Recent studies undertaken for the Great Eastern Main Line and the Essex Thameside corridors have indicated that upgraded digital signalling[29] would be capable of improving the capacity of the network and allow more trains to be operated. These studies have indicated that at least 24 trains per hour could be achievable. Similar maximum service frequencies are assumed to be achievable for the WAML, meaning an additional 2tph could potentially be operated into London Liverpool Street in the high peak hour if a robust, consistent 2-minute headway south of Broxbourne Junction could be enabled.

The aspiration for more frequent station calls in the peak or off-peak with minimal impact to journey times is likely only to be achievable with additional services operating closer together since adding station calls into other services would slow them down.

Analysis has, however, indicated that even with improved headways additional peak or off-peak hours paths cannot be spaced evenly with existing trains for the benefit of north London stations without impacting journey times of other trains. The opportunity that improved signalling headways in isolation bring is limited due to the constraints on the infrastructure, primarily the two-track nature of the line. Much greater benefits can be gained though, when combined with other options (see 6.2 below), which will allow additional off-peak services to be spaced more evenly, offering more suitable service distribution for passengers and not impacting on journey times for longer distance trains.

[29] Digital signalling removes the need for physical lineside signals. Digital in-cab signalling provides continuous communication between track and train removing the need for fixed blocks between physical signals. This results in more efficient network usage and improved train performance. See more information on digital signalling at https://www.networkrail.co.uk/running-the-railway/railway-upgrade-plan/digital-railway/

Reducing the signalling headway also has the ability to improve performance. In times of disruption and delay, the increased flexibility provided by reduced headways could allow timetables to be recovered more quickly, as trains can move closer together.

Digital signalling also allows trains to be signalled in either direction, adding in further flexibility. While this would be of limited use during normal working, this could facilitate the aim of operating more services between London Liverpool Street and Stansted Airport throughout the night. Currently, overnight maintenance activities, even if only occurring on one track, require both lines to be closed to traffic as signals only face in one direction. Subject to risk assessments, bi-directional signalling, could allow maintenance activities to be structured in such a way that enables one line to remain open, while work is carried out on the other.

Signalling improvement recommendations

Recommendation 4: Enhance signalling headway to 2-minutes south of Broxbourne – assumed with digital signalling technology

While digital signalling could bring benefits to the WAML, including performance, it is recommended that an improved headway of 2-minutes is implemented alongside other improvement options, which will be explored in section 6.2 below. Digital signalling is currently planned to be deployed on the WAML south of Stansted Airport in the funding period CP8 (2029-2034). It is important to note that the rollout of digital signalling is not set to deliver any enhancement to headways. This will need to be built into the scheme subject to a successful business case.

Option group 2 – Signalling improvements		
Benefits	**Issues**	**Cost Estimate**
• Can provide at least two additional train paths. • Could allow for more station calls in north London. • Cost efficiencies may be found if linked to the planned deployment of digital signalling in CP8. • Provides greater performance. • Could enable longer operating hours for the Stansted Express.	• Equal spacing of additional station calls not possible without additional infrastructure. • If costly, deployment may need to be delayed to link up with the planned rollout, meaning benefits may not be realised until the 2030s.	High

6.1.3 Option group 3 – passing loops[30]

Additional infrastructure in the form of a passing loop could provide more flexibility to the timetable and deliver aspired improvements to the train service by providing another location for faster services to overtake slower ones.

Three loop arrangements have been identified for analysis, including the proposal for a static loop at Ponders End promoted by London Borough of Enfield as a means to improve the service frequency at Meridian Water station. Initial investigations, carried out in partnership with the Crossrail 2 development team, identified that Brimsdown station could also be a viable candidate for a static loop. Finally, a longer dynamic loop between Ponders End and Brimsdown stations, while inevitably being more complex and costlier to deliver, has been assessed to understand the scale of additional benefits over a static loop.

In all cases tested by this study a third line is built around the back of the existing London-bound platforms, and third platforms are added to both stations.[31] The most efficient use of the additional infrastructure would be to turn the existing London-bound track into a bi-directional loop, able to be used by non-stopping trains in either direction when overtaking a train using one of the two outer lines making its station call. The basic arrangements of the Ponders End and dynamic loops are shown below in Figure 15, with proposed additional track infrastructure in red.

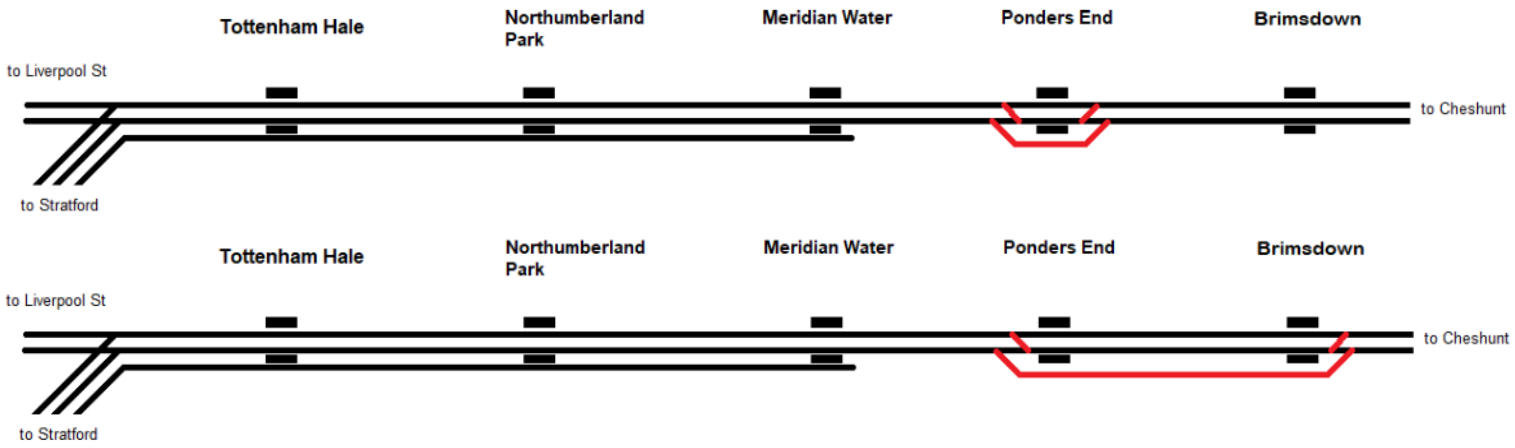


Figure 15 – Sketch diagrams of potential loop arrangements in red. Top: static, bottom: dynamic.

[30] In this subsection two types of loop are described. A 'dynamic' loop allows a train to keep moving while being passed by another train, therefore reducing the amount of acceleration and deceleration needed on the running line. This enables the train to clear the line faster, resulting in greater possible track capacity than a 'static' loop, which is shorter in length, requiring trains to do more braking and acceleration on the main line and trains must come to a stop while being overtaken.

[31] Note, the London Borough of Enfield proposal does not include a third platform.

Minimal difference between the Ponders End and Brimsdown 'static' loops was found, however Ponders End is likely to be a simpler location to construct a static loop, as there are fewer physical constraints, for example the level crossing adjacent to Brimsdown station. These both allow for a small increase in station calls in north London, with no negative impact to journey times for trains to/from Stansted Airport and Cambridge. However, these static loops will have a significant negative impact upon journey times between other destinations, most notably to the Bishop's Stortford-Stratford service, which is shown to receive a journey time detriment of up to six minutes. This is predominately caused by longer dwell times in the static loop while being overtaken by the non-stopping services. The longer dynamic loop, with third platforms, allows for slightly improved calling frequency on top of the static loops, a small improvement to some journey times, but negative impacts to some journey times remain unavoidable.

Above: Brimsdown station (including pedestrian underpass) and level crossing, looking south. The optimal position for a passing loop would be on the left of this image.

Left: Footbridge between Scotland Green Road North and Duck Lees Lane, looking north. The ramp on the east (right) side would be in the way of a third track.

Small areas of land will need to be acquired to construct these loops, and some relatively significant works would need to be undertaken to deliver them, particularly in the case of the long dynamic loop. It is likely that the level crossing next to Brimsdown station would need to be closed if a third track was proposed to be built over it. This would possibly require a bridge to be built to divert vehicular and non-vehicular traffic and ensure other existing local routes (including the route over the nearby Enfield Lock level crossing) are not overwhelmed.

The existing London-bound platforms would need to be widened and turned into island platforms at both stations to allow stopping trains to call while non-stopping trains overtake on the existing London-bound track. It is also assumed that the subway at Brimsdown station would also need to be modified or replaced with a footbridge to accommodate the third line. This could also serve as pedestrian access replacing the level crossing. Finally, the public footbridge between Scotland Green Road North and Duck Lees Lane, pictured above, would need rebuilding.

Ponders End loop proposal

This study recognises that the London Borough of Enfield (LBE) has developed proposals for a static loop at Ponders End station, primarily aimed at enabling more calls at Meridian Water station, supporting the regeneration of the local area. The proposal will receive a significant contribution from the Housing Infrastructure Fund to design and deliver the scheme.

The initial work carried out by LBE has shown that while this is possible, journey time detriments to other services, namely the Bishop's Stortford-Stratford service, are unavoidable. This has been reiterated by this study, when testing a similar option with a third platform at Ponders End station.

It is recommended that it is designed and constructed in such a way that does not preclude efficient extension into a dynamic loop at a later stage, which will be able to deliver the benefits desired to the Meridian Water development, as well as wider benefits to other passengers using other stations.

Passing loop recommendations

Recommendation 5: Provide a passing loop in north London – 'dynamic' is preferred, however a 'static' loop as per London Borough of Enfield's proposal, to be converted to 'dynamic' at a later date is also an option

Due to the negative impacts to some journey times caused by the both the static and dynamic loops, despite being able to add in some additional calls at north London stations, it is clear that they are not a suitable solution capable of providing long-term passenger service enhancements on the route.

They are, however, a relatively low-cost option (versus four-tracking, for example) which can help to deliver some service aspirations in the medium-term. The dynamic loop

does provide wider benefits over a static loop, such as that proposed by London Borough of Enfield, however this could be implemented first and potentially extended to a dynamic loop at a later date. As will be explained in section 6.2 below, the dynamic loop is able to deliver much greater benefits when combined with other options.

Option group 3 – Passing loops		
Benefits	**Issues**	**Cost Estimate**
• Provides more stops at some north London stations, with a dynamic loop offering the largest improvement. • Provides (limited) journey time benefits to some services. • Provides performance improvement through more flexible infrastructure.	• No loop is able to provide consistent 4tph at all north London stations. • No journey time improvement to most Stansted or any Cambridge services. • All loops cause a journey time disbenefit to some services.	Med-High, depending on scope

6.1.4 Option group 4 – Stansted Airport access

The single-track tunnel on the approach to Stansted Airport has been identified as a significant constraint to improving journey times to and from the airport. The removal of this constraint by providing a second tunnel is essential to delivering improved journey times to the airport in the medium-term along with a more robust timetable and stronger performance. These benefits would also apply to the 2tph heading to/from Birmingham New Street and Norwich.

Tye Green tunnel portal, looking south east towards the airport.

It is common for trains heading towards the airport to wait for a train leaving the station to pass through the tunnel before proceeding. This can add 2.5-3.5 minutes of waiting time, or 'pathing allowance', onto a journey. This pathing allowance could be removed by providing a second track and removing the need for trains to wait for the single line section to be clear, translating into a journey time benefit.

The existing tunnel passes under the runway and taxiways of the airport, so affordability and deliverability of a second tunnel alongside it while not impacting airport operations creates a high level of cost uncertainty.

Bi-directional signalling and an additional crossover could also assist in more efficient operations, eliminating some crossing moves at Stansted East Junction, as demonstrated below in Figure 16, adding further timetabling flexibility and improving performance.

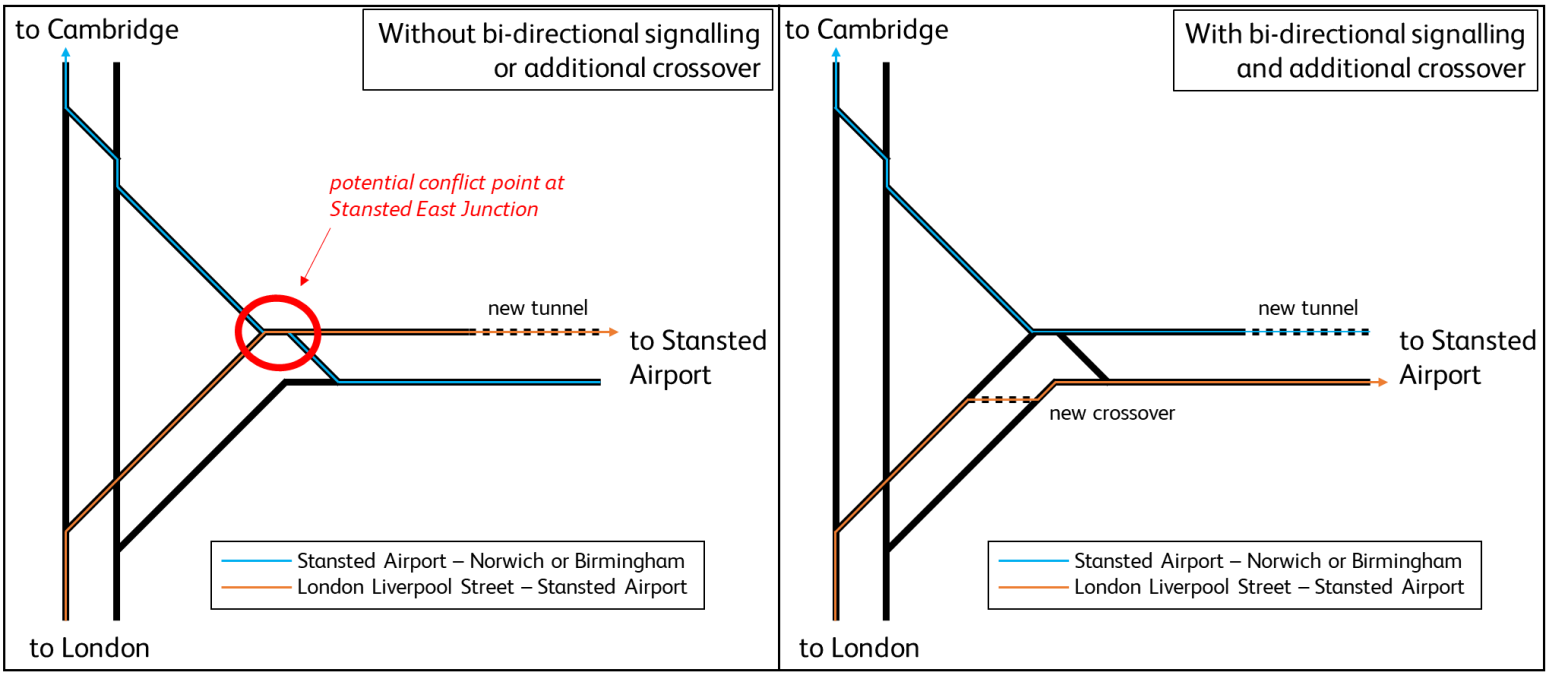


Figure 16 – Bi-directional signalling and an additional crossover could remove some conflicting moves.

As shown above, in certain circumstances, running the trains on the opposite line to normal could enable trains to run without crossing moves at Stansted East Junction. Two Stansted Expresses passing in this section would, however, still use the regular 'up' and 'down' arrangement.

Other ways to deconflict train movements would be to grade separate junctions, where flyovers or dive-unders are built, however the relatively low number of trains per hour on the branch means that this is likely not required.

Longer-term options for reducing journey times to/from Stansted Airport could include brand new alignments, potentially diverging from the WAML between Sawbridgeworth and Bishop's Stortford, could cut approximately 3 miles off the journey, also therefore reducing the journey time. This option has not been assessed by this study, as it has focussed on less transformative options capable of being delivered in around 10 years' time. This possibility has greater potential for consideration in the long-term, and could be considered as an alternative to the second tunnel if the costs and delivery challenges are insurmountable.

An alternative route could, however, avoid Bishop's Stortford, potentially weakening the town's connectivity with London the airport, where a significant

proportion of the airport's staff live. If this were to be taken forward, choices would need to be made about service composition in terms of whether some Stansted Express services would still go via the town to retain its fast services and airport connectivity.

Stansted access recommendations

Recommendation 6: Double Stansted Airport tunnel, with bi-directional signalling

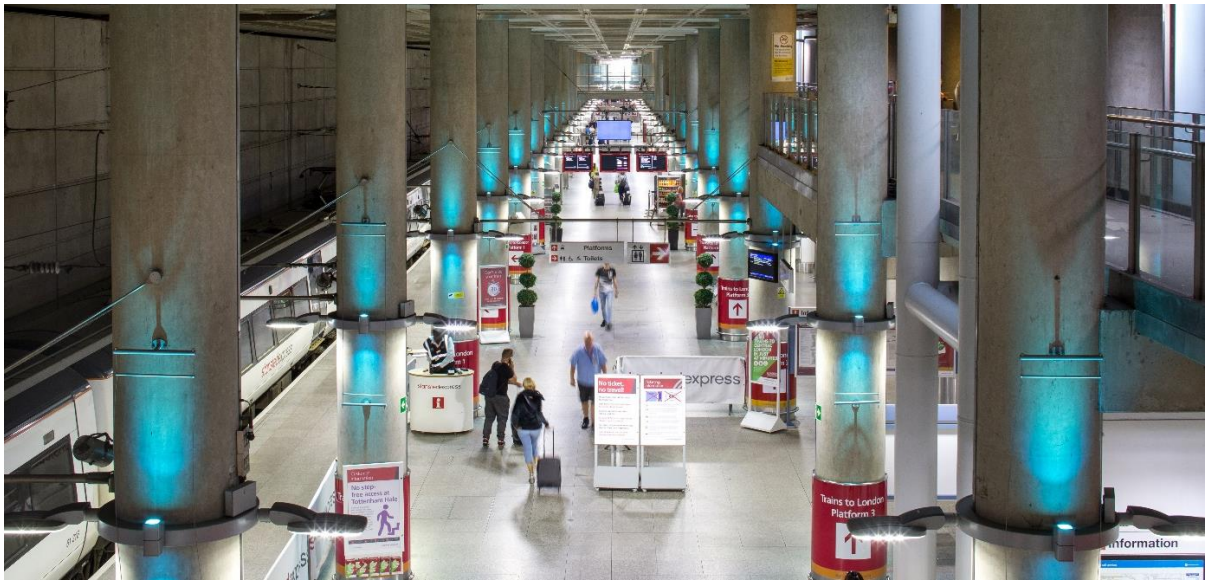
It is recommended that the single line approaching Stansted Airport is doubled. Providing a second tunnel is essential to remove a key constraint on this part of the network, and in isolation could reduce the journey time between London Liverpool Street and Stansted Airport to 44-45 minutes. Double track is also likely to deliver a performance benefit.

If both tunnels are bi-directionally signalled and an additional crossover is provided this could allow trains to run in both directions on either line, eliminating some crossing moves at Stansted East Junction.

Services between the airport and Norwich via Cambridge and Birmingham via Cambridge, Peterborough and Leicester could also benefit from small journey time savings and improved performance.

Further benefits could be gained by combining the tunnel option with others, as set out in 6.2 below.

Option group 4 – Stansted Airport access		
Benefits	**Issues**	**Cost Estimate**
• Journey times for all London-Stansted journeys reduced to 45 minutes or less. • Performance improved.	• Complex deliverability issues, potentially disruptive to airport operations during construction. • Likely to be costly.	High



6.1.5 Single option suitability summary

The commentaries provided above consider each option individually and do not assess whether options can be combined to provide even greater benefits. As explained in section 3, the WAML suffers from multiple severe constraints meaning that relatively small interventions do not bring particularly sizable benefits and may not be justifiable when considered in isolation. Combinations of options which could deliver increased benefits are assessed in section 6.2 below.

6.2 Combinations and sequencing of options

Analysis has identified that benefits delivered by individual options in isolation are in most cases limited, and sometimes have some considerable drawbacks. This is because of how severely constrained the corridor is, meaning a large or multidisciplinary intervention would be needed to unlock these constraints and deliver more sizable benefits. Perhaps the clearest example this study has identified is where the dynamic loop described in 6.1.3 is combined with optimised digital signalling, set out in 6.1.2.

Delivering a loop combined with a robust 2-minute signalling headway, enabling trains to run closer together, allows another 2tph to be added into the off-peak timetable to serve north London stations with no negative impacts on performance or journey times to/from Cambridge or Stansted Airport. Due to the rate that a non-stopping train catches up with a stopping service, it is only possible for this service to operate between London Liverpool Street and Brimsdown, calling at Hackney Downs and all stations from Tottenham Hale to Brimsdown. Extending the service further north (for example, to Broxbourne, similar to how services are bolstered in the peak) would begin to impact on journey times of Stansted Airport and Cambridge services, as these would get held up behind the additional stopping service. The combination of these two options also allows journey times for some services to be improved, principally to and from Hertford East.

It is important to note that in order to deliver the benefits described, an additional platform at London Liverpool Street could be needed, delivery of which would be challenging as discussed above in 3.11.2. Adding additional services into the timetable would also require a significant timetable change, including all main line and London Overground services on the Lea Valley lines. A complete recast of the timetable may also allow further improvements to journey times to/from Cambridge and Stansted Airport.

Further assessment to timetable the approach to, and platforming of, London Liverpool Street would be needed in order to quantify what could be possible and what infrastructure changes might be needed.

6.2.1 Peak hours

A maximum of 22 WAML trains (including London Overground) can currently arrive at London Liverpool Street in the high peak hour while maintaining an acceptable level of performance. In the peak hours, calling frequency improvements are likely to be more valuable than faster journey times, so these improvements have been prioritised in the option analysis for the peaks. The dynamic loop and digital signalling combination could in theory allow an additional 2tph to be added into the timetable, as has been recommended for other areas on the Anglia Route, making a total of 24tph.

These two additional trains would ideally serve north London stations, however analysis has concluded that even spacing with existing trains that currently serve these stations would not be possible without impacting upon journey times of long-distance services. Trains would depart just a few minutes apart, giving little benefit to passengers. It is also likely that to accommodate additional trains another platform would be needed at London Liverpool Street or Stratford, which would be challenging to provide. Therefore, it is not recommended to operate additional services in the peak.

However, the additional capacity and flexibility a dynamic loop and digital signalling brings means that beneficial changes to calling patterns could still be made without adding in additional trains.

Firstly, in the morning peak, four Stansted Expresses which follow Broxbourne-London Liverpool Street services (which stop at most stations) could be sped up by 3 minutes each by using the loop to overtake the slower service as it makes its station calls on the third line. The trains would effectively swap paths heading into London Liverpool Street. More detailed analysis of platform working at London Liverpool Street will need to be undertaken to understand whether this will be workable from a station operations perspective.

Secondly, the existing Meridian Water-Stratford train could be extended back to Brimsdown to provide additional calls at Ponders End and Brimsdown. Calls on the existing services could be reorganised to match demand requirements and give a broadly consistent high peak hour train service at all stations Northumberland Park and Waltham Cross.

Extension of the existing Stratford-Meridian Water shuttle back to Brimsdown could take place on the main line, however this would mean that the third line would not be used during peak hours. A relatively minor track modification could connect the third line back up with the main lines north of Meridian Water, which would make best use of available infrastructure and would likely provide the best performance scenario. Using the third line will also spread passengers out across platforms more evenly at Tottenham Hale station. The most cost-effective time to implement this could be at the same time as undertaking the main works to install a loop just north of here and/or when digital signalling is deployed.

Peak hours recommendations

Recommendation 7: Use dynamic loop and enhanced headway to deliver improved calling frequency in north London

It is recommended a dynamic loop and digital signalling used to provide an enhanced peak hours service, extending the Meridian Water-Stratford service and increasing station calls up to 4tph.

6.3 Freight improvement opportunities

All options allow for an hourly freight path between Stratford and Cambridge based on existing trailing weights of 2200 tonnes. In any scenario freight services can be flighted with the slower passenger services and can run at similar speeds, but must be looped to allow fast passenger services to/from Cambridge and Stansted Airport to overtake.

Looping options exist at various points on the route as per the list in Table 10 below. Some services may need to be looped a second time to align with interfacing timetables, for example if heading through Cambridge and onto the cross-country corridor via Ely. These loops are long enough for existing freight services, but some would need to be lengthened to accommodate longer and heavier trains.

	Loop	Length (metres)[32]
Down	Broxbourne	416
	Harlow Mill	563
	Stansted Mountfitchet	429
	Whittlesford	512
Up	Broxbourne	416
	Great Chesterford	512

Table 10 – Current WAML freight loop lengths.

Aspirations to increase trailing weights are mainly restricted by the lengths of these loops, rather than trailing weights restricting speed profiles, for example. These would each need to be extended to at least 525m to accommodate trains with 26 18m wagons (equivalent of 2600 tonne trailing weight). The 512m loops at Whittlesford and Great Chesterford may be sufficient, however this will need to be assessed. To accommodate longer-term aspirations of using the route for intermodal or automotive trains, loop lengths in the region of 900-1000m would be needed. In general, the longer the loop, the better it is for performance, as trains can run at higher speeds for longer before coming into a stop in the loop, reducing the amount a train needs to slow down on the running line.

As explained above, the route is not intensively used by freight trains. If this was to change and more trains were to operate, performance improvement measures may be required to add more flexibility to the timetable. The loops at Broxbourne and Harlow Mill, for example, have turnout speeds of 15 or 25mph so increasing these speeds could help maintain good performance, especially in times of late running or disruption.

[32] As per Timetable Planning Rules.

Lengthening the shorter of these loops to at least 525m, combined with turnout speed improvements if possible, to allow for longer and heavier bulk aggregates trains should be considered as independent schemes to the passenger-focussed options described above. As relatively minor schemes, if aspired in the short-term, and relevant terminals have the capability to accept the longer trains they would serve, loop lengthening schemes do not need to be entwined with the more complex passenger-orientated enhancements, which are likely to require more development time and therefore take longer to deliver.

Finally, the aspiration to run heavier freight trains may require structures to be strengthened if they are not permitted to take loads any heavier than existing. An exercise to establish structural capability should be undertaken to understand this, as works to multiple structures could add significant time and cost to a programme of freight improvement works.

Freight recommendations

Recommendation 8: Lengthen key passing loops to allow longer trains

A programme of loop lengthening is recommended which will enable freight operators to run longer trains, optimising payload per path and improving the economic viability of rail freight haulage. This will need to be considered in conjunction with looping availability on other routes as well as freight terminal capacity.

Recommendation 9: Increase turnout speeds from freight loops

Performance improvement measures such as increasing turnout speeds from loops should also be considered, particularly if infrastructure works to lengthen loops are chosen to be undertaken, as these works could take place at the same time.

6.4 Summary and preferred phasing strategy

Each of the different options were presented to the study's stakeholder group, along with the proposed sequencing, based on technical evaluation and timely delivery of benefits. Optimal sequencing of the most valuable options is critical, and Network Rail has identified five medium-term stages to steadily build up improvements to journey time, train frequency and performance. Stage 5, the delivery of four-tracking, is the longer-term end-state aspiration, included to illustrate the transformation that Crossrail 2 would be expected to enable.

The most optimal staging of options is set out below in Figure 17.

Stage	Rec. number	Intervention	Primary Driver	Fastest typical London Liverpool Street-Stansted Airport journey time (mins)	Total off-peak / peak station calls per hour (one way Northumberland Park-Waltham Cross)	Other benefits
0	3	Enhanced renewal of Broxbourne Junction *(timed with planned renewal)*	Performance	47 (current)	15 / 19 (current)	• Performance improvements • Potential small journey time improvements for Hertford East services
1a	4, 5, 7	Dynamic loop + ETCS (2-minute headway)	Station Calls	47 (1tph capable of 45)	22 / 23	• Additional station calls in north London • Performance improvements
1b	1	Line speeds (Bethnal Green North Junction – Coppermill Junction)	Journey Time	45	22 / 23	• Journey time benefits for other services, e.g. Hertford East
2	6	Second Stansted tunnel	Journey Time	41	22 / 23	• Improved journey times for Stansted trains to/from the north • Performance improvements
3	2	Line speeds (various sections north of Cheshunt)	Journey Time	40	22 / 23	• Improvement to Cambridge journey times
4	n/a	Four-tracking south of Broxbourne with Crossrail 2 *(or other similar solution providing terminal capacity)*	Performance Station Calls Journey Time Connectivity	30-35 (estimate)	Likely 60+	• Large journey time benefits for all longer-distance trains • Ultra-frequent station calls • Significant performance improvements • Improved regional connectivity

Figure 17 – Optimal sequencing of options, based on timely benefits delivery and overall programme efficiency.

This sequencing has been identified as the optimal way of delivering benefits on the route. For example, improving line speeds south of Tottenham Hale would benefit all WAML trains, so it is logical to undertake this improvement before the second Stansted tunnel, which would predominantly benefit trains serving the airport. This sequencing is also unlikely to contain any significant amount of abortive cost, as options are able to be built upon each other.[33]

Secondly, the options expected to have a lower overall capital cost are also prioritised ahead of more expensive options. Options in Stage 1 are likely to be more affordable than Stages 2 or 3, and therefore may have a greater likelihood of being funded in the medium-term. Where possible, enhancements should be aligned with planned renewals for cost efficiency. Deployment of optimised digital signalling is a clear example of where this could take place.

The delivery of the Stage 1 recommendations do not necessarily need to take place in the order shown in Figure 17 as Stage 1a and 1b could be delivered the other way around. A choice between which Stage is undertaken first will depend on factors such as;

- the preference for more station calls in north London versus improved journey times;
- the cost and overall strength of business case for one scheme over the other, and;
- whether it is seen as cost-effective to build new infrastructure with conventional signalling ahead of the planned rollout of digital signalling in CP8.

In order to deliver maximum cost efficiency, it may be prudent to reverse Stages 1a and 1b so that a loop is delivered at the same time as digital signalling (currently planned for deployment in the early 2030s), eliminating the need to introduce conventional signalling ahead of digital. The costs and benefits of these alternative sequencing options will be explored when the programme for the WAML enters the RNEP.

It is important to note that the rollout of digital signalling will not by default enhance the existing signalling headway. A specified headway improvement will need to be built into the renewal in order to deliver the benefits associated to improved headways listed above.

As indicated in Figure 17 above, it is expected that up to 23 station calls could be made at north London stations, split across various services. The peak and off-peak calling pattern in north London could be improved as per Figure 18 below.

[33] Ultimately, four-tracking will mean that a passing loop would be removed, however. It is recommended that a loop is designed and delivered with four-tracking requirements taken into account.

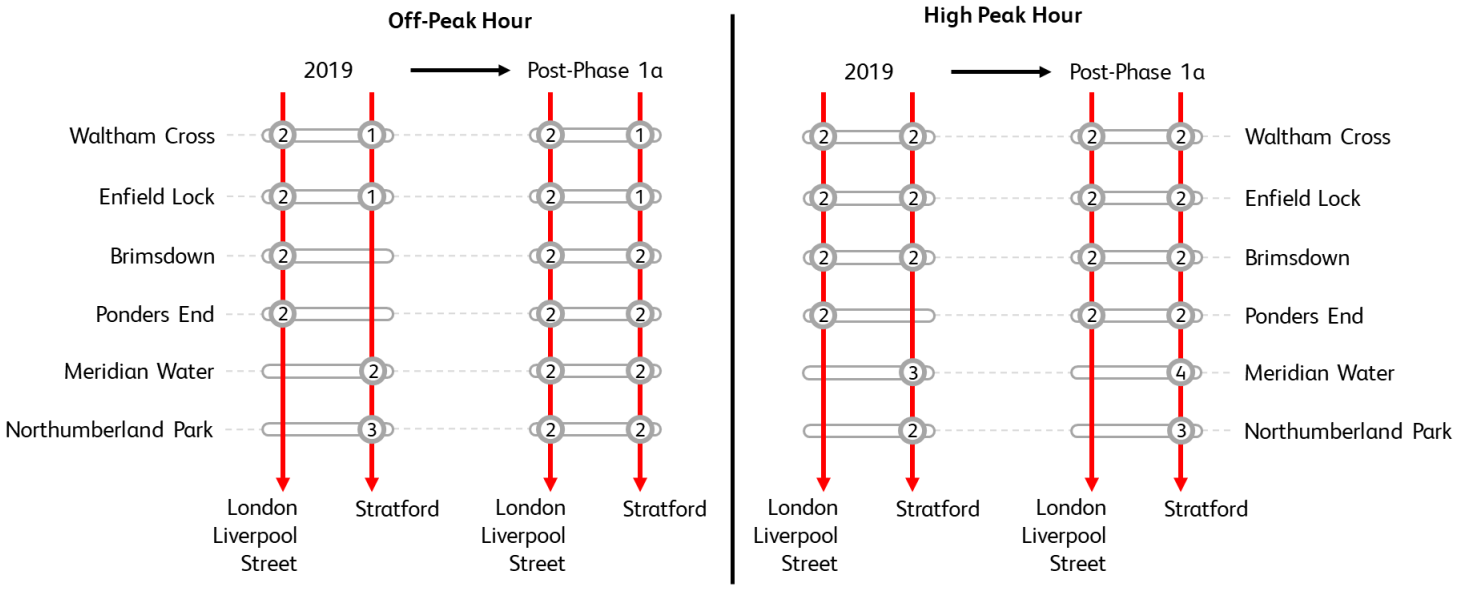


Figure 18 – With the above Phase 1a interventions, calling frequency could be improved. Example calling frequency shown.

As can be seen in Figure 18 station calls in north London can be improved to give a near consistent 4tph at all stations in both the peak and off-peak, while maintaining levels of performance. Some stations will still only be able to be served by 3tph, but most will be able to be increased to 4tph, spread across different services, starting at Bishop's Stortford, Hertford East, Meridian Water or Broxbourne (peak only). It is important to note that the stations allocated 3 or 4tph are not fixed, and could be switched to suit demand as required, however the combined number of calls cannot go above what is shown without impacting on performance and journey times for other services.

Because of additional trains heading to London Liverpool Street in the high peak hour, there is a greater reliance on using Stratford for shorter-distance services calling at these north London stations. Some passengers would need to change trains at Tottenham Hale to access London Liverpool Street, however due to the high frequency of trains which call here in the peak, this should not add a large amount of time to a journey.

Alongside these mostly passenger-orientated enhancements, longer-term aspirations for rail freight should also be considered, including the lengthening of key passing loops to enable longer and heavier freight trains to be run, increasing freight efficiency and payload per train. These should be considered as a separate programme from the passenger options and will also need to be considered in a wider context of infrastructure capability on other routes and the capability of terminals to accommodate longer trains.

Successful progression of these schemes through the RNEP will depend on the overall national funding position and relative strength of other proposed rail enhancement programmes nationwide.

As shown by the staging diagram in Figure 17, a truly transformational change is only possible with Crossrail 2 or

a similar four-tracking solution with a solution for terminus operations.

The options and sequencing established by this study are similar to those recommended by Arup's WAML improvements study, which aimed to improve journey times to and from Stansted Airport in a similar timeframe. These similar conclusions from two independent pieces of work gives confidence that the type of options recommended are the correct medium-term choices, able to deliver improvements to passenger and freight services on the route.

6.5 Stations

As introduced above, there are four WAML stations which are most likely to be at risk of future passenger overcrowding. Out of those four, Tottenham Hale is the only station which is beneficial to model at present, due to London Liverpool Street and Stratford stations having work taking place at a more advanced stage, and uncertainty around proposals for Cambridge in relation to East West Rail.

The demand forecasts undertaken for this study were modelled within the footprint of the mainline station to understand whether any overcrowding would be expected in the busiest period of the day, which for Tottenham Hale is normally around 08:00.

The modelling found that in the medium-term, no severe issues are expected at the station, and that its size and layout will be suitable for the numbers of passengers expected. The passenger crowding heat map opposite in Figure 19 shows where the heaviest passenger flows are expected, indicated by the orange and red areas. This simulation was made using the same 'Covid – High Rail Demand' demand scenario explained in section 5.

As Tottenham Hale is an interchange station and also serves a significant local population, rather than having an overwhelmingly unidirectional flow, passengers are boarding and alighting trains throughout the morning peak. The dominant passenger flows are, however, from passengers alighting trains on the southbound mainline platforms and heading towards the Victoria Line of the London Underground.

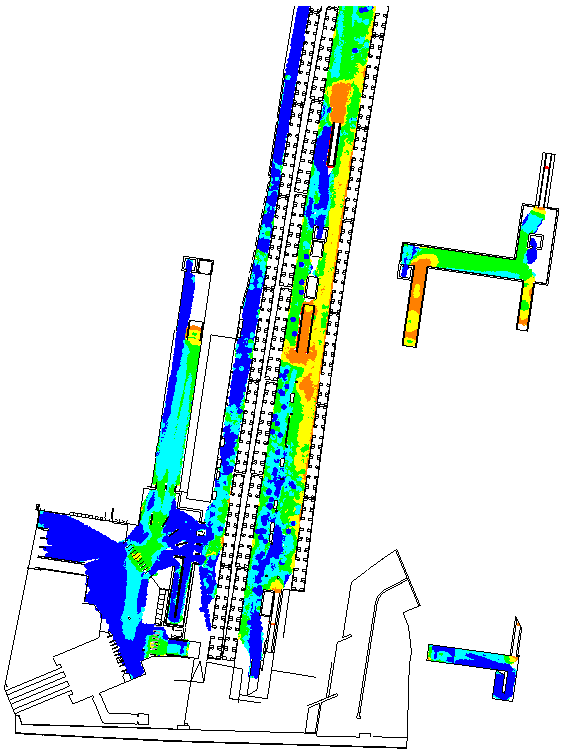


Figure 19 – Tottenham Hale forecast passenger demand – 2031 AM peak.

Demand in the busiest period in the morning peak is therefore heaviest on the southbound island platform (for trains towards London Liverpool Street and Stratford) around the stairs and escalators to the footbridges, which passengers must use to reach the Underground.

The level of demand expected at this time is likely to not cause issues with pedestrian flows, station management or station safety, however adequate staffing should be in place to encourage passenger spread and manage the platform-train interface.

Due to the pandemic and the reduction in passenger numbers, new passenger counts and surveys could not take place. It is recommended that once passenger levels stabilise as the economy is fully opened-up new data is gathered to better inform the demand model.

Continuation of the business case development work being undertaken for Stratford and London Liverpool Street is supported. Consideration of the future needs of Cambridge station is also important, given the changing nature of the train service expected to be brought about by East West Rail.

6.6 Important considerations

While this study has identified the above recommended options, which are most likely to efficiently improve the service offering on the WAML in line with stakeholder priorities, several important considerations are worth highlighting, which will need considering under business case development.

6.6.1 WAML timetable rewrite

While this study has been in development, a complete rewrite of the WAML timetable has begun to take place, necessitated by the rewrite of the interfacing ECML timetable to take into account faster journey times set to be delivered by the £1.2bn East Coast Upgrade. The Thameslink and Great Northern services to and from Cambridge will be retimed, creating a knock-on effect meaning the rest of the WAML's services will need to be retimed to fit in with these.

The preferred options identified by this study will need to be reassessed through the prism of this new timetable to ensure that they are still the correct choices before commencing with further development under the RNEP.

6.6.2 Level crossings

There are currently 64 level crossings operating on the WAML as far north as Cambridge North station, and its Hertford East and Stansted Airport branches. Types of crossing vary from 'passive' public footpaths where the user makes the decision whether it's safe to cross, to 'protected' crossings such as public highways, entrances to industrial sites and access between farmers'

fields.[34] Several busy public highways cross the WAML, including two in north London next to Brimsdown and Enfield Lock stations.

It is Network Rail's strategy[35] to reduce the risk that level crossings pose by closing them wherever possible. Where this is not possible, safety is improved and risk is kept under continuous review. On the WAML, Network Rail is currently awaiting approval from the Secretary of State for Transport on a Transport and Works Act Order (TWAO) to close several of these crossings.[36]

Any increase in train frequency for either passenger or freight services will have an impact upon level crossing barrier down time and have an impact upon each level crossing's risk profile. Proposals to introduce more trains to the network may need to take level crossing upgrades or closures into account to ensure that risk continues to be managed. The exact impacts on level crossings would be investigated at business case level and would be dependent on the infrastructure and/or train service changes implemented. For example, it is likely that if a passing loop was built at Brimsdown station, the adjacent level crossing would need closing.

Level crossing improvements or closures can contribute a significant cost to a programme of works, especially when multiple crossings are affected. Where closures of level crossings are needed, the consents required can often take a significant amount of time to achieve, especially where public or private rights have been granted across the railway and diversions or new bridges or underpasses are required.

[34] Currently there are 18 public highways, 25 public footpaths, and 21 private crossings.
[35] https://cdn.networkrail.co.uk/wp-content/uploads/2020/03/Enhancing-Level-Crossing-Safety-2019-2029.pdf
[36] Details of the crossings proposed to be closed can be found here: https://www.networkrail.co.uk/running-the-railway/our-routes/anglia/improving-the-railway-in-anglia/anglia-level-crossing-proposals/ and are included in the 'Essex and others' application. Note, several of the level crossings in the application are temporarily closed, having already been replaced with alternative means of access, such as a footbridge.

Other enhancement programmes in the east of England, for example the Ely Area Capacity Enhancements, have encountered challenges due to the risk that level crossings pose, demonstrating that the importance of level crossing risk to both programme and cost should not be underestimated. Further study of the recommended infrastructure and timetable changes would be needed to understand the upgrade or closure requirements for each level crossing.

Support from other stakeholders, such as local authorities and highways authorities is critical to achieving level crossing closures. It is important to highlight that closing level crossings can often bring benefits to the road network as well as the railway. For example, the removal of level crossings can improve local traffic flows and road journey times, reduce congestion and unlock new development opportunities.

6.6.3 Future requirements for interfacing lines

As stated in 3.3, TfL leads transport planning for the London Overground routes from London Liverpool Street to Chingford, Cheshunt and Enfield Town. These services share infrastructure with longer distance WAML services at the very south end of the route, including platforms at London Liverpool Street,[37] meaning their future requirements must also be taken into account when planning the future configuration of the WAML, particularly if additional services are proposed.

The WAML's London terminus at London Liverpool Street is also the terminus of the GEML, which serves the eastern half of East Anglia, including services to Southend-on-Sea, Colchester, Ipswich and Norwich. In 2019 Network Rail published the GEML Study[38] which recommended staged improvements to the GEML in order to deliver the required uplifts in service expected to be required over the next generation.

With this study raising the prospect of a significant timetable change, and the GEML Study recommending additional paths into London Liverpool Street, these future aspirations will need to be assessed alongside each other to ensure that enough track and platform capacity exists for each service group which requires it.

If capacity for all these service groups cannot be provided, choices will need to be made as to how capacity is divided amongst these routes and where it is most effectively allocated. It is therefore recommended, now that Network Rail has completed comprehensive studies into the GEML and WAML, that a review into access and platforming at London Liverpool Street, in conjunction with the long-term pedestrian improvement programme, is carried out.

[37] Services to/from Enfield Town and Cheshunt share infrastructure between London Liverpool Street and Bethnal Green North Junction. Services to/from Chingford share infrastructure between London Liverpool Street and Clapton Junction.
[38] https://www.networkrail.co.uk/wp-content/uploads/2019/08/Network-Rail-Great-Eastern-Main-Line-Study-2019.pdf

6.6.4 Power supply

Network Rail is developing a traction power strategy, which will set out the traction power requirements needed to deliver the Eastern Region Electrification Strategic Advice recommendations. This will also outline a controlled process to manage emerging traction power requirements in the region. As part of any further business case development, an assessment of traction power would be provided to the Eastern Region Traction Power Management Steering Group for review.

7 Recommendations

The analysis carried out for this study has produced a staged series of options for improving the WAML in the short- and medium-term. This section summarises the preferred strategy for improvements, answering the Strategic Questions agreed with the study stakeholders. This study set out to answer the following headline Strategic Question;

Headline SQ: What are the priority enhancements that could provide improved performance, journey times and service offering on the West Anglia Main Line prior to the delivery of Crossrail 2?

This study has recommended a staged series of improvements which could meet medium-term aspirations for journey time improvements for longer-distance trains and increased in station calls at suburban north London stations. The first step would be to enhance junctions in line with planned renewals to improve speeds across them, offering performance improvements. The first main stage of enhancement activity would be to construct a dynamic loop, introduce an optimised ETCS 2-minute headway and to improve line speeds south of Tottenham Hale. These three improvements combined would deliver the bulk of the improvements proposed, by enhancing journey times for Stansted trains to 45 minutes and deliver an improvement to calling frequency in north London to 4tph 'turn up and go' frequency throughout the day. To reduce journey times for Stansted Express services further (to around 40-41 minutes), the single line tunnel under the airport runway must be doubled (or an alternative double-track airport access route formed), and further targeted areas of line speed improvements would be needed. Journey times of less than 40 minutes would be expected with four-tracking.

For freight a programme of loop lengthening would need to be carried out in order to allow longer and heavier trains to run. Longer-term aspirations to run Class 4 intermodal or automotive services on the WAML have not been reassessed, however if this was to become a priority for the freight community, gauge clearance as identified in the 2017 Freight Network Study, and further loop lengthening would be required.

7.1 Responses to the sub-strategic questions

This study sought to answer six sub-strategic questions. Responses to these questions are summarised below.

SQ1: What are the current proposals to improve the capacity and journey times on the West Anglia Main Line?

There are currently limited proposals to improve the capacity and journey times for WAML passengers. This is partly due to the significant investment in new rolling stock across the WAML, giving significantly more capacity, as demonstrated by this study's demand forecasting. The most significant of these is London Borough of Enfield's proposal for a static loop at Ponders End station to increase the service frequency at Meridian Water station. This will only be possible with disadvantages to other rail users, principally those using the Bishop's Stortford-Stratford service, however could form a first step in a staged series of WAML enhancements.

Other planned projects to enhance the rail network include Cambridge South station, which will offer additional connectivity to the growing south side of Cambridge, and the Central Section of East West Rail will offer new journey opportunities between Cambridge and the midlands.

In the longer-term the ambition for vastly improved journey times and service frequency is expected to be delivered by Crossrail 2, however it is acknowledged that development has been paused, as of October 2020 with the timescale of its resumption unknown.

SQ2: What is the expected growth in passenger and freight demand on the route over the medium-term?

It is not straightforward for this study to be able to confidently state an expected percentage growth in passenger demand over the next decade or so due to the uncertainty brought about by the ongoing Covid-19 pandemic. Three high-level industry scenarios which contain a great deal of uncertainty have been tested to dampen long-term pre-pandemic forecasts. 2031 levels of usage are projected to be between 15 % lower and 26 % higher than 2016 levels of demand. Even in the most optimistic scenario, where demand is only suppressed by 5 %, sufficient capacity is expected to be available in the high peak hour in the medium-term, with no passengers expected to be standing. This is due to the introduction of a new fleet of trains by Greater Anglia, which will offer approximately 48 % more capacity in the high peak hour than the old fleet, based on new trains operating the same services as the December 2019 timetable.

For freight, the WAML sees relatively limited levels of traffic, however it is acknowledged that it is an important corridor for construction materials. National forecasts undertaken in 2019 indicated that growth in freight traffic is expected to be small.

SQ3: What additional passenger stops and/or services are expected to be required to meet the forecasted demand?

As established by SQ2, demand growth for both passengers and freight is not expected to be high enough to drive a necessity for additional train paths. There are, however, strong aspirations from a range of stakeholders for improved connectivity and faster journeys, including faster freight journeys. These aspirations mainly focus on;

- Faster journeys between London Liverpool Street and Stansted Airport/Cambridge
- Increasing the number of station calls at north London stations
- Providing an hourly freight path on the WAML in both directions
- Speeding up freight journeys

The study has therefore focussed on delivering meaningful improvements aligned to these aspirations in the most efficient and cost-effective way.

SQ4: What opportunities exist to improve journey times and service frequencies on the route?

This study has strictly assessed medium-term options, i.e. improvements which could give an improvement to services over the next 10-15 years. It has not sought to assess long-term needs, as these have already been established to be four-tracking enabled by Crossrail 2, although the delivery timescale of Crossrail 2 is uncertain.

The options identified and sequenced by this study have indicated that an improvement to journey times between London Liverpool Street and Stansted Airport could be incrementally improved by around seven minutes, and an additional seven station calls per hour could be made at stations between Northumberland Park and Waltham Cross.

Timing and delivery of these options will be subject to positive business cases and funding availability.

SQ5: What are the likely infrastructure and technology options to improve the rail network that would support the additional stops and/or services that are expected?

This study has identified a range of potential improvement options for the WAML, all of which have been tested to uncover the most worthwhile options to implement. This includes additional infrastructure in the form of a dynamic passing loop, a second tunnel into Stansted Airport, targeted areas of line speed improvement and optimised digital signalling.

SQ6: What is the most efficient phasing of options to meet the medium-term needs of the route?

The options assessed have been analysed to determine the optimal sequence in which to deliver them.

Firstly, to improve journey times for all WAML services, line speeds between Bethnal Green North Junction and Coppermill Junction should be increased up to 50mph.

Secondly, a dynamic loop will enable more frequent station calls at stations between Northumberland Park and Waltham Cross, however a universal improvement in calling patterns is not possible without improving signalling. Combining the loop with optimised digital signalling to deliver a consistent 2-minute headway would allow additional shuttle services to run in the off-peak, and the Meridian Water-Stratford service to be extended in the peak with no detriment to journey times for Stansted Airport and Cambridge services. This would give most north London stations a 4tph service.

Following these improvements at the London end of the route, a second tunnel, doubling of the track into Stansted Airport would remove a significant bottleneck allowing much greater flexibility in timetabling the Stansted Express services and enabling an improvement to journey times. Similar gains could be possible for the Norwich and Birmingham New Street services.

Finally, an improvement in line speeds mainly around and north of Bishop's Stortford are expected to contribute a further small reduction in journey times between Cambridge/Stansted Airport and London Liverpool Street.

For freight, improvements independent of the passenger-focussed improvements detailed above should be carried out, including lengthening of loops and improving loop turnout speeds.

To deliver the true transformation to calling frequency as well as passenger and freight journey times, four-tracking is needed south of Broxbourne in the form of Crossrail 2, or other similar scheme with a solution for a terminus.

7.2 Individual recommendations and preferred strategy

Nine individual recommendations have been made by this study, each of which have been assessed and assembled into a preferred strategy for delivering improvements to the passenger and freight services on the route.

Rec.	Summary
1	Stage 1 line speed improvements south of Tottenham Hale
2	Stage 2 line speed improvements north of Cheshunt
3	Increase line speed at Broxbourne Junction
4	Enhance signalling headway to 2-minutes south of Broxbourne – assumed with digital signalling technology
5	Provide a passing loop in north London – 'dynamic' is preferred, however a 'static' loop as per London Borough of Enfield's proposal, to be converted to 'dynamic' at a later date is also an option
6	Double Stansted Airport tunnel, with bi-directional signalling
7	Peak hours – use dynamic loop and enhanced headway to deliver improved calling frequency in north London
8	Freight – Lengthen key passing loops to allow longer trains
9	Freight – Increase turnout speeds from freight loops

As explained in section 6, many of these options, particularly the passenger options 1-6 have limited benefits when delivered in isolation, however benefits

grow as these are combined and built upon, and more meaningful medium-term improvements can be made.

The preferred strategy for delivering these recommendations would be to focus on those which are relatively low cost and deliver the widest benefits first. Alignment with planned renewals where possible is recommended to deliver best value for money. Full details are set out in section 6.4, however a summary of the recommendations delivery is set out in Figure 20 below.

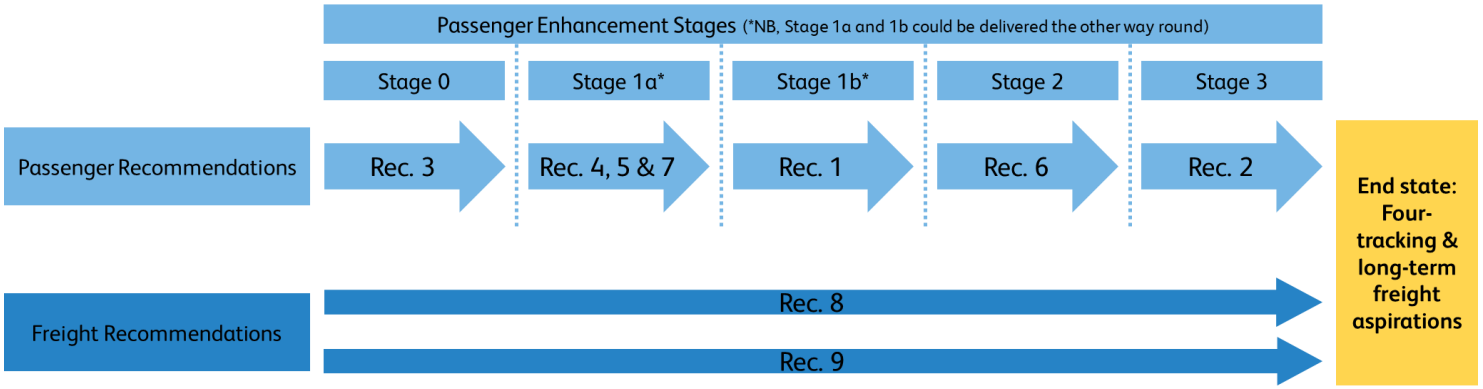


Figure 20 – Summary of recommendations staging.

7.3 Next steps

It is recommended that option feasibility assessments, including cost benchmarking, are undertaken to better understand the opportunities and challenges of each of the options, as well as their likely capital cost. This is to ensure a Decision to Initiate to enter a programme of investment into the Rail Network Enhancements Pipeline (RNEP), illustrated in Figure 21 below, is as well-informed as possible.

The urgency of improvements specifically for Stansted Airport services should be considered in the context of expected growth of Stansted Airport and wider rail usage.

Network Rail will also work closely with the West Anglia Taskforce, the sub-national Transport bodies of Transport East and England's Economic Heartland and Local Enterprise Partnerships on the opportunities for progressing the options identified in this study with greater business involvement.

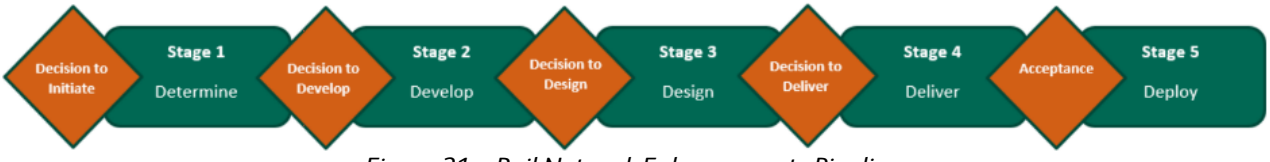


Figure 21 – Rail Network Enhancements Pipeline.

7.4 Recommendations for further study

Six items are recommended for further study, several of them as direct results of this study's analysis. Undertaking feasibility assessments into line speed improvements and loop lengthening opportunities, for example, as soon as possible will improve the evidence base ahead of the entry of a WAML programme into the RNEP. This is to better understand capabilities of potential options and begin to map out benefits before commissioning business case development.

7.4.1 Stage 1 line speed improvement viability

Raising line speeds on the section between Bethnal Green North Junction and Coppermill Junction up to 50mph has been highlighted as a potential early benefit, however it is currently unknown as to whether speeds could practically be raised here. This section has some relatively sharp track curvatures and is on a viaduct for around half its length, which may prevent line speeds being raised this high. Investigations with track and gauging engineers is required to determine whether this proposal is viable, and should be carried out as a priority.

7.4.2 London Liverpool Street platforming assessment

As expressed above, several studies have now proposed increased services to London Liverpool Street. An assessment of the station throat, platforming and pedestrian flow is therefore recommended to understand the viability of these schemes in conjunction with each other.

7.4.3 Cambridge station demand modelling

Due to the ongoing development of the EWR Central Section and uncertainty over the track layout on the southern approach to Cambridge station, it has not been possible to undertake reliable passenger demand forecasting. Network Rail will continue to work with EWR Co. to establish future requirements to ensure that Cambridge station is fit for purpose for all passengers.

7.4.4 Freight loop lengthening viability

To meet aspirations for longer freight trains, it is recommended that assessments of existing freight loops should be carried out to understand the feasibility in extending them, and also whether improvements to turnout speeds could be achieved to aid greater performance. Assessments of whether weak structures would prevent higher trailing weights should also be carried out.

7.4.5 Early/late Stansted Airport services

At present it is not possible to provide rail services to and from Stansted Airport to serve the needs of air passengers and staff wishing to travel to the airport rail in early morning or late evening, particularly at weekends. This is an issue recognised by West Anglia Taskforce members with Network Rail and Greater Anglia previously considering options to improve service coverage.

It is more challenging to provide a 24-hour (or near 24-hour) rail service to Stansted as is possible to Gatwick and Luton airports with the two track nature of the WAML meaning line closure is necessary in order for maintenance and renewal activity to take place. On other corridors, two tracks can be closed with a reduced frequency service continuing operate using other tracks.

Further consideration of how the hours of service offer could be improved for Stansted Airport was paused since the start of the pandemic but this is expected to resume following publication of this study.

It is recognised that, while the solutions to achieving this are not simple and short-term options require trade-offs, it is an important issue not just for the attractiveness of the airport but for sustainable access reducing the use of private car.

It is recommended that further development of options for improvement of service coverage continues and, in the short term, the rail industry[39] works with Stansted Airport on how the opportunity for bus/coach based 'rail equivalent' options could be provided at time where the rail offer is not possible but using rail ticketing options.

7.4.6 Rail Strategy for London Covid-19 scenarios

The Coronavirus related passenger growth scenarios used as part of the assessments for this study will be reviewed on an ongoing basis by the rail industry working with the Government. As part of the developing Rail Strategy for London, a workstream has been set up to review the growth scenarios formally in late 2021.

It is recommended that any significant change to the growth scenarios reported shall be considered for the WAML. Should any options or recommendations be impacted by this, these will be reviewed by the study's Steering Group and updated if required.

[39] Network Rail, Department for Transport and train operator, Greater Anglia.

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