



Southern Rail Access to Heathrow Feasibility Study

December 2015

Executive Summary

The purpose of this Study is to inform Government of potential market, train service and infrastructure options for a connection to Heathrow Airport from the south. Options have been developed and subsequently assessed for feasibility and value-for-money. This is to enable potential funders to decide as to whether further development work should be undertaken on the scheme.

The Study has been undertaken in four stages:

- A Market Study;
- Production of indicative train service specifications;
- Infrastructure option development;
- A value-for-money assessment.

Market Study

The Market Study considers a broad geographic scope south of Heathrow Airport and identifies the Strategic Goals of the scheme and which locations would offer the biggest potential market for a southern rail access train service.

Strategic Goals for a southern access rail link were developed in consultation with key stakeholders, after a review of relevant literature, and used to guide the development of overall scheme objectives. The Strategic Goals were considered to be:

1. To reduce highway congestion at and around Heathrow through an increase in rail mode share and reduce the environmental impact of existing travel patterns (e.g. CO₂ emissions);
2. To improve productivity and outputs from the UK economy through enhanced Heathrow and local connectivity;
3. To reduce social deprivation and increase labour productivity through greater accessibility to employment, for the benefit of both employees and employers – both to/from Heathrow and through creation of new journey opportunities;
4. To connect communities where no reasonable public transport option currently exists.

The other aim of the Market Study is to estimate the potential scale of economic benefits a southern rail access scheme could proffer. This then enables the subsequent stages of the Southern Rail Access to Heathrow Feasibility Study to focus on those locations which would offer most benefit, namely:

- London Waterloo via Richmond;
- Guildford via Woking;
- Basingstoke via Woking and Farnborough (Main).

These serve two separate catchments, the flow to London and the flow to Surrey/Hampshire.

It should be noted that it is not the final destinations of Waterloo, Guildford and Basingstoke that provide the majority of the economic benefits in the Market Study findings but instead it is intermediate stations (such as Richmond, Twickenham and Farnborough Main) and the interchange opportunities at Clapham Junction and Woking.

Indicative Train Service Specifications

The outputs of the Market Study have been used to develop a range of indicative train service specifications which aim to serve the locations mentioned above. Network capability analysis was subsequently undertaken to identify how to best accommodate the specifications on the Wessex network and in the Heathrow area and whether infrastructure enhancements would be required.

The infrastructure baseline for the specifications is the network upon completion of the works on the Windsor Lines to enable 20tph (being developed by the Wessex Capacity Programme).

Heathrow Airport to London Waterloo

It is possible to achieve either semi-fast services or stopping services between Heathrow and London Waterloo but network capacity necessitates the following patterns would be required:

- 4tph semi-fast services via Richmond.
- or*
- 2tph stopping services via Richmond and 2tph stopping services via Hounslow.

It is not possible to achieve 4tph stopping services via Richmond, the corridor which offers more economic benefit, owing to network capacity issues so 2tph via Hounslow has been assumed in the stopping specification.

Both of these service specifications provide a 4tph service between London Waterloo and Heathrow Airport without breaching the 20tph network capacity limit of the Windsor Lines. Equally, neither option increases the number of train services over the level crossings on the Richmond corridor in the peak.

Increasing the capacity of the Windsor Lines above 20tph would necessitate significant infrastructure investment due to the scale of enhancement required. This has not been examined in this Study.

Heathrow to Surrey and Hampshire

As mentioned above, the Market Study indicated that the corridors to Guildford and Basingstoke would provide the most economic benefit for a southern access service to Surrey/Hampshire. However, to enable the train specifications for the London Waterloo – Heathrow corridor, it is necessary to remove the 2tph London Waterloo –

Weybridge stopping service. Therefore this flow also needs to be considered as a Heathrow – Weybridge service could replace some of this connectivity.

Therefore, analysis was undertaken on a 4tph stopping service to Surrey and Hampshire in various combinations of the following:

- 2tph Heathrow – Guildford;
- 2tph Heathrow – Basingstoke;
- 2tph Heathrow – Weybridge.

Heathrow Airport

There are three options as to how these trains could be pathed at Heathrow Airport. They are broadly as follows:

- Scenario A - All 8tph terminate in Terminal 5 station;
- Scenario B - 4tph terminate at Terminal 5 and 4tph call at both Terminal 5 and Terminals 2&3;
- Scenario C - All 8tph call at both Terminal 5 and Terminals 2&3.

Scenarios B and C would require a turnback to be located between Terminals 2&3 and the Great Western Main Line (GWML) as no additional services can be accommodated on the GWML owing to it being at full network capacity.

Scenario C would involve the Surrey/Hampshire SRAtH services connecting to non-stop London Paddington – Heathrow services, creating Surrey/Hampshire – London Paddington through services. It should be noted that this would connect Western Route to Wessex Route, which would have performance implications which would need to be considered when deciding between the three service scenarios.

Accommodating eight SRAtH and four WRLtH¹ services at Heathrow Airport will require trade-offs in connectivity to Heathrow terminals. A holistic study of the Heathrow area would be best placed to determine which flows should serve which terminals, and how best to operationally manage the resulting interchange flows

Infrastructure Option Development

Accessing Heathrow Airport from Wessex Route

The next stage of the Study examined the feasibility of the train service proposals by determining what infrastructure would be required to facilitate access to Heathrow Airport from the south and carrying out the following set of assessments:

- Engineering feasibility;
- A station capacity assessment;
- Land and consents requirements;
- Cost estimating.

¹ Western Rail Link to Heathrow (WRLtH) is expected to enable a 4tph service from Reading to Heathrow in Control Period 6.

Options were developed to provide a range of journey time and service quantum outputs. It should be noted that it is likely there are other viable alignments that could be considered if the scheme is progressed further. These alignments were, however, deemed appropriate to deliver the outputs required.

The alignments are broadly limited to improving journey opportunities. In this Study, Network Rail has not sought to maximise any potential local regeneration opportunities that could exist in some southern access alignments. However, it should be noted that should housing growth and regeneration be a priority or requirement of the scheme funder, this could feasibly influence the potential alignments in the next stage and increase the likelihood of third party funding contributions.

Option 1A

Option 1A enables 4tph to access Heathrow Airport from the London direction. This alignment provides a route from the Staines vicinity of the Windsor Lines to the west end of Heathrow Terminal 5, similar to that developed for the original Airtrack scheme.

The new route diverges from the Staines - Windsor line north west of Staines at surface level and remains as such until it enters into tunnel to access Heathrow Airport Terminal 5 station.

Using this alignment, the journey time from Staines to Heathrow Terminal 5 would be approximately 6 – 7 minutes.

Option 1B

Option 1B enables 4tph to access Heathrow Airport from the London direction and 2-4tph from the Surrey/Hampshire direction. This option involves the same alignment as Option 1A above but also includes a railway chord in the Staines vicinity that enables services to access the Egham line to then continue on to Surrey/Hampshire destinations.

Using this chord, the journey time from Woking to Heathrow Terminal 5 would be approximately 32 – 37 minutes.

However, no net additional services can be pathed via Egham in the peak in order to prevent any increase in the down-time of level crossings in the Egham area. This limits the number of potential Heathrow services from Surrey/Hampshire to two in the peak (replacing the two Weybridge-Waterloo stopping services, which also need to be removed to allow operation of Waterloo-Heathrow services due to capacity constraints between Feltham and Waterloo), though 4tph could potentially be achieved in the off-peak if the service level was increased to match that in the peak.

Network Rail always intends to close level crossings to remove any interface between road and rail, especially if projects are undertaking works in the area or changing the train service which runs over them. Though the closure of these level crossings has not been examined in detail in this Study (and therefore relevant costs

are not included at this stage of development), the closure of any level crossing is a substantial undertaking and, in the case of these crossings, would involve significant infrastructure interventions, and significant funding, combined with input from local stakeholders and the local authority.

If Option 1B is taken forward, level crossings closure will be examined in more detail and costed at the next stage of development. A review of the business case presented in **Chapter 6** would therefore be required, noting that there is always a strong safety case supporting level crossing closure.

Option 2

Option 2 enables 4tph to access Heathrow Airport from the London direction and 4tph all day from the Surrey/Hampshire direction. This is achieved via a new tunnelled rail alignment which by-passes the level crossings in the Egham area. It also provides a journey time improvement on the Heathrow – Surrey/Hampshire flow.

The route is tunnelled out of Heathrow Airport and then rises to surface level to enable a spur to the Windsor Lines, providing Heathrow – London services. The main route then returns to tunnel and goes under the Windsor Lines and the Egham area until it rises to re-join the existing network between Egham and Virginia Water.

This alignment avoids increases in level crossing down time in the Egham area (removing this as the ruling constraint on the level of train service that can operate in the peak) but means that Heathrow services could not call at Egham station.

Using this alignment, the journey time from Woking to Heathrow Terminal 5 would be approximately 28 – 33 minutes.

Option 3

Option 3 enables 4tph to access Heathrow Airport from the London direction and 4tph all day from the Surrey/Hampshire direction with a more significant journey time reduction for the latter flow. This is achieved via a more extensive surface level rail alignment which also by-passes the level crossings in the Egham area.

The route is tunnelled out of Heathrow Airport and then rises to surface level to enable a spur to the Windsor Lines, providing Heathrow – London services. The Surrey/Hampshire route remains at surface level and runs alongside the M25 motorway to the Virginia Water – Weybridge line, re-joining the existing network between Virginia Water and Chertsey. This facilitates significantly shorter journey times to Weybridge, Woking and beyond than are possible via Options 1B or 2.

This alignment also avoids increases in level crossing down time in the Egham area (removing this as the ruling constraint on the level of train service that can operate in the peak) but means that Heathrow services could not call at Egham or Virginia Water stations.

Using this alignment, the journey time from Woking to Heathrow Terminal 5 would be approximately 23 – 28 minutes.

Option 4

Unlike the previous alignments, Option 4 considers the feasibility of approaching Heathrow Airport from the easterly direction. The route considered here is a new tunnelled rail line from west of Feltham to Heathrow Terminals 2&3 with services then continuing on to Terminal 5. In this Study, the Option 4 alignment has only been considered in relation to the London flow.

An alignment of this type would result in reduced journey times from locations east of Feltham to Heathrow Airport as services would travel less distance on the existing network before branching off to Heathrow. However, it would result in airport services being unable to call at Staines.

Using this alignment, the journey time from Feltham to Heathrow Terminals 2&3 would be approximately 4 – 5 minutes.

The table below shows the cost ranges for the options considered:

Option	Cost range (1Q15 prices)
Option 1A	£700m – £900m*
Option 1B	£800m – £950m*
Option 2	£1.4bn - £1.8bn*
Option 3	£1.4bn - £1.8bn*
Option 4	£1.0bn – 1.4bn*

**This cost does not include level crossing closure costs, future inflation, asset resilience, power supply upgrades or potential depot and stabling requirements. These costs have been prepared in accordance with our estimating policy for projects at this very early stage of development and will continue to be refined as development continues.*

Infrastructure enhancements required on the Wessex network

The network capability assessment indicated that in addition to a new line to access Heathrow Airport from Wessex Route, a range of enhancements would be required on the existing network to accommodate the southern access services. Some of these enhancements have already been identified in the Wessex Route Study as being required in any case to accommodate future South West Main Line (SWML) demand.

The enhancements required to accommodate future demand on the SWML as well as also being required for southern rail access are:

- Woking Grade Separation;
- Woking additional platform;
- Basingstoke flyover (only required for southern rail access if Heathrow services go to Basingstoke);
- Guildford station capacity enhancement (only required for southern rail access if Heathrow services go to Guildford).

As these enhancements are required irrespective of southern rail access, their costs have not been included in the appraisals for this scheme. It is important to note that none of these schemes are currently funded.

However, in addition to these items, enhancements would be required at the following locations on the Wessex network to accommodate southern access services:

- Additional turnback capability at Basingstoke (only required for southern rail access if Heathrow services terminate at Basingstoke);
- A freight recess facility in the Byfleet Curve area (only required if more than two additional services are pathed via the Curve);
- A turnback between Heathrow Terminals 2&3 and the GWML (only required if SRAtH services do not all terminate at Terminal 5).

Option Combinations

The table below summarises the service quantum and alignment combinations considered in the value-for-money assessment.

Service Concept	Infrastructure Required
Four trains per hour to London – all day.	Alignment Option 1A
Four trains per hour to London – all day. Reduced journey time.	Alignment Option 4
Four trains per hour to London – all day. Four trains per hour to Surrey/Hampshire – off-peak (two trains per hour in the peak).	Alignment Option 1B
Four trains per hour to London – all day. Four trains per hour to Surrey/Hampshire – all day. Reduced journey time.	Alignment Option 2

<p>Four trains per hour to London – all day.</p> <p>Four trains per hour to Surrey/Hampshire – all day.</p> <p>Further reduction in journey time.</p>	Alignment Option 3
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Using the first two concepts above, the table below outlines the two alternative London service options tested in this Study.

Destination and calling pattern	Infrastructure Required
<p>Two stopping services via Richmond all day.</p> <p>Two stopping services via Hounslow all day.</p>	Alignment Option 1A or Alignment Option 4
<p>Four semi-fast services via Richmond all day.</p>	Alignment Option 1A or Alignment Option 4

It should be noted that in both scenarios a Virginia Water – Weybridge service is also assumed to run to replace some of the connectivity lost on the Chertsey corridor from the removal of the Waterloo – Weybridge stopping service.

Incrementally to the Heathrow – London flow, the Study considered the following Surrey/Hampshire service options using the latter three concepts in the first table. The infrastructure requirements listed are in addition to schemes at Basingstoke, Woking and Guildford which are already examined in the Wessex Route Study to cater for SWML demand, but would also be required for southern access services.

Service Concept	Infrastructure Required
<p><u>Peak</u></p> <p>Two trains per hour to Weybridge.</p> <p><u>Off-peak</u></p> <p>Two trains per hour to Weybridge. Two trains per hour to Guildford.</p>	Alignment Option 1B

<p style="text-align: center;"><u>Peak</u></p> <p>Two trains per hour to Guildford.</p> <p style="text-align: center;"><u>Off-peak</u></p> <p>Two trains per hour to Guildford. Two trains per hour to Basingstoke.</p>	<p style="text-align: center;">Alignment Option 1B</p> <p style="text-align: center;">Basingstoke Turnback</p> <p style="text-align: center;">Freight recess facility</p>
<p style="text-align: center;"><u>All day</u></p> <p>Two trains per hour to Weybridge.</p> <p>Two trains per hour to Guildford.</p>	<p style="text-align: center;">Alignment Option 2</p> <p style="text-align: center;">or</p> <p style="text-align: center;">Alignment Option 3</p>
<p style="text-align: center;"><u>All day</u></p> <p>Two trains per hour to Guildford.</p> <p>Two trains per hour to Basingstoke.</p>	<p style="text-align: center;">Alignment Option 2</p> <p style="text-align: center;">or</p> <p style="text-align: center;">Alignment Option 3</p> <p style="text-align: center;">and</p> <p style="text-align: center;">Basingstoke Turnback</p> <p style="text-align: center;">Freight recess facility</p>

Value-for-Money Assessment

Scenario testing

The following scenarios were tested in the value-for-money assessment:

- A two-runway scenario vs a three-runway scenario;
- Whether it is more valuable for London or Surrey/Hampshire services to call at both Terminal 5 and Terminals 2&3 (as opposed to just Terminal 5) should a trade-off be required;
- A reduction and increase in the capital cost of one of the alignments to ascertain the BCR's sensitivity to capital cost changes;
- Extending Surrey/Hampshire services through Heathrow Airport to call at Old Oak Common and London Paddington;
- Standard WebTAG values of time vs airport values of time;
- Fewer stops in Surrey/Hampshire services.

Results of value-for-money assessment

The following diagram shows the value-for-money category under a range of different scenarios and shows which London and Surrey/Hampshire options offer the best value-for-money and their categories both separate and combined.

Value-for-Money category and best option	Best London option	Best Surrey/Hampshire option (as an increment to London services)	Case for combined option	
Two runway demand²	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke		
Two runway demand, fewer stops in Surrey/Hampshire services	NA	Option 1B, services from Guildford and Weybridge		
Two runway demand, London and Surrey/Hampshire services through to Terminals 2&3 and GWML³	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke		
Three runway demand (low)	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke		
Three runway demand (high)	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke		
Two runway demand, airport values of time	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke		
VfM category (as defined in WEBTAG)				
Poor (BCR < 1)	Low (1 - 1.5)	Medium (1.5 - 2)	High (2-4)	Very High (>4)

Key Findings

Train service options

- To avoid significant infrastructure investment on the Windsor Lines, any southern access service concept would need to be planned holistically with the existing and future Wessex train service to enable the optimal use of network capacity;
- Southern access services to London, Guildford and Basingstoke would provide the most economic benefit;
- The train service changes necessary to accommodate southern access services would likely result in reducing or removing some direct journey opportunities that exist today;

² Assumes all calls in Surrey/Hampshire options with London services to Terminals 2&3 and Surrey/Hampshire services terminating at Terminal 5

³ Assumes all calls in Surrey/Hampshire services with London SRAtH services to Terminals 2&3 and Surrey/Hampshire services to Old Oak Common and London Paddington via connecting to non-stop London Paddington – Heathrow services

- In order to avoid increasing the peak level of train service through the level crossings in the Egham area, it would be necessary to either alter the train service to account for this, pursue level crossings closure or choose an alignment option which by-passes the level crossings;
- A holistic study of Heathrow Airport would be best placed to further investigate the trade-offs required to optimise which future rail service groups (e.g. SRAtH, WRLtH, Crossrail) call at which Heathrow terminals;
- There is the potential for services from Surrey/Hampshire to run directly through Heathrow and join with existing Heathrow – London paths on the Great Western mainline (though this would involve trade-offs with other services, as per the previous point).

Infrastructure options

- An alignment that accesses Heathrow Airport via Terminals 2& 3 should not be considered further due to the engineering complexities associated with joining the existing Heathrow Express tunnels;
- In order to avoid increasing the peak level of train service through the level crossings in the Egham area, it would be necessary to either alter the train service to account for this, pursue level crossings closure or choose an alignment option which by-passes the level crossings.

Value-for-money assessment

- The options appraised demonstrate a wide range in the value-for-money of potential service specifications. The assessment suggests that the highest value-for-money southern rail access link concept would be achieved via Alignment Option 1B with:
 - semi-fast London Waterloo – Heathrow services;
 - Surrey/Hampshire services from Guildford and either Basingstoke or Weybridge. The appraisal showed Weybridge and Basingstoke as performing similarly in terms of value-for-money. Further assessment of the costs and benefits of these two service options would be required at the next stage of development.
- A range of options were tested for sensitivity to Heathrow demand forecasts, reduced operational expenditure savings, a reduced number of calls in Surrey/Hampshire services, capital costs and higher values of time;
- Though the value-for-money of the Surrey/Hampshire services is comparatively lower than the London services, the Surrey/Hampshire services better meet the Strategic Goals of a southern rail access link.

Future stages

- The next stage of development for the scheme would be a GRIP 1 – 2 Study;
- If Heathrow Terminal 6 proposals go ahead, it is recommended that development of southern access be integrated with development of Terminal 6 in order to ensure consistency of the designs at Heathrow.

Further Scheme Development

Following submission of this Study to the Government, should a promoter be willing to fund further development on a southern access scheme a GRIP 1-2 study would need to include the following:

- Further consideration of potential train service and infrastructure options;
- On-site surveys;
- Consideration of ownership boundaries and operational control of any new alignments;
- Investigation into the closure of the level crossings in the Egham area if Option 1B is taken forward to remove the interface between road and rail;
- Power supply modelling;
- More detailed analysis of the electrification arrangements;
- Potential enhancements to Wessex stations to cater for increased numbers of passengers with luggage;
- A study on maintenance arrangements and how these may need to be reviewed to better accommodate the airport service;
- Upgrades required on Wessex network to provide adequate asset resilience;
- Consideration of depot and stabling arrangements;
- A more detailed land and consents strategy.

Contents

Executive Summary	2
Contents.....	14
1.0 Purpose of Study	15
2.0 Context and Approach.....	16
3.0 Market Study	20
4.0 Potential Train Services.....	27
5.0 Infrastructure Option Development.....	38
6.0 Value-for-Money Assessment	57
7.0 Summary	70

1.0 Purpose of Study

The purpose of this Study is to inform Government of potential market, train service and infrastructure options for a connection to Heathrow Airport from the south. Options have been developed and subsequently assessed for feasibility and value-for-money. This is to enable potential funders to decide as to whether further development work should be undertaken on the scheme.

Journeys to and from airports are an important factor in the planning of the future railway. As the rail industry's Long-Term Planning Process seeks to make recommendations as to the network's future operation and enhancement, the requirements of airport passengers form a key input.

The balancing of airport and commuter requirements presents a challenge when considering future network capacity as airport passengers and commuters have priorities which do not always align. It necessitates that both flows be considered in a holistic manner, alongside freight services, to achieve a whole network solution.

The airports picture in the UK is currently subject to deliberation through the recent work of the Airports Commission led by Sir Howard Davies. As part of the consideration of airport capacity in south east England, the Government has remitted Network Rail to undertake the Southern Rail Access to Heathrow Feasibility Study into the feasibility of a new rail line serving Heathrow Airport from the south. This is in response to one of the recommendations in the Airports Commission's interim report of December 2013⁴.

This Study has been undertaken at a pre-GRIP (Governance of Railway Infrastructure Projects) level of development. The GRIP process is Network Rail's framework for the development of projects. GRIP describes how Network Rail manages and controls projects that enhance or renew the national rail network. Network Rail has developed this approach to managing projects in order to minimise and mitigate the risks associated with delivering projects. A project that has not yet entered GRIP will not have undertaken any on-site surveys or detailed design work and will be based on a number of assumptions, such is the case with this Study.

⁴ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/271231/airports-commission-interim-report.pdf

2.0 Context and Approach

2.1 Connectivity to Heathrow Airport

Heathrow Airport is currently directly served by the Piccadilly Line, Heathrow Express and Heathrow Connect services. Crossrail and Western Rail Link to Heathrow will improve connectivity to Heathrow Airport when they are implemented in Control Period 5 (CP5) and Control Period 6 (CP6) respectively.

Despite this enhanced connectivity to the west and into Central London, it has long been recognised that a significant proportion of Heathrow's demand comes from the south where passengers are likely to access the airport by road, which is partly due to the non-competitive journey times available by rail.

Improved rail links from the south are therefore seen as important in improving connectivity, journey times and overall passenger experience whilst creating modal shift away from car travel. This Study considers the feasibility and value-for-money of implementing such a rail link from the South.

2.2 Previous work on southern rail access to Heathrow Airport

Previous work on southern rail access was undertaken by BAA under the banner of 'Airtrack'.

This was abandoned in 2011 owing to local opposition to the impact of extended level crossing down-time along the route. This work has been borne in mind during the development of this Study.

Heathrow Airport Terminal 5 station has a safeguarded 'box' that was included in the Terminal 5 designs to enable a future southern rail access link to connect to the terminal more easily. More detail on the layout at Heathrow Airport can be found in **Chapters 4 and 5**.

2.3 Approach and Scope

The geographic scope for consideration in this Study is shown in **Image 1**.

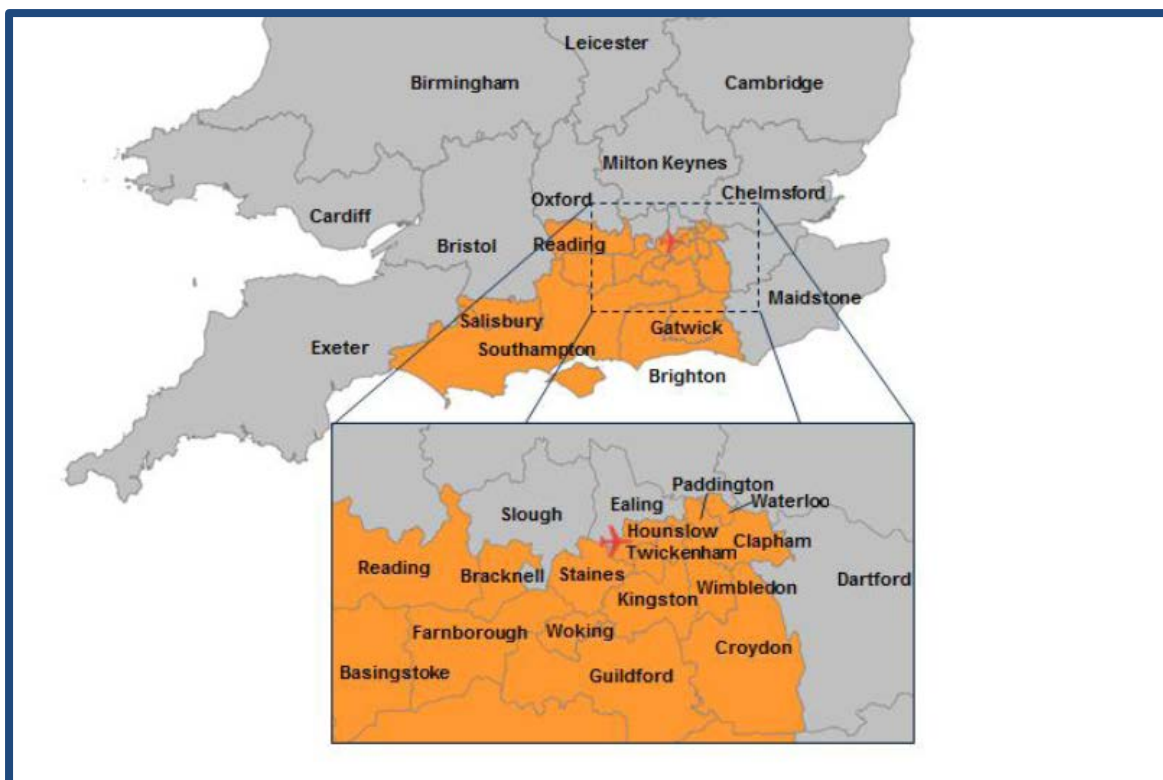


Image 1 – Geographic scope for Southern Rail Access to Heathrow Feasibility Study

The scope is primarily in South and South West London, Hampshire, Surrey and Berkshire.

The Study has been undertaken in four stages:

- A Market Study;
- Production of indicative train service specifications;
- Feasibility;
- Value-for-money assessment.

Market Study

The Market Study considers the broad geographic scope outlined above and identifies which locations would offer the biggest potential market for a southern rail access train service.

The aim of the Market Study is also to estimate the potential scale of economic benefits a southern rail access scheme could proffer. This then enables the subsequent stages of the Southern Rail Access to Heathrow (SRaH) Study to focus on those locations which would offer most benefit.

The methodology and outputs of the Market Study are covered further in **Chapter 3**.

Indicative Train Service Specifications

The outputs of the Market Study have been used to develop a range of indicative train service specifications which aim to serve the locations identified as being the most valuable. The following two assessments were then carried out:

- Network capability assessment;
- On-train crowding assessment.

The infrastructure baseline for the specifications is the network upon completion of the works on the Windsor Lines to enable 20tph (being developed by the Wessex Capacity Programme).

The train service specifications are discussed in more detail in **Chapter 4**.

Option Development

The next stage of the Study examined the infrastructure requirements to facilitate access to Heathrow Airport from the south by assessing the following:

- Engineering feasibility;
- Station capacity;
- Land and consents requirements;
- Cost estimating.

More detail on these elements of the feasibility assessment is included in **Chapter 5**.

Digital Railway

The Digital Railway is an industry-wide programme designed to benefit Great Britain's economy by seeking to accelerate the digital enablement of the railway in several key areas, including infrastructure, train operation, capacity allocation, ticketing and stations. On Wessex Route this could include new signalling technologies to help increase the capacity of the network.

The timescales for the rollout of digital railway technology across the country are not yet known. However, as the two programmes continue to develop, the SRAtH scheme will be able to take advantage of the opportunities and benefits proffered by digital railway solutions and any new infrastructure will be consistent with the Digital Railway.

Value-for-Money Assessment

The train service specifications and infrastructure options have been used to undertake a value-for-money assessment of a SRAtH scheme. More detail on this assessment is included in **Chapter 6**.

Heathrow Airport Potential Expansion

Government is currently considering the recommendations of the Airport Commission's report on airport capacity in London and the South East. There are two proposals for expansion at Heathrow Airport:

- A three runway airport – proposed by Heathrow Airport Ltd;
- A two runway airport, with an extension of the northern runway to the west – proposed by Heathrow Hub Ltd.

The Commission recommended the former of these two proposals as being the most viable option for expansion. As Government is yet to confirm whether it wishes to proceed with either proposal, the Study's base assumptions relate to Heathrow Airport as is now.

However, consideration has been given to expansion scenarios and this has been included in the relevant areas of this Study.

3.0 Market Study

3.1 Purpose

The aim of the Market Study is to estimate the potential scale of economic benefits that could be achieved from the delivery of a range of service options in order to indicate which markets a southern rail access link should aim to serve. This enables the train service specifications to be focussed on locations that will offer the most economic benefit.

3.2 Methodology

The Market Study took southern access rail link Strategic Goals and converted them into service-level Conditional Outputs. The Conditional Outputs were used as inputs to demand modelling, and the modelled demand and revenue forecasts were put through a value-for-money assessment to identify the best value markets.

Strategic Goals

Strategic Goals for a southern rail access link were developed in consultation with key stakeholders, after a review of relevant literature, and used to guide the development of overall scheme objectives. While they were developed in order to understand what the implementation of this scheme should aim to deliver, they were not linked to specific routes or service options. The Strategic Goals were considered to be:

1. To reduce highway congestion at and around Heathrow through an increase in rail mode share and reduce the environmental impact of existing travel patterns (e.g. CO₂ emissions);
2. To improve productivity and outputs from the UK economy through enhanced Heathrow and local connectivity;
3. To reduce social deprivation and increase labour productivity through greater accessibility to employment, for the benefit of both employees and employers – both to/from Heathrow and through creation of new journey opportunities;
4. To connect communities where no reasonable public transport option currently exists.

Conditional Outputs

The market study used the Strategic Goals to develop a set of ten service-level Conditional Outputs, which informed the service specification for a southern rail access link service. These were used as an input to demand and revenue modelling, which estimated the potential scale of economic benefits that meeting each Conditional Output could deliver, in turn informing decisions on which markets a southern rail access link should serve. It should be noted that a potential southern access rail scheme will not aim to meet all the Conditional Outputs, and indeed it will

not be possible or good value to meet some combinations of Conditional Outputs simultaneously.

These Conditional Outputs were developed at a high level and without full consideration of feasibility, deliverability, and specific infrastructure requirements. Journey times were assumed to be unchanged on other parts of the network to those specified. For modelling purposes, each Conditional Output was given a representative service pattern. Where conditional outputs were tested in combination, the frequency on any service pattern was capped at 2 trains per hour (tph), with the exception of Conditional Output 1. The Conditional Outputs are set out below.

1. Introduce direct service 8tph between Heathrow and Inner/Central London serving intermediate destinations with the following services:
 - a. Local 4tph Heathrow – Waterloo via Clapham Junction
 - b. +2tph semi fast services Heathrow – Waterloo (with split/joining of semi-fast services)
 - c. +2tph Clapham – Heathrow (i.e. assumed not run to operate as far as to/from Waterloo)
2. Introduce direct service 2tph Heathrow – Guildford via Woking. Extended to Gatwick via Guildford and Dorking
3. Introduce direct service 2tph Heathrow – Basingstoke via Woking
4. Introduce direct service 2tph Heathrow – Weybridge via Chertsey
5. Introduce direct service 2tph Heathrow – Wokingham via Ascot
6. Introduce direct service 2tph Heathrow – Farnham via Ascot
7. Introduce direct service 2tph Heathrow – Windsor (Riverside)
8. Direct services to the maximum number of Heathrow terminals
9. Improved wider Heathrow rail connectivity via interchanges
10. Improved direct or interchange connectivity between Wessex and Great Western Communities (measured by demand)

Do-Minimum Service Assumptions

The market study tested the Conditional Outputs against a ‘do-minimum’ scenario, consisting of current rail services and proposed rail schemes that will directly impact Heathrow Airport’s accessibility from London and the south.

Existing services assumed in the do-minimum are:

- Heathrow Express
- Heathrow Connect
- RailAir bus services
- Piccadilly Line services.

The do minimum scenario also included:

- Crossrail services to Heathrow replacing Heathrow Connect services
- The addition of Western Rail Link to Heathrow (WRLtH), a direct rail link between the Great Western Main Line (GWML) and Heathrow Terminal 5. This scheme is

not fully committed, but has been assumed in the baseline to avoid this market study producing benefits to passengers who would primarily be served by WRLtH.

The following were not included in the do-minimum scenario:

- Capacity impacts, including train lengthening and the programme of capacity improvements on Wessex Route. These are not included as they will not impact forecast demand;
- The InterCity Express Programme, which, in the study area, relates primarily to the GWML;
- The Piccadilly line upgrade, increasing frequency and reducing journey times;
- Old Oak Common and HS2, including any potential Heathrow spur.

Airport Demand Assumptions

Base year (2013/14) trip matrices of existing demand by zone and market segment were obtained from airport survey data and Heathrow employee surveys.

This data was grown with a selection of demand growth forecasts from Heathrow Airport Limited, the Airports Commission, and Heathrow Hub, under various two and three runway capacity scenarios. It was assumed that employee demand would grow in proportion to passenger demand, and that the share of surface access trips from each zone grew uniformly. The impact of land use changes, which were believed to be unlikely to significantly change the conclusions of the market study, was excluded. Yearly forecasts were determined by linear interpolation, and the demand capped at the final forecast year (2040 or 2043 depending on the source of the forecasts). It was assumed that the baseline mode share per zone was unaffected by potential socioeconomic changes, and only impacted by transport schemes.

Infrastructure Assumptions

Acknowledging that new infrastructure will be required to connect to Heathrow, assumptions were made on the alignment to determine the southern rail access link journey time to Heathrow, which impacts demand forecasts and economic benefits. To determine the sensitivity of the results to journey times, the Conditional Outputs were assessed with a range of indicative alignments and associated journey times.

The potential alignments considered by the Market Study were:

- A western alignment connecting to the Windsor lines via Staines, allowing access to London;
- An eastern alignment connecting to the Windsor lines via Feltham, allowing access to London, with a ten minute journey time saving compared to the Western alignment;
- An Egham Station stopping route, allowing access to Surrey/Hampshire;
- An Egham Station avoiding route, allowing access to Surrey/Hampshire, with an eight minute journey time saving compared to the Egham Stopping route.

Interchange Assumptions

The Market Study assessed the impact of providing connectivity to further potential key zones beyond Woking (such as Portsmouth and Gatwick Airport) both as direct services and with an interchange.

3.3 Demand Modelling

Demand forecasting was undertaken to estimate the size of the potential market for each Conditional Output. Two different models and methodologies were used to forecast demand, corresponding to the two potential southern rail access link markets; journeys to and from Heathrow Airport, and any other journeys that non-airport passengers might make on southern rail access link services.

Heathrow Airport Demand

The Heathrow Airport demand model is a mode choice model in the form of a hierarchical logit function. This is the standard tool used to assign total demand between multiple categories in accordance with generalised cost for each mode. The model allows full mode choice in the study area based on generalised cost, responsive to changes in the characteristics of southern rail access link services. It provides demand and revenue forecasting, and allows different demand responses by journey purpose. The airport demand model does not incorporate any crowding-related demand constraints or revenue loss associated with crowding, demand response to land use changes, the impact of any schemes not included in the Do Minimum scenario, or any demand uplift as a result of improvements to access times.

Generalised cost is used as a representative and consistent measure of a mode's utility, and in this model includes elements of travel time, access and egress time, wait time, fares, service frequency and required interchanges. The valuation of these components was taken from the PDFH, WebTAG Unit A1.3, and the Heathrow Economics Study.

The model was constructed with relation to geographic boundaries referenced in the geographic scope of the market study, based on UK Districts. Each zone was assigned a key station, from which the generalised cost of travel to Heathrow could be calculated for each possible transport mode. The model was also segmented by journey purpose: airport employees or airport passengers, divided into UK residents or non-UK residents, further divided by a journey purpose of business or leisure.

The model structure provides an incremental mode choice between 'all rail modes' and other public transport modes, and an absolute mode choice between different rail modes. For levels above the rail nest, the model works incrementally to reflect changes in demand and mode share as a result of changes in the generalised cost of travel. The introduction of additional rail modes reduces the composite cost of 'all rail modes', making 'all rail modes' a more attractive choice in the decision between rail and non-rail, abstracting demand to rail from other transport modes. The model was calibrated to set parameters which provided a best fit to observed mode shares.

An exception to this structure is used where rail modes currently obtain less than 2% of the market. The incremental structure will not forecast demand where a mode currently carries no demand and may under-forecast where demand is very low. In these cases, the mode choice model uses absolute level forecasting for all modes. Demand data input into this model was obtained from three sources: Heathrow Airport passenger survey data, Heathrow workforce travel data and MOIRA OR18 (Southern East) and OR19 (Southern West).

Non-Airport Demand

Non-airport demand describes journeys not starting or ending at Heathrow Airport. This demand was forecast using MOIRA and a gravity model, the most commonly used method of deriving trips where no existing matrix is available. The gravity model forecasts demand by considering the attraction between origin-destination pairs, based on the relative population and employment and the rail service provided. However, it does not account for the impact of competing modes.

The Conditional Outputs were coded into MOIRA to forecast demand for origin-destination pairs where the change in Generalised Journey Time (GJT) between the Do-Minimum and Option was less than 30 per cent. Where the change exceeded 30 per cent, or where there was currently no rail demand, the gravity model was used to forecast demand. The gravity model grouped stations according to MOIRA zoning, and assigned census data on population and employment to the closest station. The model was calibrated based on the origin and destination population and employment and the rail GJT between modes (from MOIRA). Exogenous growth was applied to the base year forecast.

3.4 Economic Modelling

An economic appraisal was undertaken to estimate the market value of delivering each Conditional Output. Demand and revenue data was taken from the two demand models discussed, and the benefits appraised over a 60-year period, using DfT WebTAG-consistent methodology. The benefits appraised were:

- Incremental increase in rail revenues
- Value of journey time savings (aviation values of time were used in the market study)
- Monetised non-user benefits relating to a decrease in car miles, such as reduced road congestion and environmental externalities. Marginal External Costs of car use were taken from the WebTAG data book.

The cost of delivering these Conditional Outputs was not assessed. Delivery of Conditional Outputs was assessed against a 'Do Minimum' scenario which included current services and committed improvements. Demand was capped 20 years from the appraisal start for non-airport passengers and in 2043 for airport passengers.

The appraisal considered the impact of both varying future capacity at Heathrow Airport and of the impact of improved rail journey times to Heathrow. The market study assumed journey time reductions due to new infrastructure connecting Heathrow Airport to the Windsor Lines and an optional route for Surrey/Hampshire

services that bypassed Egham station. These assumptions were purely for modelling purposes.

3.5 Wider Impact Assessment

The market study also included an estimate of Wider Economic Benefits. In line with WebTAG guidance, this focused on those wider economic impacts that form part of a scenario's net impact on welfare and the economy at the national level but are not captured in the assessments of conventional user benefits. The three categories of wider impact included were:

- Agglomeration – the increase in productivity benefits from increased clustering of firms
- Output change in imperfectly competitive markets – the benefits of increased economic activity are assumed to exceed the costs to the firms involved, in real-world markets
- Tax revenues from labour market impacts – a reduction in commuting costs may incentivise non-workers to participate in the labour market, with a resultant impact on productivity and the resultant tax impact

The assessment focused on net national impacts, rather than local area impacts that are likely to be mainly offset at the national level by losses in other areas. Wider impacts vary with employment levels rather than passenger journey numbers, but employment at Heathrow has been assumed to grow at the same rate as passenger journeys.

3.6 Results

A southern rail access link to Heathrow generated significant demand and revenue under even the most conservative Heathrow two-runway capacity scenario. Delivery of the Conditional Outputs could facilitate an additional 8.9m annual rail trips in 2033/4, of which 4.8m were airport journeys, growing the expected number of Heathrow airport journeys by rail from approximately 17m to 22m by 2033/34 of a total 56m passengers per annum. The appraisal of this scenario forecast benefits of £6.8bn (PV 2010), with the majority of benefits arising from airport journeys. It should be noted that this represents an upper estimate of the potential benefits available to capture under this growth scenario, and no single service or combination could be expected to achieve this total benefit.

The most valuable Conditional Outputs were Waterloo-Heathrow services (COs 1a and 1b), forecast to deliver 60-year benefits of £1.58bn and £1.56bn (PV 2010) respectively. The next most valuable Conditional Outputs were for services via Woking to Guildford and Basingstoke (COs 2 and 3), forecast to deliver 60 year benefits of £1.57bn and £1.29bn (PV 2010) respectively. The Serving Basingstoke via SATH would only be beneficial if the service provides a significantly better service than a service via a Western Access to Heathrow link. All other Conditional Outputs were forecast to deliver significantly lower benefits.

3.7 Capacity implications on the Windsor Lines into London Waterloo

During the Market Study process, it was important to understand the implications that additional passengers from Heathrow might have on AM and PM peak capacity requirements into London Waterloo. The Windsor Lines are busy, and the Wessex Route Study sets out a strategy for dealing with existing and future crowding over the next 30 years. Running services from Heathrow into Waterloo will mean that there will be additional passengers on this line potentially exacerbating an existing problem.

Analysis has been carried out that demonstrates that whilst additional passengers from Heathrow into London will make crowding worse, the scale of the increase in the number of passengers is small compared with the number of commuters that are expected to use the service in the future. It could result in around a one to two per cent increase in peak demand into Clapham Junction and Waterloo. This is the equivalent of one to two years of growth that would be expected without SRAtH.

It also means that additional passengers will be on trains between Heathrow and Waterloo, but getting off before the most crowded point on the network. This will result in some passengers on peak trains standing for a longer period of time.

These impacts can be mitigated by accelerating the program of capacity relief by one to two years or running peak Heathrow trains via the Hounslow loop, where crowding is less of an issue.

3.8 Other Key Findings

The market study highlighted several other key messages:

- The main drivers of value in the Waterloo-Heathrow services were serving the London market, and the opportunity to directly serve areas with strong local demand on route. Waterloo-Heathrow services also enabled significant interchange opportunities allowing them to serve areas not directly on route;
- The value in services via Woking was driven by serving Woking station, which provides significant interchange opportunity to make services accessible to demand from a number of more distant zones. Direct services to further afield have limited potential, especially direct services to the key demand centres beyond Woking, as they generate a small proportion of total demand while bringing a significant increase in operating costs;
- Waterloo-Heathrow services and services via Woking serve largely distinct passenger catchments;
- A southern rail access scheme would provide interchange opportunities at Heathrow airport between Wessex routes and the Great Western Mainline, and potentially direct services across Heathrow;
- Reducing journey times significantly increases forecast benefits;
- Scheme benefits are very sensitive to Heathrow Airport growth scenarios. If the higher two-runway forecasts from the Airports Commission were met, total 60 year benefits could rise from £6.8bn to £7.7bn - £8.3bn (PV 2010). Under three-runway and Heathrow Hub forecasts, benefits could range from £8.1bn - £9.4bn (PV 2010).

4.0 Potential Train Services

4.1 Input to Indicative Train Service Specifications

Following completion of the Market Study, Network Rail developed a set of indicative train service specifications for Southern Rail Access to Heathrow (SRAtH).

There were two main inputs to this process which informed and shaped these train service specifications, the Market Study findings and known network constraints. These inputs are detailed below.

Market Study Findings

The Market Study findings were used to inform the development of train services by identifying the locations that a southern rail access train service should be aiming to serve. These are as follows:

- London Waterloo via Richmond
- Guildford via Woking
- Basingstoke via Woking and Farnborough (Main)

These serve two separate catchments, the flow to London and the flow to Surrey/Hampshire.

The London Waterloo via Richmond corridor is on the route known as the 'Windsor Lines'. These are shown in purple in **Image 2**. Basingstoke is on the SWML, shown in red, and Guildford is on the Portsmouth Direct Line, shown in brown.

It should be noted that it is not the final destinations of Waterloo, Guildford and Basingstoke that provide the majority of the economic benefits in the Market Study findings but instead it is intermediate stations (such as Richmond, Twickenham and Farnborough Main) and the interchange opportunities at Clapham Junction and Woking.

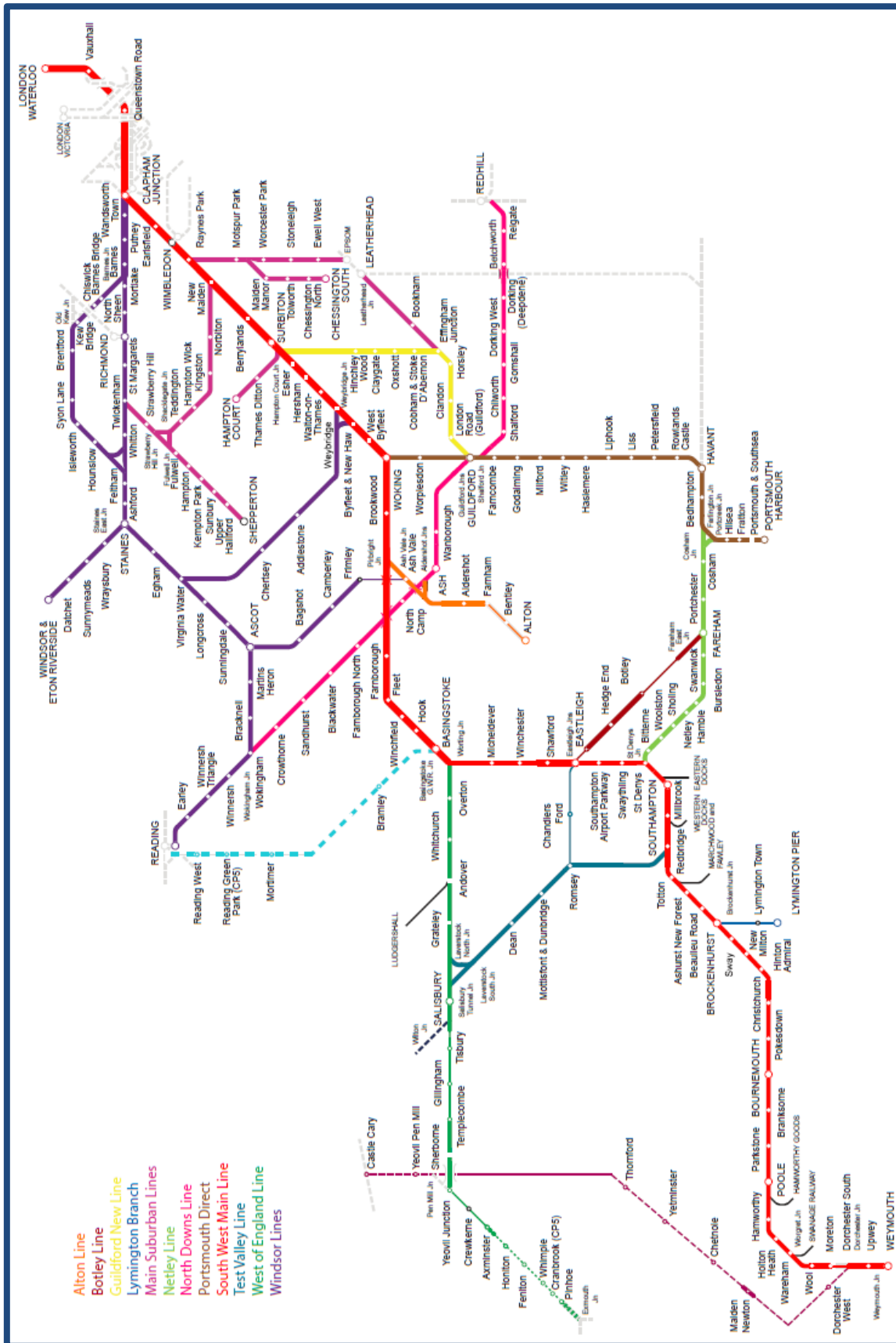


Image 2 – Wessex Route

Known Network Constraints

When developing the train service proposals for southern rail access, cognisance was given to the constraints that are expected to remain on the network at the end of Control Period 5 (CP5). These constraints influence the number of train services that run in each section of the rail network and so an understanding of them is vital.

The relevant constraints on Wessex Route (where all the southern rail access services would originate) and what they mean for the train service offering are as follows.

Windsor Lines

Network Rail (through the Wessex Capacity Programme) is currently working on a number of capacity interventions on the Windsor Lines into London Waterloo to enable a future train service frequency of 20tph in peak hours.

Works developed have included:

- Full reopening of Waterloo International Terminal (WIT) to provide five platforms (Platforms 20-24) dedicated to Windsor Line services at Waterloo, with remodelling of the throat of WIT to support an intensive level of train service;
- Construction of a turnback facility on the route via Hounslow (most likely at Hounslow) in order to support additional services on the route.
- An additional platform at Queenstown Road;
- S&C alterations at Queenstown Road.

The WIT scheme will be completed in CP5. The precise combination of the other works noted that will be delivered in CP5 is still under discussion with DfT. Once completed, the above works will result in a notional capacity of 20tph in peak hours. However, it is not a single constraint that defines this 20tph limit; several constraints together define this service limit, namely:

- Five platforms are available in WIT, each of which can notionally accommodate 4tph or one train roughly every 15 minutes, giving 20tph in total - though Platform 19 may also be available for use by Windsor Line services. This must also be considered in combination with the capacity of the station throat at Waterloo;
- All trains must be funnelled through a single platform in each direction at Queenstown Road and Vauxhall. 20tph is the practical limit in each direction;
- 20tph can be accommodated through the flat junction at Barnes, as trains diverge between the main line via Richmond, and the Hounslow Loop. However, the timetable still needs to be carefully structured around this junction;
- Level crossing down-times and timetable structure on the Richmond corridor which limits this route to today's 12tph peak service level;
- Feltham has one through platform in each direction with all trains calling. This limits the practical capacity to 12tph.

Raising the train service level above this 20tph would necessitate significant infrastructure investment as it would likely require the following scale of enhancements:

- Provision of additional station platform and/or throat capacity at Waterloo;
- Likely provision of a peak-flow platform facility in Platform 2 at Vauxhall (and associated station capacity works);
- Provision of an additional running line through Queenstown Road station that does not impact upon Main Line capacity and/or reconsideration of the number of stopping trains at Queenstown Road;
- Grade-separation of Barnes Junction;
- Three- or four-tracking of most (and likely all) of the route between Barnes and Twickenham, or partial 3 or 4-tracking between Barnes and Hounslow;
- Closure and/or alteration of the level crossings between Barnes and Richmond to permit a substantial increase in train service over them;
- Signalling changes to reduce the current platform re-occupation time at Feltham (and, if applicable, Staines), or provision of additional through platform capacity.

Owing to the scale of cost of these interventions a separate dedicated airport service has been discounted as an option and the capacity of the Windsor Lines has therefore been fixed at 20tph. Allocation of train services, including those to Heathrow Airport, would need to be done holistically in order to achieve a whole-network solution.

Surrey and Hampshire

The known constraints on the corridors that would be used to access Guildford and Basingstoke via Woking are as follows:

- Woking Station – There is a flat junction at the west end of Woking Station. At present, trains arriving into Woking from Guildford (on the 'Up Portsmouth' line) need to directly cross the paths of trains departing from Woking towards Basingstoke or Farnham, before merging with other services towards London at Woking station, ultimately limiting the number of trains that can be robustly accommodated across this junction. This, combined with the intensive level of service with limited platform capacity, constrains the Woking area.
- Level crossings in the Egham Area – There are three level crossings in the Egham Area that cause local road congestion owing to the amount of time that barriers are currently down in the peak. The Office of Rail and Road (ORR) has advised that no additional services can be pathed via Egham in the peak whilst these level crossings are in operation.
- Guildford Station – Guildford Station is not well configured for turnback moves from the Woking direction and its layout lacks flexibility.
- Basingstoke Station – There is a flat junction at Basingstoke which is used by trains from the Reading direction. Trains from London which are turning back at Basingstoke have to cross the whole station layout.

Heathrow Airport

The safeguarded box for southern rail access at Terminal 5 Station can accommodate two platform faces, in addition to the two Heathrow Express platforms currently in operation.

This will likely limit the number of southern access services to 8tph in total, given turnround times and potential crossing moves, and capacity requirement for existing services via Terminals 2&3 and WRLtH services.

4.2 Indicative train service specifications

Heathrow Airport – London Waterloo

A 4tph service from Heathrow to London Waterloo via the Windsor Lines can be achieved by making the following service alterations to the Windsor Lines specification:

- Rebalancing services between the Richmond corridor and Hounslow corridor (as proposed in the Wessex Route Study);
- Replacing the 2tph Waterloo – Weybridge stopping services with 2tph Waterloo to Heathrow services;
- Extending the Hounslow Loop services to Heathrow Airport.

When appraising the Heathrow Airport – London Waterloo services, a shuttle service between Weybridge and Virginia Water has been assumed as a service of this type would be required to replace the connectivity between Chertsey, Addlestone and Weybridge that is lost by removing the 2tph London Waterloo – Weybridge stopping service.

The extension of the Hounslow Loop services to Heathrow results in the loss of direct journey opportunities between the Hounslow corridor and the Richmond corridor.

It is possible to achieve either semi-fast services or stopping services to Heathrow but network capacity necessitates the following patterns would be required:

- 4tph semi-fast services via Richmond.

or

- 2tph stopping services via Richmond and 2tph stopping services via Hounslow.

It is not possible to achieve 4tph stopping services via Richmond, the corridor which offers more economic benefit, owing to network capacity issues so 2tph via Hounslow has been assumed.

Both of these service patterns would provide a 4tph service between Waterloo and Heathrow Airport without breaching the 20tph network capacity limit of the Windsor Lines. Equally, neither option increases the number of train services over the level crossings on the Richmond corridor in the peak.

Surrey and Hampshire

The Market Study indicated that the corridors to Guildford and Basingstoke would provide the most economic benefit for a southern access service. However, to enable the train specifications for the Waterloo – Heathrow corridor, it is necessary to

remove the 2tph Waterloo – Weybridge stopping service. Therefore this flow also needs to be considered as a Heathrow – Weybridge service could replace some of this connectivity.

Therefore, analysis was undertaken on a 4tph stopping service to Surrey and Hampshire in various combinations of the following:

- 2tph Heathrow – Guildford;
- 2tph Heathrow – Basingstoke;
- 2tph Heathrow – Weybridge.

The aforementioned shuttle service between Weybridge and Virginia Water would not be required if Heathrow services were to serve Weybridge.

The analysis identified that a range of enhancements would be required on Wessex Route to accommodate the southern access services. Some of these enhancements have already been identified in the Wessex Route Study as being required in any case to accommodate future SWML demand. Each location and proposed enhancement is detailed below, it is important to note that none of these schemes are currently funded.

Woking Area

The Wessex Route Study proposes grade separation of Woking Junction and an additional platform at Woking Station to enable additional train paths on the SWML. These enhancements would also be required to accommodate train paths for SRAtH. **Image 3** shows the proposed enhancements in the Woking area.

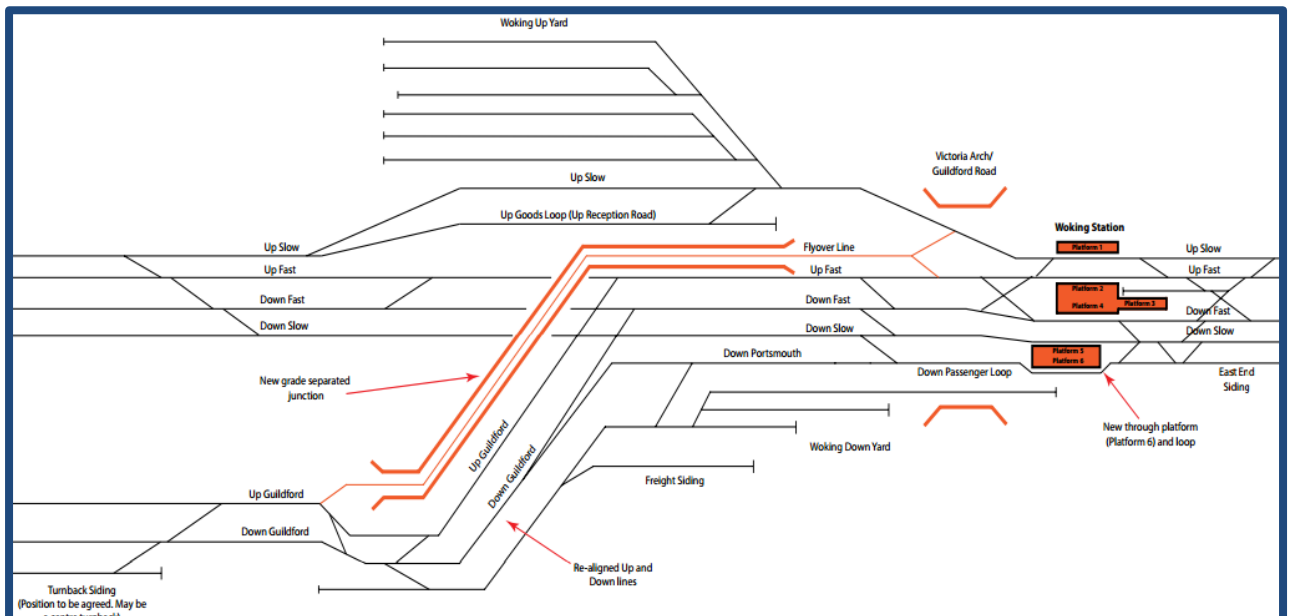


Image 3– Proposed Woking Flyover and new Platform 6

In addition to these infrastructure enhancements, accommodating Heathrow services at Woking would also likely require some alterations to train Line service timings in the contra-peak direction.

Guildford Area

The Wessex Route Study proposes increasing the capability of Guildford Station via alterations to the track layout and at least one additional platform. These enhancements would also be required to accommodate train paths for SRAtH terminating at Guildford.

Basingstoke Area

The Wessex Route Study proposes increasing the capability in the Basingstoke area by grade separating Basingstoke Great Western Junction to enable additional freight, cross-country and SWML train paths. This enhancement would also be required to accommodate SRAtH train paths terminating at Basingstoke. **Image 4** shows the proposed enhancements in the Basingstoke area.

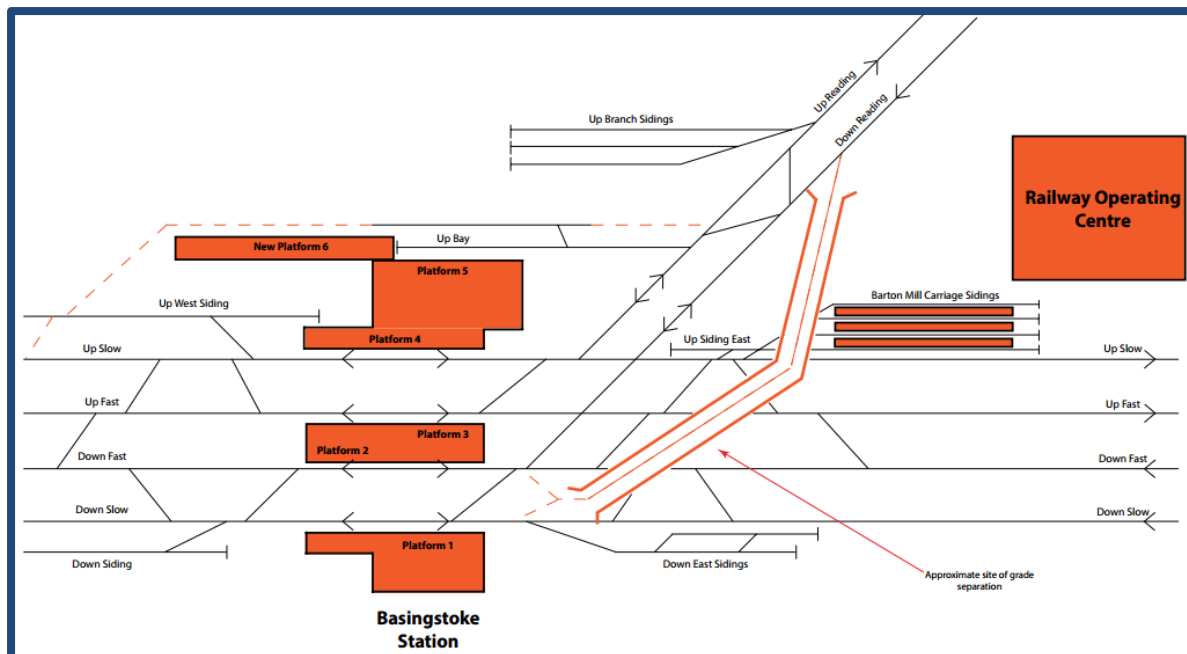


Image 4 – Proposed potential Basingstoke layout

However, owing to the need to turn southern access trains round at the south side of the station, additional turn round capacity would be required in addition to the grade separation works to accommodate SRAtH services. This is discussed in more detail in **Chapter 5**.

Byfleet Curve

Byfleet Curve is located at the junction where the Chertsey Line meets the SWML and is currently used as a freight regulation point. As SRAtH services would increase the number of passenger services running over Byfleet Curve, a freight regulation point may need to be re-provided. This is discussed in more detail in **Chapter 5**.

Heathrow Airport

Heathrow Airport rail infrastructure consists of three stations:

- Terminals 2&3
- Terminal 4
- Terminal 5.

Image 5 below shows the schematic layout of these stations.

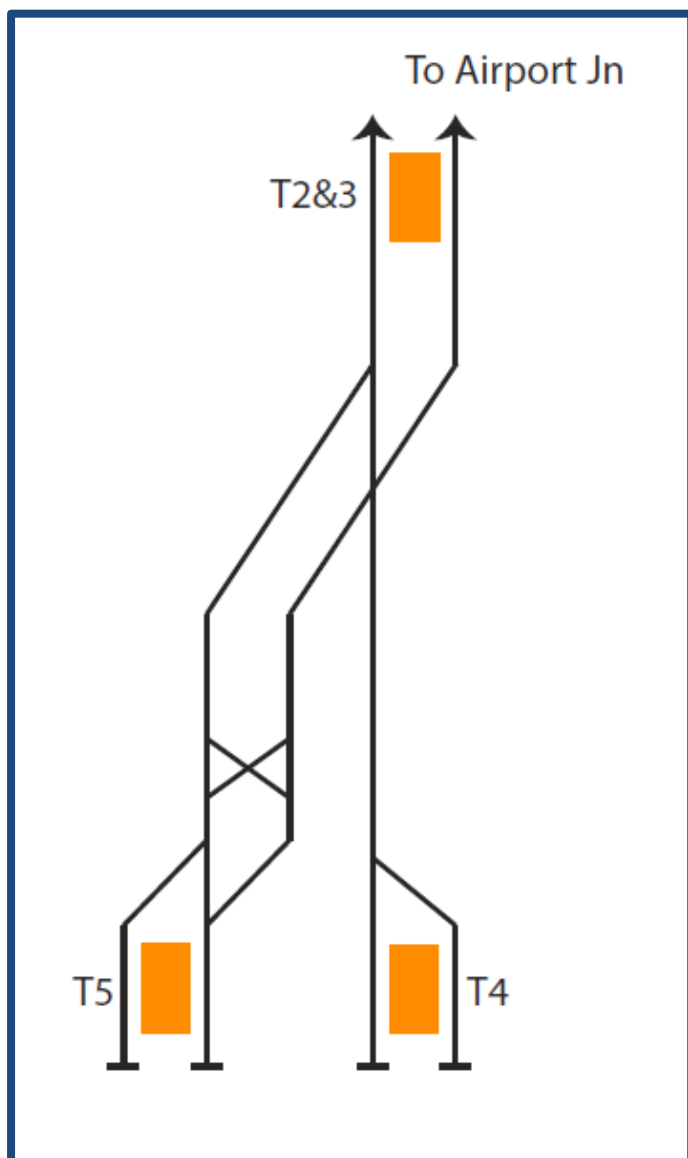


Image 5 – Layout of Heathrow Airport Terminals

By the end of CP6 there is expected to be three rail service groups (excluding the Piccadilly Line) calling at Heathrow Airport:

- Heathrow Express;
- Crossrail;
- WRLtH services.

Heathrow Express

Heathrow Express operates a 4tph non-stop service from London Paddington to Heathrow Terminals 2&3 and then Terminal 5.

Heathrow Express' track access agreement expires in 2023 but for the purpose of this study a 4tph non-stop London Paddington – Heathrow service has been assumed to operate.

Crossrail

Crossrail is a cross-London passenger train service between Reading, Maidenhead and Heathrow Airport in the west and Abbey Wood and Shenfield in the east, via a new tunnel under central London. Crossrail services will be introduced in phases as infrastructure changes and testing is completed, with the route fully operational from 2019.

It will provide new journey opportunities from Heathrow Airport direct to locations across central London and the City. Full implementation will see 4tph in each direction serving Heathrow Terminals 2&3, and then Terminal 4. The majority of these services will originate from Abbey Wood with all running via the Crossrail core and Paddington, and stopping at most stations between Paddington and Heathrow. The 2tph existing Heathrow Connect services will be removed.

Western Rail Link to Heathrow

The development of WRLtH forms part of Network Rail's CP5 Enhancement Delivery Plan, with construction anticipated to be completed in CP6, subject to a satisfactory business case and the agreement of acceptable terms with the Heathrow aviation industry. It is currently in GRIP stage 3 (option selection).

The project aims to deliver a 4tph service between Heathrow Terminal 5 and Reading with optimum journey times. It is anticipated to be operational in CP6 subject to funding, a value-for-money assessment and agreement of acceptable terms with the aviation industry.

Image 6 shows the services that are expected to be in operation at Heathrow Airport by the end of CP6.

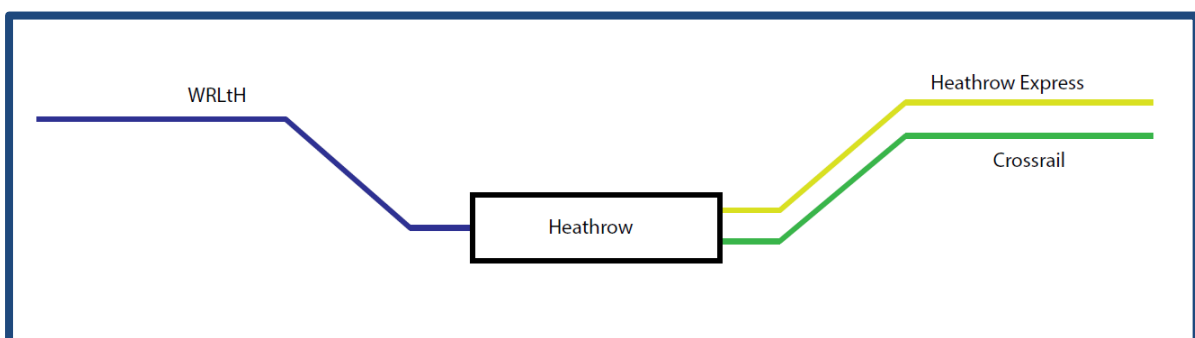


Image 6 – Services in operation at Heathrow Airport at the end of CP6

Section 4.1 has already outlined that the maximum number of SRAtH services that could operate to Heathrow Airport would be 8tph.

There are three options as to how these trains could be pathed at Heathrow Airport. They are broadly as follows:

- Scenario A - All 8tph terminate in Terminal 5;
- Scenario B - 4tph terminate at Terminal 5 and 4tph call at both Terminal 5 and Terminals 2&3;
- Scenario C - All 8tph call at both Terminal 5 and Terminals 2&3.

Scenarios B and C would require a turnback to be located between Terminals 2&3 and the Great Western Main Line (GWML) as no additional services can be accommodated on the GWML owing to it being at full network capacity.

Scenario C would involve the Surrey/Hampshire SRAtH services connecting to the non-stop London Paddington – Heathrow services, creating Surrey/Hampshire – London Paddington through services. It should be noted that this would connect Western Route to Wessex Route, which would have performance implications which would need to be considered when deciding between the three service scenarios.

The three potential service scenarios are shown in **Image 7** below.

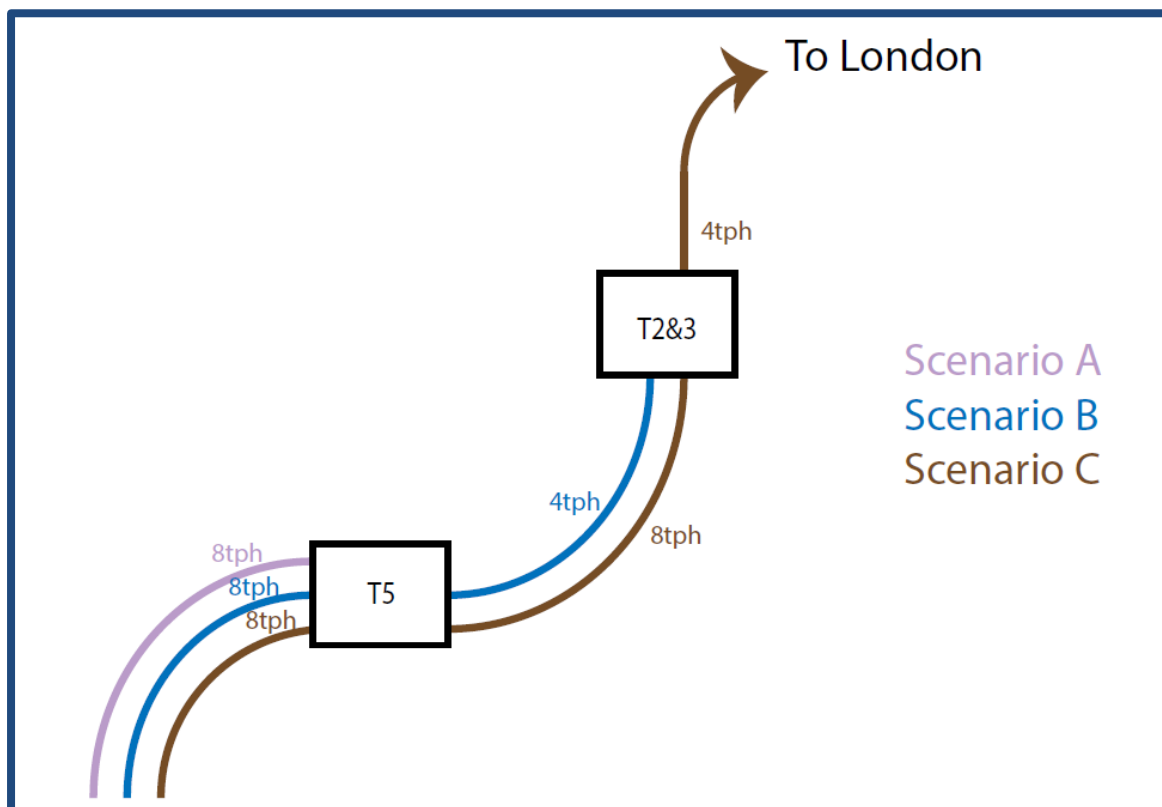


Image 7 – Potential service scenarios for SRAtH at Heathrow Airport

Accommodating all twelve SRAtH and WRAtH services at Heathrow Airport will require trade-offs in connectivity to Heathrow terminals. A holistic study of the Heathrow area would be best placed to determine which flows should serve which terminal stations, and how best to operationally manage the resulting interchange flows

Potential Expansion

Government is currently considering the recommendations of the Airport Commission's report on airport capacity in London and the South East and it is not yet known if any expansion proposals will be progressed.

Heathrow Airport Limited's proposal, which was recommended by the Airports Commission, involves construction of a new Terminal 6 and reconstruction of the current Terminal 5 station to serve both terminals.

This would involve relocation of the Terminal 5 platforms and if these proposals go ahead it would seem sensible for development of SRAtH to be integrated with development of Terminal 6 in order to ensure consistency of the designs at the Heathrow end.

5.0 Infrastructure Option Development

5.1 Approach

Once an understanding of what enhancements would be required to accommodate the proposed train services had been reached, infrastructure options were developed and assessed for their engineering feasibility.

Options were developed for both a new line to access Heathrow Airport from the existing network, and the enhancement works required to increase the capability of the locations on Wessex Route identified in **Section 4.2**.

The feasibility assessment has been undertaken at a pre-GRIP level and used existing maps, drawings and other desktop tools. Site visits were carried out but no survey work has been commissioned. The cost estimates have been developed using Network Rail's standard methodology for projects at an early stage.

Section 5.2 outlines the options developed to access Heathrow Airport from Wessex Route. The feasibility assessment has included the following:

- Engineering feasibility;
- Scale of cost;
- Indicative construction programme;
- Land and consents.

Section 5.3 describes the options to enhance locations on the existing rail network that require increased capacity to accommodate SRAtH services and where a proposed scheme is not already in existence. These locations are:

- Heathrow Airport;
- Basingstoke Station;
- Byfleet Curve.

5.2 Access to Heathrow Airport

Options were developed to provide a range of journey time and service quantum outputs. The range of options accounts for the following range of outputs:

- Direct services from London to Heathrow Airport;
- Direct services from London and Surrey/Hampshire to Heathrow Airport;
- Direct services from London and Surrey/Hampshire to Heathrow Airport which, on the Surrey corridor, bypass the constraint of the level crossings in the Egham Area;
- Direct services from London and Surrey/Hampshire to Heathrow Airport which, on the Surrey corridor, bypass the constraint of the level crossings in the Egham area and also provide a significant journey time reduction between Heathrow and Woking;
- Direct services from London to Heathrow Airport which provide a journey time reduction between London and Heathrow.

Heathrow Airport Terminal 5 station has a safeguarded 'box' that was included in the Terminal 5 designs to enable a future southern rail access link to connect to the terminal more easily. The box includes a set of stub tunnels which allows easier access from the west side of the airport. Therefore Options 1 – 3 below connect in to Heathrow Terminal 5 from the westerly direction. However, Option 4 considers the feasibility of accessing Heathrow Airport from an easterly direction.

It should be noted that it is likely there are other viable alignments that could be considered if the scheme is progressed further. These alignments were, however, deemed appropriate to deliver the outputs listed above.

Both the strategic outcomes listed in **Chapter 3** and the outputs listed above are broadly limited to improving journey opportunities. In this Study, Network Rail has not sought to maximise any potential local regeneration opportunities that could exist in some southern access alignments. However, it should be noted that should housing growth and regeneration be a priority or requirement of the scheme funder, this could feasibly influence the potential alignments in the next stage and increase the likelihood of third party funding contributions.

Option 1A

Option output and description

Option 1A enables 4tph to access Heathrow Airport from the London direction. This alignment provides a route from the Staines vicinity of the Windsor Lines to the west end of Heathrow Terminal 5. **Image 8** shows where the indicative Option 1A alignment would join the existing network, which is similar to that developed for the original Airtrack scheme.

The new route diverges from the Staines - Windsor line north west of Staines at surface level and remains as such until it enters into tunnel to access Heathrow Airport Terminal 5 station.

Using this alignment, the journey time from Staines to Heathrow Terminal 5 would be approximately 6 – 7 minutes.

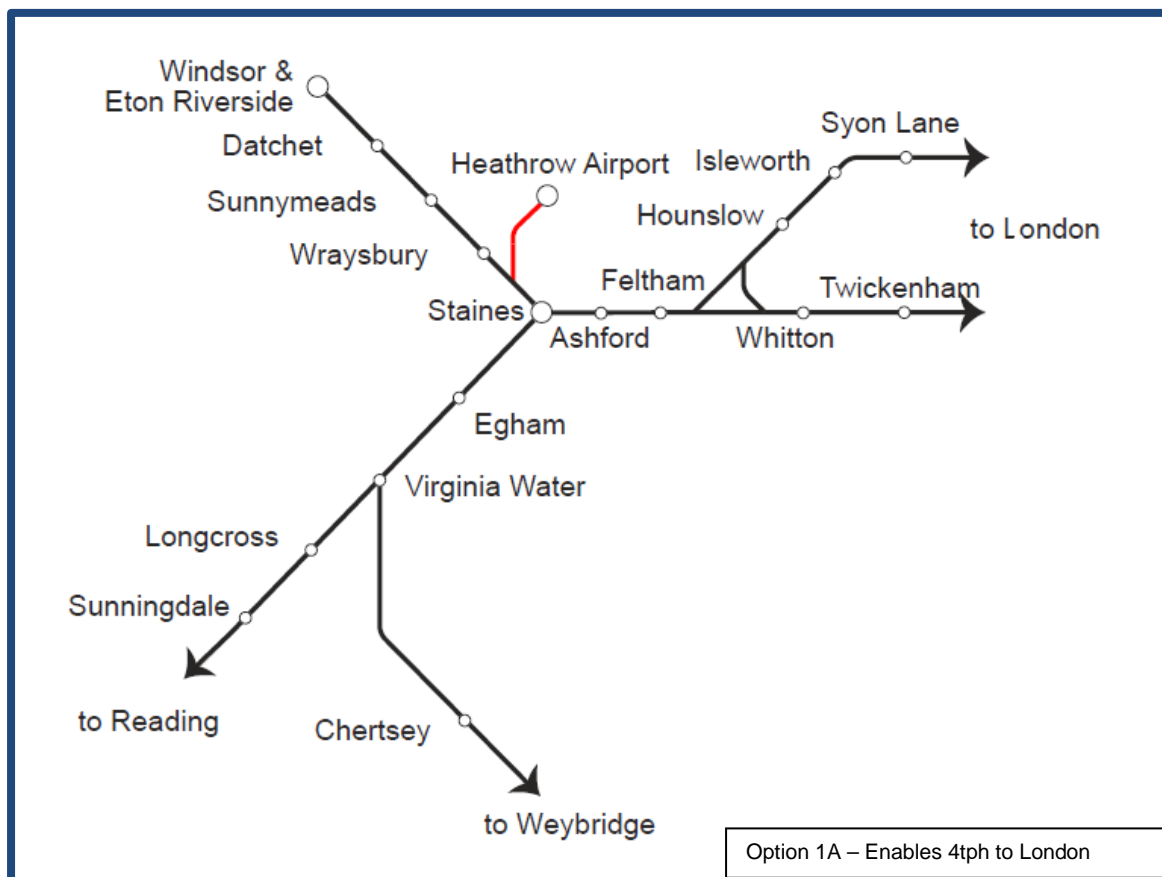


Image 8 – Option 1A indicative alignment

Engineering feasibility

The choice of alignment is heavily constrained by the existing Wraysbury and King George VI reservoirs, the adjacent M25 motorway and the presence of a large borrow pit which dates from the time of the motorway's construction. The area is generally flat, dominated by motorway and the embankments surrounding the reservoirs.

The River Colne and the Wraysbury River also run in a general north to south direction (towards the River Thames) parallel with the proposed alignment.

The tunnelled section of the proposed alignment passes under the A3113 (Airport Way), the A3044 (Stanwell Moor Road) and the airport's Western Perimeter Road. The information currently available suggests that the existing stub tunnels to the west of Terminal 5 (to which the new alignment must connect) end under the Western Perimeter Road. The shallow depth of these stub tunnels suggests that it might be technically difficult to create a tunnel that connects directly to them without disrupting use of the carriageways that lie above. This risk would need to be further investigated as part of any future development of the scheme.

The M25 motorway lies immediately to the west of the alignment. There are a number of significant structures at Junction 14 of the motorway that are likely to be supported on piled foundations. However, the proposed alignment is believed to pass

far enough from any piles for the effects of tunnel construction to be negligible, but this is a matter that would also require further investigation.

A single footpath across Staines Moor would require diversion to accommodate the proposed alignment.

It should be noted a significant length of the existing Windsor Line, with which the proposed new track connects, is below the 1 in 1000 year flood level (Flood Zone 2) advised for planning purposes by the Environment Agency. This necessitates that flood prevention measures be built into the scheme design.

Land and consents

Acquiring the land necessary to construct this alignment will require Compulsory Purchase powers obtained through a Development Consent Order (DCO). Where possible, purchase can be agreed by private treaty via engagement with affected landowners.

The DCO process is lengthy and complex. There are fixed statutory timescales set out for the process and there is an extensive amount of pre-application work. The application and professional fees alone for a DCO of this size would be significant. Broadly speaking, a DCO would provide for:

- Development consent (planning permission);
- Environment Permits;
- Powers to construct, alter, maintain and operate;
- Powers to interfere with navigation rights;
- Compulsory acquisition (temporary and permanent);
- Amendments to, or exclusion of, other legislation;
- Closure or alteration of roads and footpaths.

This alignment is also at risk of becoming subject to Special Parliamentary Procedure (SPP) owing to the amount of open space and common land affected by this route. There is no fixed timescale for SPP but ordinarily one would expect it to take a minimum of 12 months.

An assessment of likely claims and compensation has been undertaken using desktop investigations. The scheme cost below therefore includes an allowance for land and consents, but does not include potential legal fees required for the DCO. At this early stage of development land registry title searches, site surveys and intrusive investigations have not been undertaken.

The land parcels affected by this alignment are predominantly open space but some highways and industrial land are also included.

Scale of cost

This scheme has been estimated to cost £700 - £900m in 1Q15 prices.

This cost does not include future inflation, asset resilience, power supply upgrades or potential depot and stabling requirements.

Indicative construction programme

An early estimation of construction duration has been undertaken. Options 1A and 1B were assessed jointly and this can be found in the assessment of Option 1B below.

Option 1B

Option description

Option 1B enables 4tph to access Heathrow Airport from the London direction and 2-4tph from the Surrey/Hampshire direction. This option involves the same alignment as Option 1A above but also includes a railway chord in the Staines vicinity that enables services to access the Egham Line to then continue on to Surrey/Hampshire destinations.

The former West Curve at Staines remained in occasional use for freight traffic until the mid-1960s after which time the embankment that carried it was removed and a multi-storey car park built on part of the site. The current Staines Chord proposal recreates this connection on a similar alignment. The indicative location of where the new alignments would join the existing network is shown in **Image 9**.

Using this chord, the journey time from Woking to Heathrow Terminal 5 would be approximately 32 – 37 minutes.

⁵ The first quarter of 2015.

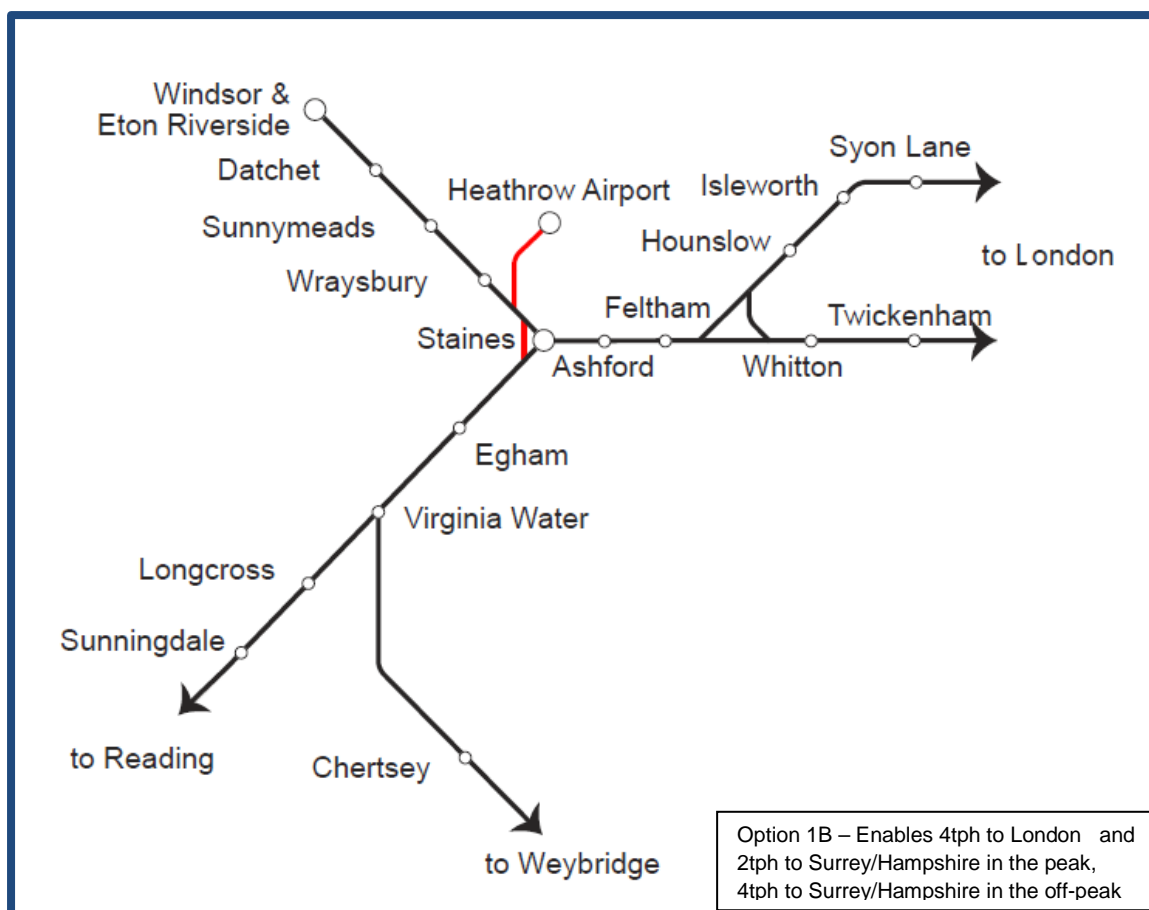


Image 9 – Option 1B indicative alignment

However, as mentioned in **Chapter 4**, no net additional services can be pathed via Egham in the peak in order to prevent any increase in the down-time of level crossings in the Egham area. This limits the number of potential Heathrow services from Surrey/Hampshire to two in the peak (replacing the two Weybridge-Waterloo stopping services, which also need to be removed to allow operation of Waterloo-Heathrow services due to capacity constraints between Feltham and Waterloo), though 4tph could potentially be achieved in the off-peak if the service level was increased to match that in the peak.

Network Rail always intends to close level crossings to remove any interface between road and rail, especially if projects are undertaking works in the area or changing the train service which runs over them. Though the closure of these level crossings has not been examined in detail in this Study (and therefore relevant costs are not included at this stage of development), the closure of any level crossing is a substantial undertaking and, in the case of these crossings, would involve significant infrastructure interventions, and significant funding, combined with input from local stakeholders and the local authority.

If Option 1B is taken forward, level crossings closure will be examined in more detail and costed at the next stage of development. A review of the business case presented in **Chapter 6** would therefore be required, noting that there is always a strong safety case supporting level crossing closure.

Engineering feasibility

The site of the proposed chord is located in central Staines and runs roughly parallel to the town centre by-pass (the A308) across an area largely dedicated to the provision of car parking serving the adjacent shopping centre. An access ramp serving the car park would need to be reconstructed on a new alignment.

This is discussed further in the land and consents section below.

The alignment of the chord is substantially dictated by existing developments adjacent to Staines town centre.

Land and consents

Acquiring the land necessary to construct this alignment will require Compulsory Purchase powers exercised through a DCO. The provisions and issues surrounding a DCO for Option 1A also apply here. As per the previous option, an allowance for land and consents has been included in the scheme cost below, but it does not include potential legal fees required for the DCO.

Some of the land parcels affected by this alignment are open space, highways and industrial land as outlined in Option 1A. However, this option also necessitates acquisition of land in commercial use which is of higher value and may be more complex to acquire.

Scale of cost

This scheme has been estimated to cost £800m - £950m in 1Q15⁶ prices for both the new line to Heathrow and the chord at Staines.

This cost does not include future inflation, asset resilience, power supply upgrades, potential depot and stabling requirements and any required alterations to or closure of level crossings.

Indicative construction programme

At this early stage, the construction period of Option 1B is estimated to be approximately five years. This would follow design development, any necessary land acquisition, consents and discharge of consent conditions of the scheme which would likely take four - six years.

Option 2

Option 2 enables 4tph to access Heathrow Airport from the London direction and 4tph all day from the Surrey/Hampshire direction. This is achieved via a new tunnelled rail alignment which by-passes the level crossings in the Egham area. It also provides a journey time improvement on the Heathrow – Surrey/Hampshire flow.

⁶ The first quarter of 2015.

The route is tunnelled out of Heathrow Airport and then rises to surface level to enable a spur to the Windsor lines, providing Heathrow – London services. The main route then returns to tunnel and goes under the Windsor Lines and the Egham area until it rises to re-join the existing network between Egham and Virginia Water. The indicative location of where the new alignment would join the existing network is shown in **Image 10**.

This alignment avoids increases in level crossing down time in the Egham area (removing this as the ruling constraint on the level of train service that can operate) but means that Heathrow services could not call at Egham station.

Using this alignment, the journey time from Woking to Heathrow Terminal 5 would be approximately 28 – 33 minutes.

Infrastructure constraints at Heathrow mean that 4tph is likely to be the maximum practical frequency achievable via this alignment, when combined with 4tph between Heathrow and Waterloo in the Heathrow area.

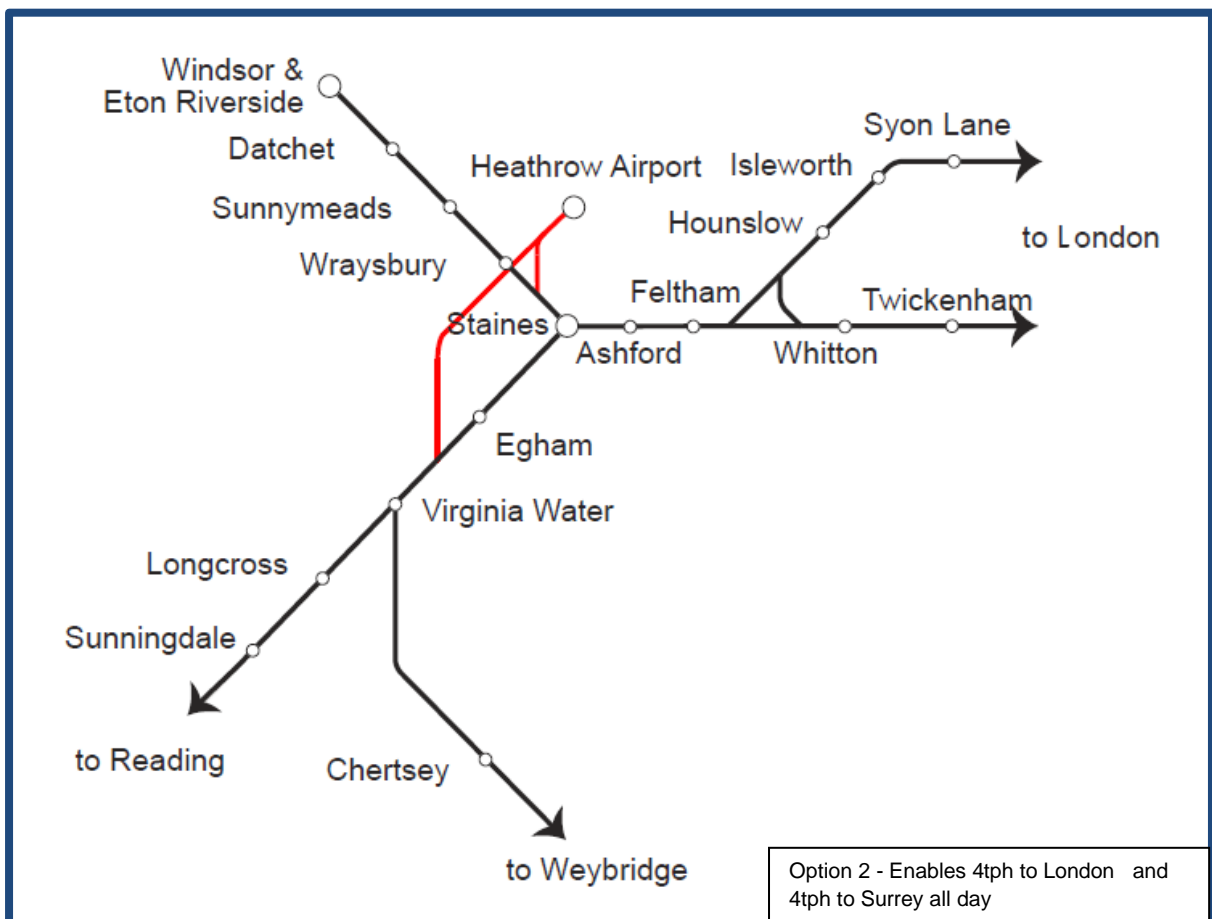


Image 10 – Option 2 indicative alignment

Engineering feasibility

The well-developed urban area surrounding Egham, land in National Trust ownership at Runnymede and the deep foundations of structures around M25 Junction 13 (including Runnymede Bridge across the River Thames) place significant constraints on the potential alignment of tunnels beneath the area.

In addition, historical gravel workings exist to the east of the M25 motorway which includes Queensmead Lake. Further investigations would be required to determine the bed level of these workings and whether or not they might need to be locally filled to provide an adequate amount of cover to the crown of the tunnel to allow a tunnel boring machine to pass safely beneath.

The Wraysbury River lies to the west of the northern section of the proposed alignment and the River Colne to its east. Both rivers flow in a general north to south direction parallel to this part of the alignment. However, the Wraysbury River turns slightly to the east at the southern end of Staines Moor before re-joining the River Colne in central Staines. As a result, the Wraysbury River would likely need to be diverted locally to make space for the northern portal of the tunnel under Egham. The tunnel portal itself and its approaches will require careful bunding to ensure that an appropriate threshold is provided at the entrance to the tunnel to ensure it is not inundated when the area is subject to flooding.

The section of route across Staines Moor faces the same issues as described in Option 1A.

Scale of cost

This scheme has been estimated to cost £1.4bn - £1.8bn in 1Q157 prices.

This cost does not include future inflation, asset resilience, power supply upgrades or potential depot and stabling requirements.

Indicative construction programme

At this early stage, the construction period of Option 2 is estimated to be approximately five-six years. This would follow design development, any necessary land acquisition consents and discharge of consent conditions of the scheme which would likely take four-six years.

Land and consents

Acquiring the land necessary to construct this alignment will require Compulsory Purchase powers exercised through a DCO. The provisions and issues surrounding a DCO for Option 1A also apply here, including the risk of being subject to SPP. As per the previous options, an allowance for land and consents has been included in the scheme cost below, but it does not include potential legal fees required for the DCO.

⁷ The first quarter of 2015.

The number of landowners affected by this alignment is higher than Option 1A or 1B owing to the alignment being more extensive. Land use includes open space, residential and industrial. A large amount of the alignment is in tunnel at which only sub-surface land acquisition is required. However, the alignment is at surface level at its extremities which therefore necessitates surface level land acquisition.

Option 3

Option description

Option 3 enables 4tph to access Heathrow Airport from the London direction and 4tph all day from the Surrey/Hampshire direction with a more significant journey time reduction for the latter flow. This is achieved via a more extensive surface level rail alignment which also by-passes the level crossings in the Egham area.

The route is tunnelled out of Heathrow Airport and then rises to surface level to enable a spur to the Windsor lines, providing Heathrow – London services. The Surrey/Hampshire route remains at surface level and runs alongside the M25 motorway to the Virginia Water – Weybridge line, re-joining the existing network between Virginia Water and Chertsey. This facilitates significantly shorter journey times to Weybridge, Woking and beyond than are possible via Options 1B or 2.

The indicative location of where the new alignment would join the existing network is shown in **Image 11**.

This alignment also avoids increases in level crossing down time in the Egham area (removing this as the ruling constraint on the level of train service that can operate) but means that Heathrow services could not call at Egham or Virginia Water stations.

Using this alignment, the journey time from Woking to Heathrow Terminal 5 would be approximately 23 – 28 minutes.

Infrastructure constraints at Heathrow mean that 4tph is likely to be the maximum practical frequency achievable via this alignment, when combined with 4tph between Heathrow and Waterloo in the Heathrow area.

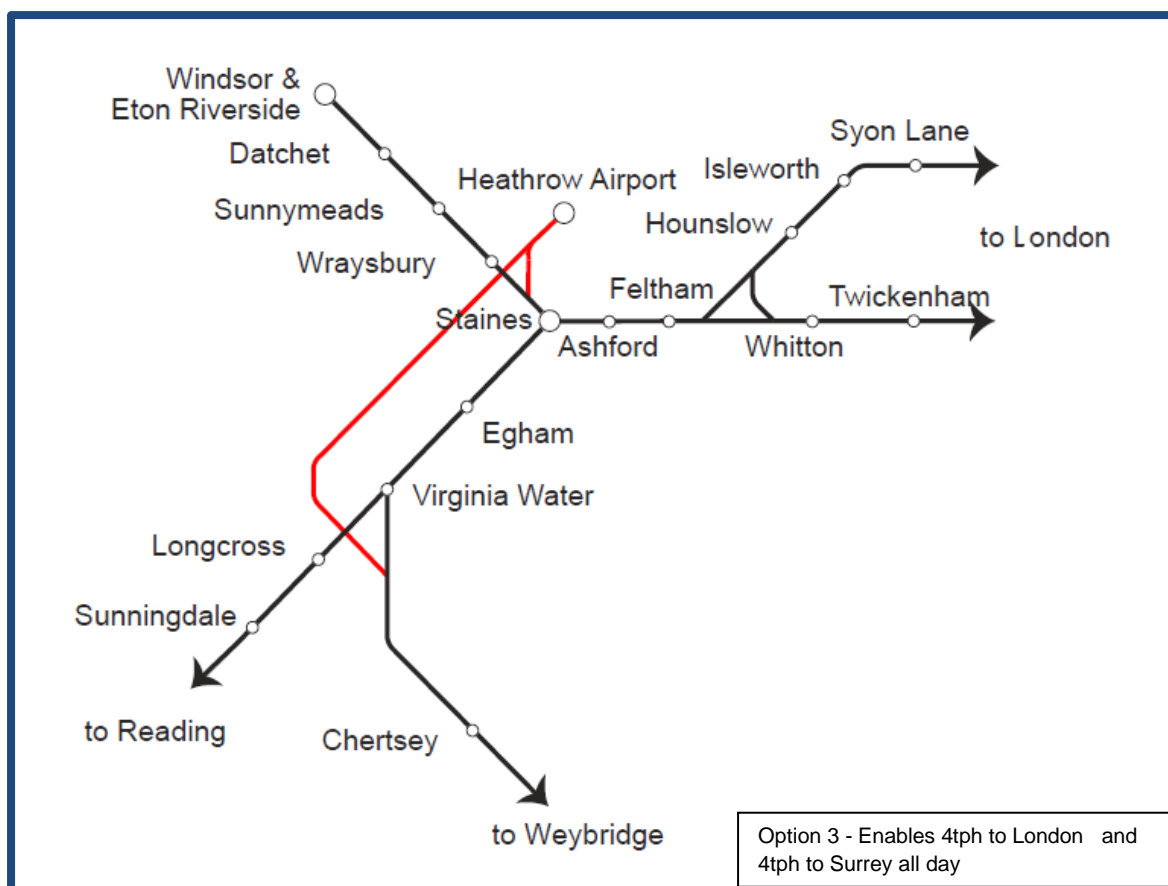


Image 11 – Option 3 indicative alignment

Engineering feasibility

Possible corridors in which to construct a new railway southwards towards Chertsey are significantly constrained by existing urban developments, the M25 motorway and the River Thames. In practical terms the choice of surface level alignment is limited to one that follows the east side of the M25 motorway as closely as possible.

Construction of three major new structures (in addition to numerous single span bridges and culverts) will be required to carry the proposed route across:

- the River Thames at Runnymede;
- the southbound M25 off slip road at Junction 13;
- the M3 motorway at Junction 12.

A new Runnymede railway bridge would be situated immediately to the east (downstream) of the existing M25 motorway bridge across the River Thames. Extreme care would be needed in the design and detailing of the new railway bridge to ensure that its sensitive treatment complements that of the adjoining structures.

The M25 motorway is carried on an embankment south of the River Thames and passes over the A308 on a two span bridge. At this point an off slip road diverges from the southbound (anti-clockwise) carriageway to join the A308 immediately to the east of the Runnymede roundabout. There is an extremely limited amount of land available at this point in which to divert the proposed alignment of the new railway

further from the M25 motorway to create headroom over the existing slip road. The result of this is that the railway must be carried on a high viaduct well above surrounding ground level, causing potentially severe visual intrusion and significant environmental impacts.

Junction 12 of the M25 is where it crosses the M3 motorway and is therefore an important node on the national motorway network. Slip roads are provided at the junction to facilitate the flow of traffic in all directions to and from the M3 motorway and as a result the junction comprises a complex arrangement of slip roads on multiple levels. Care will be required in the design of the new railway viaduct crossing the junction to ensure that neither its construction nor future maintenance interfere with the free flow of traffic on the motorways beneath.

It should be noted that this alignment would result in the most visual intrusion due to the extent of the surface level infrastructure and its height in some locations.

The section of route across Staines Moor faces the same issues as described in Option 1A.

Land and consents

Acquiring the land necessary to construct this alignment will require Compulsory Purchase powers exercised through a DCO. The provisions and issues surrounding a DCO for Option 1A also apply here, including the risk of being subject to SPP. As per the previous options, an allowance for land and consents has been included in the scheme cost below, but it does not include potential legal fees required for the DCO.

The number of landowners affected by this alignment is higher than all previous options due to the alignment being more extensive. Land use includes open space, residential and highways/roads.

The exact scope of land acquisition required for an alignment of this type would become clearer when the full extent of the construction requirements along the route is better understood after further scheme development.

Scale of cost

This scheme has been estimated to cost £1.4bn - £1.8bn in 1Q158 prices.

This cost does not include future inflation, asset resilience, power supply upgrades or potential depot and stabling requirements.

⁸ The first quarter of 2015.

Indicative construction programme

At this early stage, the construction period of Option 3 is estimated to be approximately 5-6 years. This would follow design development, any necessary land acquisition consents and discharge of consent conditions of the scheme which would likely take four-six years.

Option 4

Option description

Unlike the previous alignments, Option 4 considers the feasibility of approaching Heathrow Airport from the easterly direction. The route considered here is a new tunnelled rail line from west of Feltham to Heathrow Terminals 2&3 with services then continuing on to Terminal 5. In this Study, the Option 4 alignment has only been considered in relation to the London flow, it is shown in **Image 12**.

An alignment of this type would result in reduced journey times from locations east of Feltham to Heathrow Airport as services would travel less distance on the existing network before branching off to Heathrow. However, it would result in airport services being unable to call at Staines.

Using this alignment, the journey time from Feltham to Heathrow Terminals 2&3 would be approximately 4 – 5 minutes.

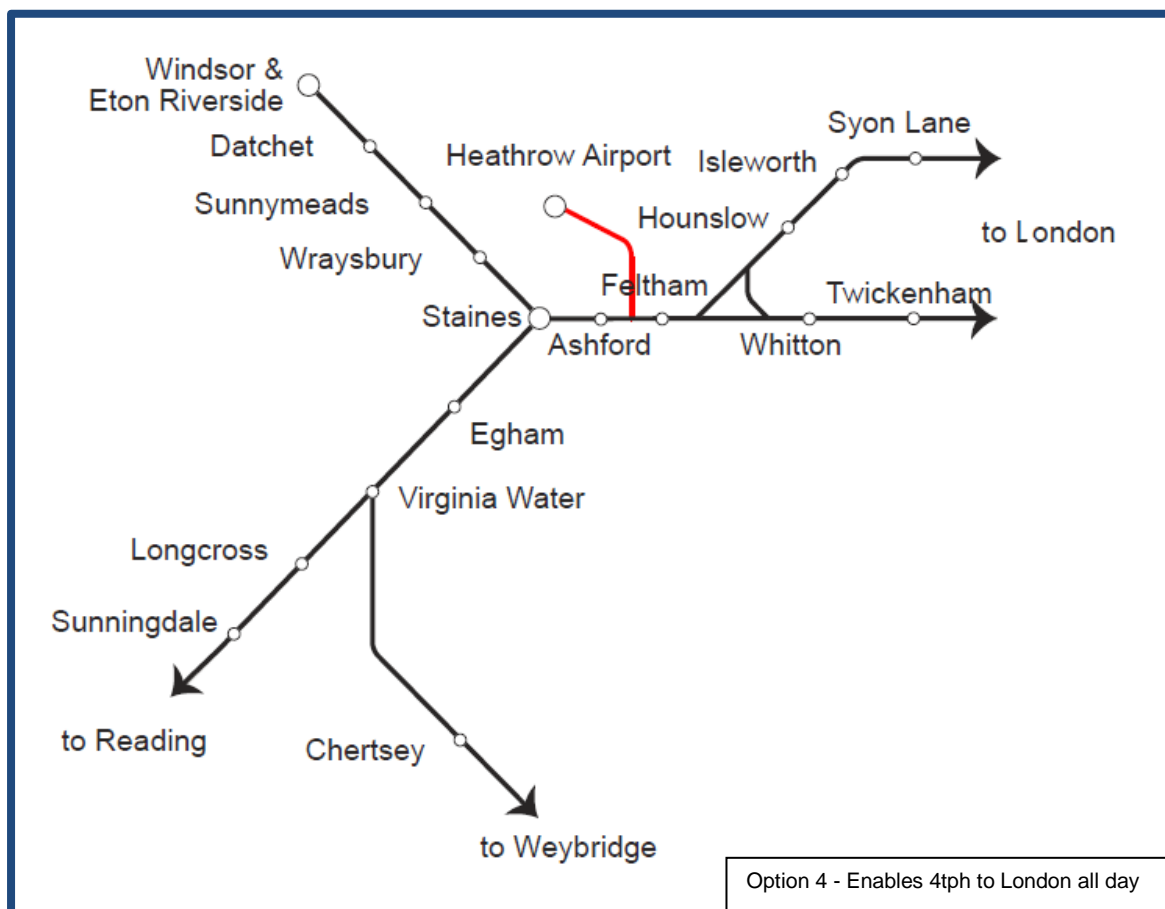


Image 12 – Option 4 indicative alignment

Engineering feasibility

The proposed alignment is significantly constrained by the pattern of urban development that has historically taken place in the area and the need to minimise the effects of potential surface settlement, caused by tunnelling operations, on existing properties.

The southern end of the alignment is shown as being constructed in retained cut / cut and cover tunnel in order to minimise long term land take and to reduce likely severance issues. The southern end of the alignment may equally well be constructed in bored tunnel as an extension to that proposed north of the A30 road, but at the expense of increasing the construction period required.

The northern end of the route would need to connect in to the two existing tunnels to the north of Terminals 2&3 that are currently used by Heathrow Express and will be used by Crossrail from 2019. The existing tunnels follow substantially the same vertical alignments, which would necessitate construction of an underground flat junction with the proposed new route. This is likely to create a very significant operational constraint.

At surface level, this area of the airport is occupied by aircraft stands, taxiways and one of the airport's two main existing runways. Whilst construction of such a junction might be technically feasible (extensive investigation has not been possible at this pre-GRIP stage of development), the risks inherent in its construction, together with its impact on the operation of existing train services and the airport itself, would make an alignment of this sort undesirable in engineering terms.

It is therefore recommended that an alignment that accesses Heathrow Airport via Terminals 2 & 3 should not be considered in future stages of development due to the engineering complexities associated with joining the existing Heathrow Express tunnels.

Land and consents

Acquiring the land necessary to construct this alignment will require Compulsory Purchase powers exercised through a DCO. The provisions and issues surrounding a DCO for Option 1A also apply here, including the risk of being subject to SPP. As per the previous options, an allowance for land and consents has been included in the scheme cost below, but it does not include potential legal fees required for the DCO.

The most prominent feature of the proposed route is Bedfont Lakes Country Park which was formerly an area of gravel and sand workings later backfilled with refuse. Following appropriate remediation work the country park was created in the early 1990s and is now an important local amenity. It became a Local Nature Reserve in 2000 and a Site of Importance for Nature Conservation (of Metropolitan Importance) in 2007.

The alignment also encounters an in-use quarry, a business park and an industrial estate. The alignment shown in **Image 14** assumes cut and cover construction at the

southern end of the alignment, but further investigation into the land use of the area indicates that a fully tunnelled approach would be more acceptable in order to minimise disruption and claims from existing landowners.

Therefore the scheme costs below assume a fully tunnelled alignment.

Scale of cost

The cost of Option 4 is significantly higher than Option 1A due to the extent of tunnelling involved and the complexities of the construction of the junction with the existing tunnels.

This scheme has been estimated to cost £1.0bn - £1.4bn in 1Q15 prices.

This cost does not include future inflation, asset resilience, power supply upgrades or potential depot and stabling requirements.

Indicative construction programme

At this early stage, the construction period of Option 4 is estimated to be approximately 5-6 years. This would follow design development, any necessary land acquisition consents and discharge of consent conditions of the scheme which would likely take four-six years.

5.3 On-network works

Heathrow Airport

As described in **Chapter 4**, there are service scenarios that involve WRLtH or SRAtH services continuing beyond Terminal 5 to Terminals 2&3 but needing to turnback before reaching the GWML, which is at full capacity. To enable this, a turnback siding at Airport Junction has been designed.

Implementing the turn back could potentially reduce the linespeed of the line from the GWML to the Heathrow branch by approximately 5mph. It is not possible to carry out detailed track modelling this early in the project lifecycle so the potential impact of this linespeed reduction is not yet known. The impact would need to be quantified in the next stage of development as any solution that compromises the capacity of the GWML would not be viable.

This scheme has been estimated to cost £20m – 30m in 1Q15 prices. This cost does not include potential land purchase or future inflation.

Basingstoke

As described in **Chapter 4**, if southern access services terminate at Basingstoke additional turnback capacity would be required at the south side of the station in addition to the grade separation works proposed in the Wessex Route Study.

If these proposals are not to be prejudiced, the range of options available for provision of a new turnback facility, and its associated platform, are somewhat limited. This Study assumes construction of a new platform, as an eastern extension to the existing Platform 1. The indicative alignment for this scheme can be seen in **Image 13**.

This scheme has been estimated to cost £30 – 40m in 1Q15 prices. This cost does not include potential land purchase or future inflation.

Ideally, development of a scheme such as this would be integrated with any other enhancements in the Basingstoke area, such as the aforementioned grade separation, to achieve the optimum solution.

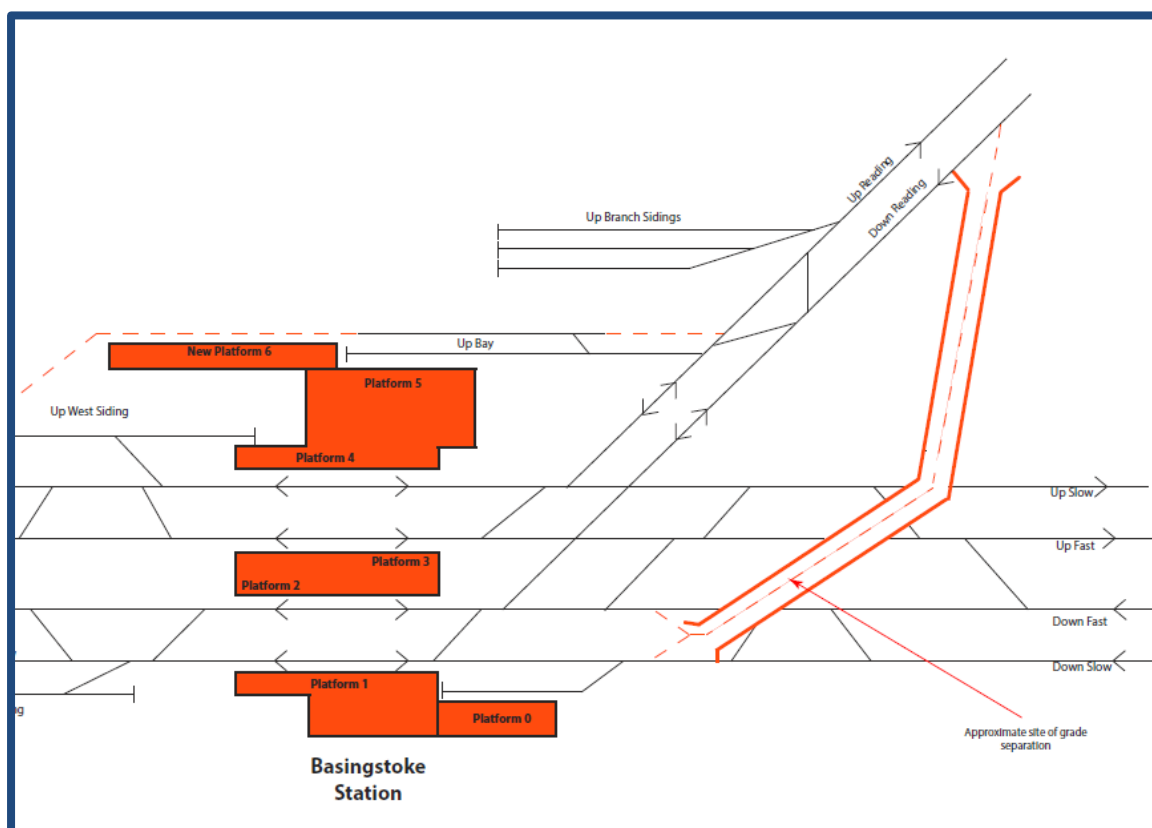


Image 13 – Basingstoke additional platform indicative alignment

Byfleet Curve

As described in Chapter 4, Byfleet Curve is located where the Chertsey Line meets the South West Main Line and is currently used as a freight regulation point, due to the infrequent passenger service over this section of route. As Southern Rail Access services would increase the number of passenger services running over Byfleet Curve, a freight regulation point may need to be re-provided.

Although the area surrounding the Virginia Water – Weybridge line is not heavily developed, there are few areas along the route where the distance between line side

developments is sufficient to provide space for a freight loop capable of accommodating a 775m long train.

The only area where freight refuge capable of accommodating a 775m train might be provided without infringing on existing residential and commercial development is the Addlestone Moor area. **Image 14** shows one potential layout for a central freight regulation point in this location.

This scheme has been estimated to cost £35m – 45m in 1Q15 prices. This cost does not include potential land purchase or future inflation.

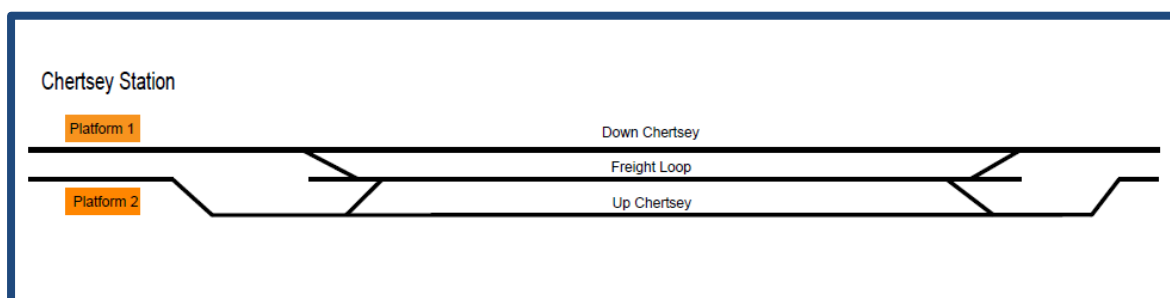


Image 14 – Freight recess facility indicative alignment

5.4 Other Key Considerations

Digital Railway

The Digital Railway is an industry-wide programme designed to benefit Great Britain's economy by seeking to accelerate the digital enablement of the railway in several key areas, including infrastructure, train operation, capacity allocation, ticketing and stations. On Wessex Route this could include new signalling technologies to help increase the capacity of the network.

The timescales for the rollout of digital railway technology across the country are not yet known; however, as the two programmes continue to develop, the SRAtH scheme will be able to take advantage of the opportunities and benefits proffered by digital railway solutions.

Operational arrangements

The Digital Railway programme is examining the potential acceleration of the implementation of ETCS across the network. As the output of this work is not yet known, this Study has assumed conventional signalling on the new rail alignments. This assumption should be reviewed at the next stage of development.

The new alignments would tie in to Wessex Route in an area that will be controlled from the new Basingstoke ROC (Rail Operating Centre) from the end of CP5. Depending on the alignment chosen, a new workstation may be required in the ROC to enable control of the new sections of network. This will need to be considered further when more details of the scheme are known and workload assessments can be carried out in later GRIP stages.

Alternatively, the new alignment could potentially be controlled from the Thames Valley Signalling Centre on Western Route, which could have the same issue with workstation capacity.

Station Capacity

An assessment of station capacity was undertaken to establish whether the additional passengers from a southern access service would make a significant difference to passenger flows at Wessex stations.

Due to the existing high volume of passengers in the peak on Wessex stations, the addition of southern rail access passengers would mean only a small percentage increase in station patronage in the peak. This is unlikely to warrant any capacity driven station enhancements.

However, the accessibility of affected stations would need to be reviewed should the scheme be developed further as some stations do not have lifts and are likely to see an increase in the number of passengers with luggage.

Electrification Arrangements

Wessex Route, along with the wider Southern network, is DC electrified (third rail) whereas Western Route, including Heathrow Airport, is AC electrified (overhead line). Linking these two networks therefore requires careful consideration of how the electrification arrangements are managed.

Where possible, Network Rail tries to avoid new sections of DC electrification in order to meet ORR policy. Therefore this study has assumed that the new rail alignments are AC electrified and that the AC electrification would be extended onto the Wessex network. This would result in short sections of route with both AC and DC electrification which would require immunisation. Rolling stock would therefore need to be dual voltage (capable of running on both AC and DC networks).

If the scheme were to progress further, more detailed consideration of electrification designs and the resulting operational arrangements would be required.

Power Supply

The value-for-money assessment in **Chapter 6** does not include any costs for power supply enhancements. It is not yet known if any power supply upgrades would be required to support the levels of service proposed in **Chapter 4**.

This would need further investigation at the next stage of development.

Rolling Stock

A diagramming exercise has indicated that the London – Heathrow services would be broadly diagram neutral as the removal of the London - Weybridge stopping service counters the extension of the looping services. If a half-hourly local shuttle

service were run on the Chertsey corridor to replace the connectivity lost by the removal of the Weybridge stopping service, this would likely require two additional units.

The Surrey/Hampshire options require approximately 10 – 12 additional units depending on the service option chosen.

As stated in the previous section, the current assumption is that any rolling stock serving Heathrow Airport would need to be dual voltage in order to run on both DC and AC networks.

Depots and Stabling

The incumbent operator of the South West franchise has indicated that after the implementation of the Wessex Capacity Programme, there will be no spare depot capacity in the areas in question.

This infers that the implementation of a southern access scheme that requires additional rolling stock would likely require new depot facilities. New depot and stabling locations and designs have not been considered in this study and therefore the value-for-money appraisals in **Chapter 6** have not accounted for this potential cost.

The Airtrack scheme included a proposal for a new depot in the Feltham area.

Maintenance and Resilience

Network Rail currently carries out its asset maintenance duties between the hours of 0100 and 0500 on Wessex Route. If this regime were to be continued, a new southern access service could not operate in these hours which would prevent a 24-hour service offering.

If a 24-hour service offering were desired, as is often the case for airport services, asset maintenance on the route would need to be re-assessed and a new approach developed.

Additionally, the increased number of services on the network would have an impact on asset resilience. It is likely that some assets on the Wessex network at key junctions or track sections would need to be replaced to enable them to be renewed less frequently in the longer-term. The value-for-money appraisal in Chapter 6 does not account for these works as at this stage the potential scope and cost of the works are not known. However, these works should be defined and included in future cost estimates of the scheme in the next stage of development.

If the aforementioned 24-hour service were implemented, this asset replacement would be more extensive to support an alternative maintenance strategy along with potential new infrastructure to support diversionary route capability.

6.0 Value-for-Money Assessment

6.1 Key Findings

The options appraised demonstrate a wide range in the value-for-money of potential service specifications. The assessment suggests that the highest value-for-money southern rail access link service, serving both the London and Surrey/Hampshire markets, would be (assuming only 4 trains per hour (tph) can continue beyond Terminal 5 to Terminals 2&3):

- semi-fast London Waterloo – Heathrow services on the Western alignment infrastructure (Option 1A), calling at both Terminal 5 and Terminals 2&3 at Heathrow Airport; plus,
- Surrey/Hampshire services on the Staines Chord infrastructure (Option 1B), calling at T5 only at Heathrow.

A range of options were tested looking at reduced journey times and different calling patterns for the Surrey and London services, extending Surrey services through to Terminals 2&3 and onwards to Old Oak Common and London Paddington. Sensitivity tests have also been carried out for higher Heathrow demand forecasts, reduced operational expenditure savings, capital costs and higher values of time.

The following diagram shows the value-for-money category under a range of different scenarios and shows which London and Surrey/Hampshire options offer the best value-for-money and their categories both separate and combined.

<i>Value-for-Money category and best option</i>	<i>Best London option</i>	<i>Best Surrey/Hampshire option (as an increment to London services)</i>	<i>Case for combined option</i>
<i>Two runway demand⁹</i>	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
<i>Two runway demand, fewer stops in Surrey/Hampshire services</i>	NA	Option 1B, services from Guildford and Weybridge	
<i>Two runway demand, London and Surrey/Hampshire services through to Terminals 2&3 and GWML¹⁰</i>	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
<i>Three runway demand (low)</i>	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
<i>Three runway demand (high)</i>	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
<i>Two runway demand, airport values of time</i>	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
<i>VfM category (as defined in WEBTAG)</i>			
Poor (BCR < 1)	Low (1 - 1.5)	Medium (1.5 - 2)	High (2-4)
			Very High (>4)

6.2 Methodology

A range of service options were defined with specific characteristics including journey time and calling patterns. Indicative infrastructure options to accommodate these service options were then defined, and the capital costs of these schemes were estimated. These are detailed in **Chapters 4 and 5**. The service specifications were run through two demand models, one for journeys starting or ending at Heathrow airport ('airport journeys'), and the other for non-airport journeys. The airport journey demand output was run through a model of passenger crowding for Windsor line demand only. The demand and revenue outputs from all models, capital cost and operating cost inputs were fed into a discounted cash flow (DCF) appraisal template to produce value-for-money assessments. This process is represented in **Image 15**.

⁹ Assumes all calls in Surrey/Hampshire options with London services to Terminals 2&3 and Surrey/Hampshire services terminating at Terminal 5

¹⁰ Assumes all calls in Surrey/Hampshire services with London SRaTh services to Terminals 2&3 and Surrey/Hampshire services to Old Oak Common and London Paddington via connecting to non-stop London Paddington – Heathrow services

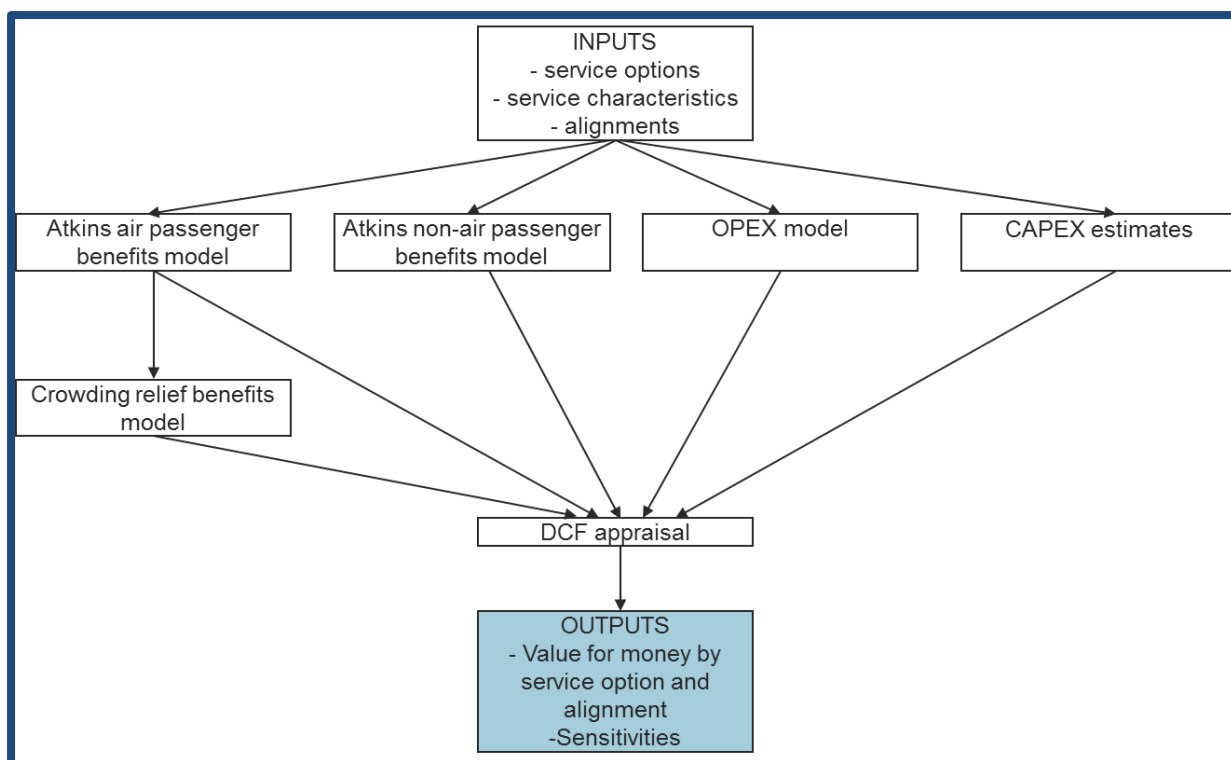


Image 15 – Elements of appraisal process

Demand Modelling

The two demand models used by Atkins in the market study were adapted for use in the value-for-money assessment. See **Chapter 3** for a full explanation of these models. The following changes were made to the Atkins' models for the value-for-money assessment:

- Airport journeys model
 - Generic Conditional Output service specification options replaced with ten main southern access rail link specifications, each with defined journey times, service frequencies and calling patterns
 - Values of time changed from aviation values to standard WebTAG values
 - Marginal external costs of car use changed from generic England values to South East values
- Non-airport journeys model
 - Old Oak Common added as a zone in the gravity model, with population and employment forecasts to attract demand
 - The gravity model was extended to model full, reduced and season ticket journeys separately as a proxy for journey purpose.

Crowding Modelling

The demand figures for London passengers' airport journeys were run through a model of peak hour crowding on the Windsor Lines to estimate the crowding-related cost of adding new southern access rail link passenger journeys to this line. A crowding assessment was not made for journeys on any other area of the network.

Option Appraisal

Demand and crowding information was fed into a Discounted Cash Flow (DCF) model, with estimated capital and operational expenditure assumptions, and the costs and benefits appraised over a 60-year period. Benefits for each service option were appraised incrementally to allow the total value-for-money of both individual service options and combinations to be understood.

Initially, four London options were tested:

- 4tph semi-fast Waterloo-Heathrow services via Western alignment infrastructure, routed via Richmond
- 4tph stopping Waterloo-Heathrow services via Western alignment infrastructure, routed 2tph via Richmond and 2tph via Hounslow
- 4tph semi-fast Waterloo-Heathrow services via Eastern alignment infrastructure, routed via Richmond
- 4tph stopping Waterloo-Heathrow services via Eastern alignment infrastructure, routed 2tph via Richmond and 2tph via Hounslow

Six Surrey/Hampshire options were then assessed as increments to the best value-for-money London option:

- 2tph Weybridge-Heathrow services (all day) and 2tph Guildford-Heathrow services (excluding peak hours) via the Staines chord infrastructure
- 2tph Basingstoke-Heathrow services (excluding peak hours) and 2tph Guildford-Heathrow services (all day) via the Staines chord infrastructure
- 2tph Weybridge-Heathrow services and 2tph Guildford-Heathrow services via the Egham tunnel infrastructure
- 2tph Basingstoke-Heathrow services and 2tph Guildford-Heathrow services via the Egham tunnel infrastructure
- 2tph Weybridge-Heathrow services and 2tph Guildford-Heathrow services via the Chertsey link infrastructure
- 2tph Basingstoke-Heathrow services and 2tph Guildford-Heathrow services via the Chertsey link infrastructure

These options were first appraised assuming that the 4tph London services called at T5 and T2&3, and the 4tph Surrey services called at T5 only, then were appraised assuming London services terminated at T5 while Surrey services also called at T2&3.

Options were then appraised for extending Surrey services through to the Great Western Main Line, calling at Heathrow T5, Heathrow T2&3, Old Oak Common and London Paddington.

Finally, several sensitivity tests were conducted on values of time and demand forecasts for different Heathrow Airport expansion scenarios (three runway forecasts from both Heathrow Airport Ltd and the Airports Commission were used.)

Methodological and Modelling Considerations

- Some southern access paths are provided by removing an existing stopping Weybridge – London via Staines service. This service is currently the only service in off-peak hours for passengers from Chertsey and Addlestone, and allows them to interchange at Weybridge onto fast South West Main Line services. In Surrey/Hampshire service options that call at Weybridge, the proposed southern rail access services directly replace this service. Under Surrey service options that do not call at Weybridge, these passengers retain a service, including a link to other stations on the South West Mainline, but lose the ability to interchange onto fast services at Weybridge. In London only service options, a Weybridge - Virginia Water shuttle was modelled to retain a service at Chertsey and Addlestone, and their link to the Windsor lines at Virginia Water and the South West Mainline at Weybridge. These increase interchange requirements for some passengers compared to the baseline.
- Surrey options that use the Staines Chord infrastructure operate a restricted 2tph service in peak hours to maintain the existing peak service quantum through the level crossings in the Egham area. The other two Surrey/Hampshire infrastructure options bypass Egham and are not affected by this issue.
- Old Oak Common was not included in the airport journeys model, as it will not affect access times to Heathrow from the study catchment area. It was included in the modelling of non-airport journey as a population and employment centre.
- The impact of HS2 interchange at Old Oak Common and potential Heathrow-HS2 connectivity was not quantified in this assessment.
- The impact of a southern rail access scheme on crowding has been quantified for Windsor line services during peak hours. This is the busiest part of the network that will be affected by southern rail access passengers.

6.3 Assumptions

Key assumptions used in the value-for-money assessment were:

Characteristics of Southern Rail Access services

- Fares on southern rail access services do not include an airport service premium, and were set equal to current single fares plus £0.20 per mile on new infrastructure. The minimum fare was set at £3. Fares were consistent across alignments and service patterns;
- Journey times were based on the indicative service specifications, further discussed in **Chapter 4**;
- Southern rail access services operate between 0500-0000;
- Surrey services operate as 4 cars, London services operate as 10 cars.

Other Assumptions

- The central case used WebTAG values of time.
- The central case used Heathrow Airport Limited's two-runway passenger demand forecast.

- The geographical distribution of airport trips was fixed.
- The total number of airport trips was driven by demand forecasts, and there was no additional generation of airport trips.

Capital Costs

As discussed in previous chapters, this feasibility report has not fully assessed asset resilience, power supply upgrades or potential depot and stabling requirements. Therefore the cost of these items has not been included in the value-for-money assessment. These items will need to be considered in more detail at the next stage of development and their impact on the business case reviewed.

6.4 Results

The process of arriving at a final value-for-money assessment is detailed below. Throughout this section the following notation is used to refer in shorthand to the options appraised.

LWF	L ondon service, W estern alignment infrastructure, Semi- F ast calling pattern
LWS	L ondon service, W estern alignment infrastructure, S topping calling pattern
LEF	L ondon service, E astern alignment infrastructure, Semi- F ast stopping pattern
LES	L ondon service, E astern alignment infrastructure, S topping calling pattern
SSGW	S urrey service, S taines Chord infrastructure, serving G uildford and W eybridge
SSGB	S urrey service, S taines Chord infrastructure, serving G uildford and B asingstoke
SEGW	S urrey/Hampshire service, E gham Tunnel infrastructure, serving G uildford and W eybridge
SEGB	S urrey/Hampshire service, E gham Tunnel infrastructure, serving G uildford and B asingstoke
SCGW	S urrey/Hampshire service, C hertsey Link infrastructure, serving G uildford and W eybridge
SCGB	S urrey service, C hertsey Link infrastructure, serving G uildford and B asingstoke

London Options

Comparison of the four London options described above, assuming the London services ran to T5 and T2&3, showed:

- The Western alignment's (LWF and LWS) longer journey time brings lower user benefits to Heathrow passengers than the Eastern alignment's (LEF and LES) shorter journey time.
- The Western alignment's overall costs to Government are lower than the Eastern alignment's.
- Semi-fast services (LWF and LEF) bring higher user benefits to Heathrow passengers than stopping services (LWS and LES), but semi-fast services are also more disruptive to the Wessex market, indicated by more crowding.
- Semi-fast services have lower operating costs than stopping services. All London options were associated with a reduction in operating costs. This was driven by a decrease in train miles and journey time leading to reduced requirements for

diagrams and staff. The reduction in train miles and journey time was driven by multiple changes: the breaking up of some current services into two shorter journeys; replacing current paths with significantly shorter distance southern access rail link paths; and a reduction in the length of some portions of services.

The results of the appraisal are shown below.

Results of socio-economic appraisal	LWF	LWS	LEF	LES
	£m PV	£m PV	£m PV	£m PV
Net benefits to consumers and private sector (plus tax impacts)				
User benefits - to / from Heathrow	1,266	854	1,491	974
User benefits - Non Heathrow	-358	-167	-448	-207
User benefits - Crowding	-29	-13	-45	-21
NUBs	167	121	179	112
Rail user and non user disruption disbenefits during possessions	-4	-4	-7	-7
sub-total (a)	1,043	792	1,170	852
Costs to government (broad transport budget)				
sub-total (b)	64	274	268	466
Net Present Value (NPV) (a-b)	979	518	901	386
Benefit Cost Ratio to Government (BCR) (a/b)	16.4	2.9	4.4	1.8
Present Values (PVs) are in 2010 market prices and are discounted to 2010 using Social Time Preference discount rates: see Table A.1. The appraisal is in accordance with the DfT's WebTAG appraisal guidance. Results are shown for the relevant option/scenario etc relative to the Base Case. For net benefits etc, benefits are shown as positive. For costs to government etc, costs are shown as positive.				

It should be noted that operating cost savings are very dependent on rolling stock assumptions which at this point are indicative and have not been subject to a detailed diagramming exercise.

Surrey/Hampshire options

The best value-for-money London option is running semi-fast services on the Western alignment infrastructure. The costs and benefits of the six Surrey/Hampshire options described above were appraised incrementally to the best value-for-money London option, assuming that the Surrey services only called at T5 in the Heathrow area. This appraisal showed:

- The overall costs to Government are lowest when the Staines Chord infrastructure is used (SSGW and SSGB), and highest for the Chertsey link (SCGW and SCGB).
- Serving the Guildford and Basingstoke markets (SSGB, SEGB, SCGB) brings higher user benefits for both Heathrow and non-Heathrow journeys than serving the Guildford and Weybridge markets (SSGW, SEGB, SCGW).
- Serving the Guildford and Basingstoke markets is more expensive than serving the Guildford and Weybridge markets.

- The case for the Staines chord is significantly stronger than the case for the more expensive Egham tunnel and Chertsey link options.

The results of the appraisal are shown below.

Results of socio-economic appraisal	SSGW	SSGB	SEGW	SEGB	SCGW	SCGB
	£m PV	£m PV	£m PV	£m PV	£m PV	£m PV
Net benefits to consumers and private sector (plus tax impacts)						
User benefits - to / from Heathrow	85	117	121	159	146	169
User benefits - Non Heathrow	59	174	81	159	30	140
User benefits - Crowding	0	0	0	0	0	0
NUBs	30	52	44	67	53	76
Rail user and non user disruption disbenefits during possessions	0	0	-8	-8	-8	-8
sub-total (a)	174	342	238	377	221	376
Costs to government (broad transport budget)						
sub-total (b)	204	353	558	738	637	822
Net Present Value (NPV) (a-b)	-30	-11	-320	-361	-416	-445
Benefit Cost Ratio to Government (BCR) (a/b)	0.9	1.0	0.4	0.5	0.3	0.5
Present Values (PVs) are in 2010 market prices and are discounted to 2010 using Social Time Preference discount rates: see Table A.1. The appraisal is in accordance with the DfT's WebTAG appraisal guidance. Results are shown for the relevant option/scenario etc relative to the Base Case. For net benefits etc, benefits are shown as positive. For costs to government etc, costs are shown as positive.						

The best value-for-money Surrey/Hampshire option is running services on the Staines Chord infrastructure to Guildford and Basingstoke. However, small changes in assumptions around capital costs and journey times can shift the balance between serving Basingstoke or Weybridge. At this stage of development, it is not clear which of these markets would form the best option.

The Surrey/Hampshire results are driven by journey time and stopping pattern assumptions that may be too conservative. Some stations are served despite adding little to the overall benefit of running services. An appraisal of the Surrey/Hampshire options have also been completed based on removing stops at Brookwood, Byfleet & New Haw, Hook, West Byfleet, Winchfield, and Worplesdon and lowering journey times as a result. This increases the benefits to and from Heathrow and some non-Heathrow markets but decreases the benefit from those stations where the stops have been removed. Overall, the case for the best Surrey option is slightly improved.

Alternative Heathrow calling patterns

The results presented above assumed that 4tph London services called at T5 and T2&3, while 4tph Surrey services called at T5 only. An appraisal was also undertaken for an option where 4tph Surrey/Hampshire services called at T5 and T2&3 while 4tph London services called at only T5.

When the direct T2&3 call was removed from the London services, the user benefits for Heathrow journeys were approximately halved for all four options, as were crowding disbenefits and non-user benefits, while user disbenefit for non-Heathrow journeys remained unchanged. Capital costs were marginally lower, but the services generated significantly less revenue on Heathrow journeys.

When a direct T2&3 call was added to the Surrey/Hampshire services, the user benefits for Heathrow journeys were between three to five times higher, and non-user benefits rose by a similar proportion. Non-Heathrow user benefits were unchanged. Capital costs were slightly higher, but the services generated significantly more revenue on Heathrow journeys.

The BCR for the best value-for-money London option fell from 13.6 to 1.7, while for the best value-for-money Surrey/Hampshire option it rose from 1.0 to 2.6. Calling at both T2&3 and T5 compared to only T5 increases the value-for-money for all London and Surrey/Hampshire options.

Combined Central Case

The best value-for-money London option was running semi-fast services on the Western alignment infrastructure, calling at both T5 and T2&3 at Heathrow Airport. The best value-for-money Surrey option was running services on the Staines Chord infrastructure to Guildford and Weybridge, calling at both T5 and T2&3 at Heathrow Airport. While operating under the assumption that there are a maximum of four potential paths available for southern rail access link services between T5 and T2&3, these two options could not be combined.

The best value-for-money combined London and Surrey/Hampshire option is to run London services to both T2&3 and T5, and Surrey/Hampshire services to T5 only. The results of the appraisal are shown below.

Results of socio-economic appraisal	v2 Tot LWF+SSGB(T5)
	£m PV
Net benefits to consumers and private sector (plus tax impacts)	
User benefits - to / from Heathrow	1,343
User benefits - Non Heathrow	-184
User benefits - Crowding	-29
NUBs	217
Rail user and non user disruption disbenefits during possessions	-3
sub-total (a)	1,344
Costs to government (broad transport budget)	
sub-total (b)	346
Net Present Value (NPV) (a-b)	998
Benefit Cost Ratio to Government (BCR) (a/b)	3.9
Present Values (PVs) are in 2010 market prices and are discounted to 2010 using Social Time Preference discount rates: see Table A.1. The appraisal is in accordance with the DfT's WebTAG appraisal guidance. Results are shown for the relevant option/scenario etc relative to the Base Case. For net benefits etc, benefits are shown as positive. For costs to government etc, costs are shown as positive.	

Extension of Surrey services to Great Western Main Line

There is the potential for services from Surrey/Hampshire to run directly through Heathrow and join with existing Heathrow – London paths on the Great Western mainline (though this would involve trade-offs with other services, as described in Chapter 4). Surrey services that called at Heathrow T5, Heathrow T2&3, Old Oak Common and London Paddington were appraised, incremental to the case where London services call at both T5 and T2&3.

When Surrey services are extended through Heathrow to London Paddington, there is an increase in both benefits and revenue for Heathrow and non-Heathrow journeys. However, there are considerable issues to overcome to allow this to happen, for example:

- The risk of translating performance issues from one route to another.
- Management of the operation of services from one network to the next.
- Operator mapping and management.

The value-for-money of the Surrey/Hampshire options is increased. The change in results for the highest value Surrey/Hampshire option is shown below.

Results of socio-economic appraisal		SSGB to T2&3 and Pad
		£m PV
Net benefits to consumers and private sector (plus tax impacts)		
User benefits - to / from Heathrow		221
User benefits - Non Heathrow		294
User benefits - Crowding		0
NUBs		112
Rail user and non user disruption disbenefits during possessions		0
	sub-total (a)	627
Costs to government (broad transport budget)		
	sub-total (b)	305
Net Present Value (NPV) (a-b)		322
Benefit Cost Ratio to Government (BCR) (a/b)		2.1
Present Values (PVs) are in 2010 market prices and are discounted to 2010 using Social Time Preference discount rates: see Table A.1. The appraisal is in accordance with the DfT's WebTAG appraisal guidance. Results are shown for the relevant option/scenario etc relative to the Base Case. For net benefits etc, benefits are shown as positive. For costs to government etc, costs are shown as positive.		

The benefits shown in this appraisal can be split into those arising from two service changes; first, the extension of Surrey services from T5 to T2&3, and second, the extension from T2&3 to Paddington. Further investigation should be undertaken into the balance of benefits gained from each aspect, to establish whether the value-for-money displayed is driven principally by removing the need for Surrey Heathrow passengers to interchange at the airport to reach T2&3, or by providing through journey opportunities to London.

Sensitivities

The following sensitivity tests were undertaken:

- London and Surrey options were tested with the lowest and highest Heathrow Airport three-runway passenger forecasts, the Heathrow Airport Limited three-runway forecast and the Airports Commission three-runway carbon traded forecast. Higher Heathrow Airport demand forecasts resulted in higher user benefits for Heathrow journeys and higher non-user benefits, but also higher crowding disbenefit on the Windsor lines. There was higher revenue from Heathrow journeys, and no change in costs.
- A sensitivity on the London options removed all operational expenditure savings resulting from a reduction in diagrams and staff, while retaining those driven by reduced train miles, representing a scenario where some expected operating expenditure savings were not fully realised. This significantly increased the options' cost and while options still demonstrated value-for-money, the extent of this was reduced.
- A sensitivity on the Surrey options used aviation values of time, which are notably higher than normal WebTAG values of time, for Heathrow passengers. These increased values were used both when allocating mode choice in the Heathrow

demand model and for appraisal purposes. This significantly increased user benefits for Heathrow journeys and slightly increased non-user benefits. Revenue for Heathrow journeys was reduced.

- Finally, sensitivity tests on the capital costs of Option 2 (Egham Tunnel) have been carried out; it shows that even with a 40 per cent reduction in capital costs, Option 1B (via Staines Chord) still demonstrates better value-for-money.

Abstraction

Analysis of Heathrow Airport journeys by origin/destination zone highlighted differing levels of abstraction between London and Surrey services. London options show a high number of journeys on southern rail access link services, of which only a small proportion are incremental rail journeys. Surrey options show a much smaller number of journeys on southern rail access link services, but a very high proportion of these are incremental journeys.

This is supported by forecast mode share changes by origin/destination zone. London zones typically show a smaller reduction in car mode share than Surrey zones, and the majority of forecast southern rail access link journeys are abstracted from existing rail modes.

The following graph shows the annual SATH journeys from each zone as a result of running a fast London service to Heathrow via the Western alignment. It shows that from Waterloo, nearly 1.5 million passengers per annum will use SATH, but only around 10 per cent of them are new rail users.

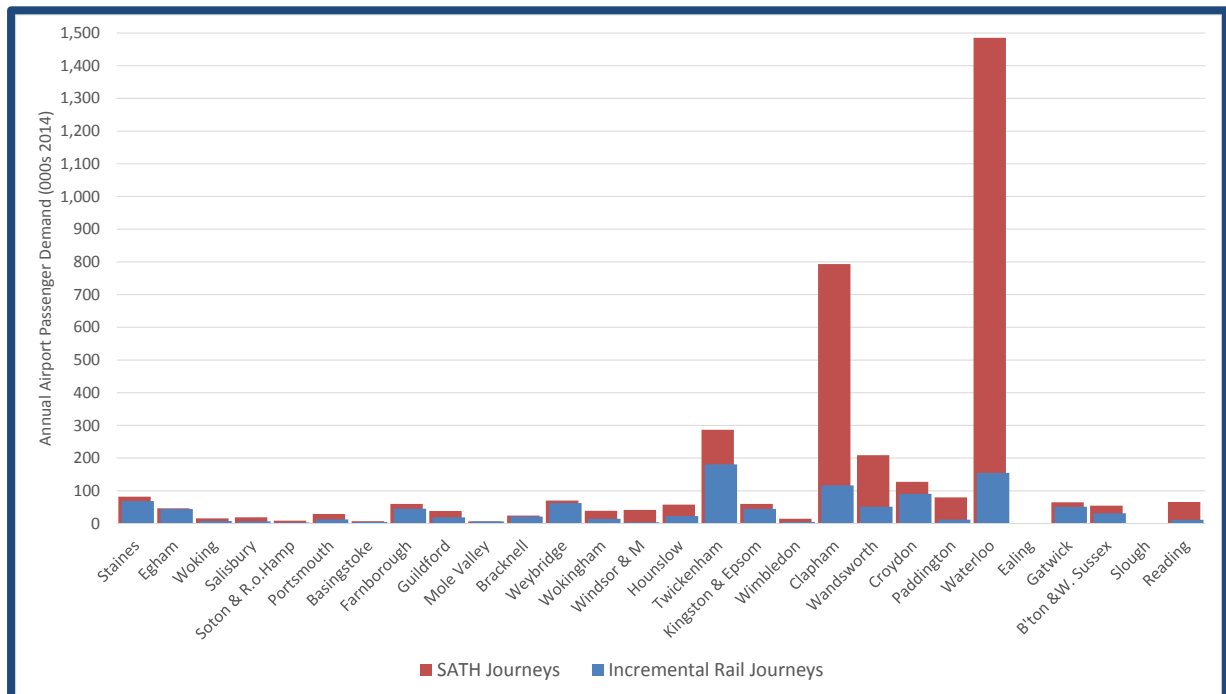


Image 16 – Ratio of incremental rail journeys from potential SRaTh locations

Assessment Against the Strategic Goals

The best performing London and Surrey/Hampshire combined option has been qualitatively assessed against the Strategic Goals set out in the Market Study (see Chapter 3) below.

Strategic Goal	Qualitative Assessment of main option against Strategic Goal
<p>1. To reduce highway congestion at and around Heathrow through an increase in rail mode share and reduce the environmental impact of existing travel patterns (e.g. CO₂ emissions).</p>	<p>Providing London – Heathrow southern access link services does not abstract many trips from cars onto rail. Instead it diverts passengers away from existing or committed routes such as the Piccadilly Line, Crossrail or Heathrow Express. This benefits public transport users by providing cheaper / faster alternatives.</p> <p>Direct Surrey/Hampshire – Heathrow services demonstrate a higher level of abstraction from car journeys than London services.</p>
<p>2. To improve productivity and outputs from the UK economy through enhanced Heathrow and local connectivity.</p>	<p>This scheme will improve connectivity between Heathrow and London/Surrey/Hampshire, providing clustering and agglomeration opportunities for more firms. This could in turn attract more businesses to locate in London, Surrey/Hampshire or around Heathrow to benefit from improved connections to their suppliers and customers.</p> <p>Improved connectivity to Surrey and/or Hampshire will provide better access to a key employment centre, improving the productivity of Heathrow's workforce.</p>
<p>3. To reduce social deprivation and increase labour productivity through greater accessibility to employment, for the benefit of both employees and employers – both to/from Heathrow and through creation of new journey opportunities.</p>	<p>Improved connectivity to Surrey and/or Hampshire will provide access to a labour market for employers in and around Heathrow, improving the productivity of Heathrow's workforce.</p> <p>Serving Heathrow from Surrey and/or Hampshire will provide direct public transport to a key employment centre where none exists currently, providing greater employment opportunities.</p>
<p>4. To connect communities where no reasonable public transport option currently exists.</p>	<p>With a southern access link, communities in Surrey and/or Hampshire would have the option of using public transport to get to Heathrow for business and leisure travel.</p>

7.0 Summary

This chapter outlines the combinations of services and infrastructure options that have been investigated in this Study, the scenarios under which they were assessed and subsequently the key findings.

7.1 Services and infrastructure considered

The table below summarises the service quantum and alignment combinations considered for feasibility and value-for-money as part of this Study. The descriptions of the alignments can be found in **Chapter 5**.

Service Concept	Infrastructure Required
Four trains per hour to London – all day.	Alignment Option 1A
Four trains per hour to London – all day. Reduced journey time.	Alignment Option 4
Four trains per hour to London – all day. Four trains per hour to Surrey/Hampshire – off-peak (two trains per hour in the peak).	Alignment Option 1B
Four trains per hour to London – all day. Four trains per hour to Surrey/Hampshire – all day. Reduced journey time.	Alignment Option 2
Four trains per hour to London – all day. Four trains per hour to Surrey/Hampshire – all day. Further reduction in journey time.	Alignment Option 3

Using the first two concepts above, the table below outlines the two alternative London service options tested in this Study.

Destination and calling pattern	Infrastructure Required
Two stopping services via Richmond all day. Two stopping services via Hounslow all day.	Alignment Option 1A or Alignment Option 4
Four semi-fast services via Richmond all day.	Alignment Option 1A or Alignment Option 4

It should be noted that in both scenarios a Virginia Water – Weybridge service is also assumed to run to replace the connectivity lost on the Chertsey corridor from the removal of the Waterloo – Weybridge stopping service.

Incrementally to the Heathrow – London flow, the Study considered the following Surrey/Hampshire service options using the latter three concepts in the first table. The infrastructure requirements listed are in addition to schemes at Basingstoke, Woking and Guildford which are already recommended in the Wessex Route Study to cater for South West Main Line (SWML) demand, but would also be required for southern access services. It should be noted that none of these schemes are currently funded.

Service Concept	Infrastructure Required
<u>Peak</u> Two trains per hour to Weybridge.	Alignment Option 1B
<u>Off-peak</u> Two trains per hour to Weybridge. Two trains per hour to Guildford.	
<u>Peak</u> Two trains per hour to Guildford.	Alignment Option 1B Basingstoke Turnback Freight Recess Facility
<u>Off-peak</u> Two trains per hour to Guildford. Two trains per hour to Basingstoke.	

<p><u>All day</u></p> <p>Two trains per hour to Weybridge.</p> <p>Two trains per hour to Guildford.</p>	<p>Alignment Option 2</p> <p>or</p> <p>Alignment Option 3</p>
<p><u>All day</u></p> <p>Two trains per hour to Guildford.</p> <p>Two trains per hour to Basingstoke.</p>	<p>Alignment Option 2</p> <p>or</p> <p>Alignment Option 3</p> <p>and</p> <p>Basingstoke Turnback</p> <p>Freight Recess Facility</p>

7.2 Scenario testing

The following scenarios were tested in the value-for-money assessment:

- A two-runway scenario vs a three-runway scenario;
- Whether it is more valuable for London or Surrey services to call at both Terminal 5 and Terminals 2&3 should a trade-off be required;
- A reduction and increase in the capital cost of one of the alignments to ascertain the BCR's sensitivity to capital cost changes;
- Extending Surrey services through Heathrow Airport to call at Old Oak Common and London Paddington;
- Standard WebTAG values of time vs airport values of time;
- A reduced number of calls in Surrey/Hampshire services.

7.3 Key Findings

Train service options

- To avoid significant infrastructure investment on the Windsor Lines, any southern access service concept would need to be planned holistically with the existing and future Wessex train service to enable the optimal use of network capacity;
- Southern access services to London, Guildford and Basingstoke would provide the most economic benefit;
- The train service changes necessary to accommodate southern access services would likely result in reducing or removing some direct journey opportunities that exist today;
- In order to avoid increasing the peak level of train service through the level crossings in the Egham area, it would be necessary to either alter the train

service to account for this, pursue level crossings closure or choose an alignment option which by-passes the level crossings;

- A holistic study of Heathrow Airport would be best placed to further investigate the trade-offs required to optimise which future rail service groups (e.g. SRAtH, WRLtH, Crossrail) call at which Heathrow terminals;
- There is the potential for services from Surrey/Hampshire to run directly through Heathrow and join with existing Heathrow – London paths on the Great Western mainline (though this would involve trade-offs with other services, as per the previous point).

Infrastructure options

- An alignment that accesses Heathrow Airport via Terminals 2& 3 should not be considered further due to the engineering complexities associated with joining the existing Heathrow Express tunnels;
- In order to avoid increasing the peak level of train service through the level crossings in the Egham area, it would be necessary to either alter the train service to account for this, pursue level crossings closure or choose an alignment option which by-passes the level crossings.

Value-for-money assessment

- The options appraised demonstrate a wide range in the value-for-money of potential service specifications. The assessment suggests that the highest value-for-money southern rail access link concept would be achieved via Alignment Option 1B with:
 - semi-fast London Waterloo – Heathrow services;
 - Surrey/Hampshire services from Guildford and either Basingstoke or Weybridge. The appraisal showed Weybridge and Basingstoke as performing similarly. Further assessment the costs and benefits of these two service options would be required at the next stage of development.
- A range of options were tested for sensitivity to Heathrow demand forecasts, reduced operational expenditure savings, a reduced number of calls in Surrey/Hampshire services, capital costs and higher values of time;
- Though the value-for-money of the Surrey/Hampshire services is comparatively lower than the London services, the Surrey/Hampshire services better meet the Strategic Goals of a southern rail access link;
- The following table summarises the best performing option and its value-for-money category in the assessment.

Value-for-Money category and best option	Best London option	Best Surrey/Hampshire option (as an increment to London services)	Case for combined option
Two runway demand¹¹	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
Two runway demand, fewer stops in Surrey/Hampshire services	NA	Option 1B, services from Guildford and Weybridge	
Two runway demand, London and Surrey/Hampshire services through to Terminals 2&3 and GWML¹²	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
Three runway demand (low)	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
Three runway demand (high)	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
Two runway demand, airport values of time	Option 1A Semi-Fast	Option 1B, services from Guildford and Basingstoke	
VfM category (as defined in WEBTAG)			
Poor (BCR < 1)	Low (1 - 1.5)	Medium (1.5 - 2)	High (2-4)
			Very High (>4)

- Though the value-for-money of the Surrey/Hampshire services is comparatively lower than the London services, the Surrey/Hampshire services better meet the Strategic Goals of a southern rail access link.

Future stages

- The next stage of development for the scheme would be a GRIP 1 – 2 Study;
- If Heathrow Terminal 6 proposals go ahead, it would seem sensible for development of southern access to be integrated with development of Terminal 6 in order to ensure consistency of the designs at Heathrow.

7.4 Further Scheme Development

Following submission of this Study to the Government, should a promoter be willing to fund further development on a southern access scheme a GRIP 1-2 study would need to include the following:

- Further consideration of potential train service and infrastructure options;
- On-site surveys;

¹¹ Assumes all calls in Surrey/Hampshire options with London services to Terminals 2&3 and Surrey/Hampshire services terminating at Terminal 5

¹² Assumes all calls in Surrey/Hampshire services with London SRaTh services to Terminals 2&3 and Surrey/Hampshire services to Old Oak Common and London Paddington via connecting to non-stop London Paddington – Heathrow services

- Consideration of ownership boundaries and operational control of any new alignments;
- Investigation into the closure of the level crossings in the Egham area if Option 1B is taken forward to remove the interface between road and rail;
- Power supply modelling;
- More detailed analysis of the electrification arrangements;
- Potential enhancements to Wessex stations to cater for increased numbers of passengers with luggage;
- A study on maintenance arrangements and how these may need to be reviewed to better accommodate the airport service;
- Upgrades required on Wessex network to provide adequate asset resilience;
- Consideration of depot and stabling arrangements;
- A more detailed land and consents strategy.