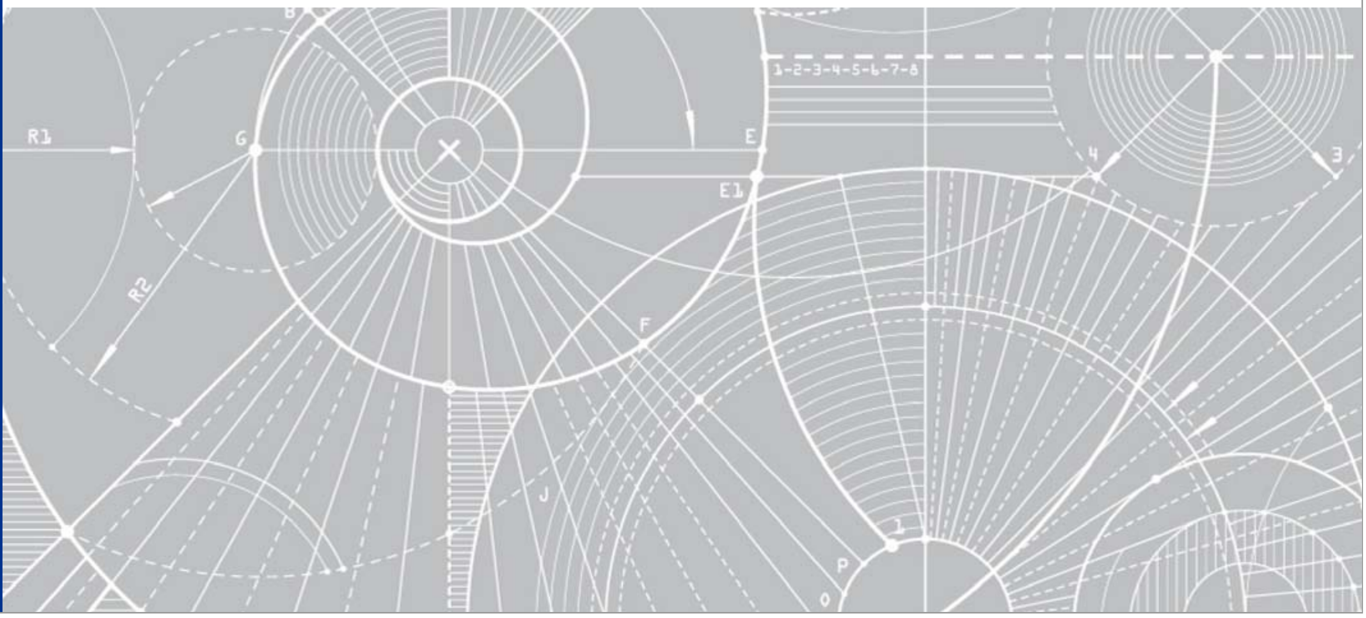
Inner Thames Estuary Airport Phase 1B

AIRPORTS COMMISSION

Surface Access Impacts Study (Study 4)

FINAL REPORT (Version 1 | Revision F)

10th July 2014



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Executive Summary

Background

The Airports Commission (AC) was established in 2012 by the UK Government to examine the need for additional UK airport capacity and to recommend how any additional capacity requirements can be met in the short, medium and long term. The Commission is due to submit a Final Report to the UK Government by summer 2015 assessing the environmental, economic and social costs and benefits of various solutions to increase airport capacity, considering operational, commercial and technical viability.

The AC published an Interim Report in December 2013 that short-listed three options to address the UK's long-term aviation connectivity and capacity needs, two focussed on expanding Heathrow Airport and one on expanding Gatwick. The report also indicated that additional analysis was required to establish the credibility of a new hub airport in the Inner Thames Estuary (ITE) as a potential fourth option on the short-list.

This report details the aforementioned additional analysis undertaken on the ITE option by Jacobs on behalf of the AC with respect to surface transport (Study 4). It sits alongside three other parallel but independent workstreams on environmental impacts (Study 1), operational feasibility (Study 2), and socio-economic impacts (Study 3). The surface access study focussed specifically on four key elements as follows:

- Estimating airport passenger and employee surface transport demand;
- Identifying surface transport measures to meet airport-related demand, accounting for capacity implications related to background growth and non-airport travel demand;
- Assessing the engineering feasibility and high-level cost of the surface transport measures identified to meet forecast travel demand;
- Assessing the environmental cost of the identified surface transport measures.

The ultimate aim of the study was to provide guidance to the AC on the feasibility and likely issues associated with the most viable packages of surface transport measures. The terms of reference for these packages were defined as follows:

- An 'opening year' (2030) package consisting of surface access elements designed to provide a reasonable degree of service for airport passengers at a minimum cost;
- A 'mature year' (2050) package consisting of elements designed to provide a high quality degree of service for airport passengers, befitting a world-class 21st century hub airport operating at full capacity.

Inner Thames Estuary airport proposals

To aid the additional assessment of the ITE option, the AC announced a general call for evidence on feasibility in January with a deadline of the 23rd May. Over 170 responses were received from interested parties both in favour and against a new hub airport in this location, including significant submissions from the following organisations:

- Mayor of London/Greater London Authority (GLA)/Transport for London (TfL);
- Foster + Partners;
- Metrotidal Tunnel and Thames Reach Airport Ltd (MTTRA).

Each of these submissions built upon initial proposals put forward by the same organisations in the run-up to the December 2013 Interim Report, and were centred on the provision of an airport in the ITE that would effectively replace Heathrow as the UK's aviation hub and would be designed to handle up to 150 million passengers per annum (mppa) once fully operational. A fourth organisation, the Independent Aviation Advisory Group (IAAG), submitted a significant proposal for a London Gateway Airport in the ITE in the run-up to the December 2013 Interim Report but did not revise or update their proposal in May.

The assumptions and surface access options proposed in each of these four submissions were reviewed by Jacobs early in the study programme. A key assumption made in three of the proposals was a high public transport mode share of 60-65% for air passengers making surface access trips to the airport. Foster + Partners and MTTRA stated explicitly in their 2013 submissions that the rail mode share for air passengers would be 60% while the Mayor of London indicated that for testing purposes it was assumed all public transport trips would use rail. These submissions also indicated that a high proportion of airport employees would commute using public transport, ranging from 60% using rail (identified in both the MTTRA and Foster + Partners proposals) to an overall 75% public transport mode share (identified by the Mayor of London) – as with passengers, the Mayor assumed for testing purposes that all employee commuting trips by public transport would be made by rail.

While the submissions differed markedly in terms of surface transport proposals they put forward, there were a number of common elements across many, as follows:

- The provision of an express service via High Speed 1 (HS1) from St. Pancras connecting to the airport via a spur to the south east of Gravesend – included in all submissions with minor variations and assumed by Jacobs to take approximately 26 minutes between St. Pancras and the airport;
- The extension of both branches of Crossrail from Abbey Wood in the south via Dartford, Gravesend and Hoo Junction and from Shenfield in the north via Billericay – the southern branch extension was included in all three submissions, while both MTTRA and Foster + Partners included a northern branch extension – the southern branch service was assumed to take approximately 51 minutes between Tottenham Court Road and the airport;
- The provision of a semi-fast service from Waterloo to the airport via Bromley South and Swanley – included in the Foster + Partners and MTTRA submissions, and IAAG highlighted the potential for a similar service to Waterloo via Ebbsfleet/Gravesend – this was assumed to take 42 minutes between Waterloo and the airport;
- Regional services linking to North Kent and South Essex (via a river crossing to the Fenchurch Street line) – included in the Mayor of London, IAAG and Foster + Partners submissions.

In addition, the Mayor of London proposed a new express service from Waterloo via London Bridge, Canary Wharf and Barking Riverside that was assumed to take 28 minutes to travel between Waterloo and the airport. This and the schemes summarised above were assembled into four rail packages for assessment.

Forecasting methodology

The approach to forecasting surface transport demand for an airport in the ITE was broken down into a number of key stages as follows:

- Estimating total peak-hour demand to and from the airport by main mode of surface transport (either private vehicle, bus/coach, or rail);
- Allocating total peak-hour trips to and from the airport to geographic regions in the UK;
- Assigning rail trips from different geographic regions to different rail corridors – a number of options for rail access to the airport were tested consisting of different combinations of schemes;
- Assigning road-based trips to and from the airport to the strategic road network in the south-east.

The rail and road assessments were undertaken with reference to a core and an extended transport baseline, which listed transport infrastructure and services expected or likely to be in place by 2030 regardless of any airport expansion that may be delivered in the UK. A key requirement of this study was to identify surface access impacts associated specifically with an airport in the ITE, as opposed to impacts arising as a result of background growth. Full details of the schemes included in these baselines are provided in Appendix A.

Headline assumptions for passenger and employee trips to and from an airport in the ITE were established based on a benchmarking exercise focussed on Heathrow Airport and other international exemplars. This process led to the following key assumptions:

- 103 million passengers per annum (mppa) in 2030, rising to 143mppa in 2050;
- 84,300 local on- and off-airport jobs directly related to the airport in 2030, rising to 117,000 in 2050 (based on a 2011 study by Optimal Economics)[1];
- Busy day and peak hour factors sourced primarily from analysis of activity at UK airports – a peak-hour for passenger surface transport of 0700-0800 was identified, which is significant as the daily profile of staff arrivals and departures at various UK airports suggested that more staff would be travelling to the airport during that peak hour than away from it;
- Headline passenger and employee mode shares of 40% and 25% by rail – these were considerably lower than the submission assumptions and were defined primarily based on benchmarking of Heathrow and international exemplars and assumptions regarding improvements to rail services and demand management measures at an airport in the ITE in future;
- Vehicle occupancy assumptions for passengers and staff travelling by car, based on an analysis of Heathrow data and accounting for some benefits derived from traffic management schemes.

Further details on the methodology used to forecast demand at the ITE Airport can be found in Chapter 3.

Rail assessment

Following an assessment of the ITE submissions received by the AC and discussions with relevant organisations, four rail options were assembled to be assessed as part of this study. These were as follows:

- Rail Option 1 – minimum requirements – consisting of the HS1 express spur, the Crossrail southern extension, and rail connections from South Essex and North Kent via shuttle services from Grays and Strood stations (Network Rail advised during the study that running direct services to the airport from the Chatham Main Line and Fenchurch Street Line would be difficult due to severe line utilisation issues) – see Figure 35 on page 70;
- Rail Option 2 – enhanced National Rail connections – consisting of Option 1 plus the addition of a direct service to Waterloo calling at Bromley South and Swanley (the ‘Waterloo Stopper’) – see Figure 36 on page 71;
- Rail Option 3 – Crossrail northern extension – consisting of Option 2 plus the extension of the northern branch of Crossrail from Shenfield through Billericay to the airport – see Figure 37 on page 72;
- Rail Option 4 – enhanced express connections – consisting of Option 2 plus the addition of the Mayor of London’s express service to Waterloo via Barking Riverside, Canary Wharf, and London Bridge – see Figure 38 on page 73.

Generalised Cost estimates (accounting for the impact of rail journey times, wait times, interchange times and assumed fares) were developed for each identified scheme and the parameters from a calibrated sub-rail mode share model were used to forecast sub-rail mode share to the ITE in each option, indicated in the table below. This rail mode share forecast was then assigned to rail corridors serving the airport and was compared with background demand estimates provided by TfL and Network Rail, and the following conclusions were drawn.

[1] Source: http://www.heathrowairport.com/static/Heathrow/Downloads/PDF/Heathrow-Related-Employment-Report.pdf

Overall forecast rail mode share for the ITE Airport

Rail mode	Option 1	Option 2	Option 3	Option 4
HS1	34%	29%	28%	21%
AEX	~	~	~	23%
Crossrail	43%	36%	39%	28%
Network Rail	22%	35%	33%	28%
North Kent Lines	*12%*	*11%*	*11%*	*9%*
South Essex Lines	*10%*	*10%*	*7%*	*7%*
Waterloo Stopper	~	*15%*	*15%*	*11%*
TOTAL	**100%**	**100%**	**100%**	**100%**

In 2030, from a purely demand/capacity viewpoint, rail option 1 provides sufficient rail capacity to cater for the predicted demand. Loadings of just under 50% are predicted on HS1, between 26%-93% on the various sections of Crossrail (much of these loadings are non-airport related background demand), between 25%-110% on the North Kent lines (with the one line section which is over-capacity - Swanley-Strood - predicted to be close to capacity in 2020 without the ITE airport) and between 14%-93% on the South Essex Lines. This option would provide passenger choice between a premium, uncrowded, HS1 service to St Pancras, a crowded (in the central sections) Crossrail service to Central London, and generally uncrowded local services to Kent and Essex. It represents the "minimal acceptable" option and there appears to be little difference when compared with the current situation experienced by rail passengers travelling to and from Heathrow. The disadvantages of the option are that there is not a direct link to south and west Central London, with passengers required to interchange at St Pancras or the central Crossrail stations – there would therefore be negative impacts for rail passengers who currently access Heathrow via rail termini in south and west Central London.

The introduction of the Waterloo stopper in option 2 reduces the predicted loadings on HS1, Crossrail and other Network Rail services, but the predicted loadings on the Waterloo stopper service itself are between 120%-145% (assuming 2 tph). Of this total demand, the vast majority (90%-115%) is predicted to come from non-airport related background demand, rather than ITE airport demand. Discussions with Network Rail indicated that capacity limitations on this line are severe, with a flat rail junction at Herne Hill. However, there is the possibility of opening up the ‘Bromley North Branch Line’ via London Bridge, which could accommodate some local demand and leave sufficient capacity for ITE airport demand on the route to Waterloo. If this link can be constructed and if other local capacity issues can be resolved, the advantage of option 2 over option 1 is that it provides a direct connection between the ITE airport and Waterloo.

The introduction of the Crossrail northern extension in option 3 is predicted to carry almost zero demand as it is a much longer route from central London than the Crossrail southern extension so it was logical to assume that Crossrail passengers boarding in the core section would wait on platforms for southern branch services rather than incur a longer journey time. In addition, due to the assumption that the line would run on the surface between Canvey Island and Shenfield, few stations have been defined in Essex between Shenfield and the ITE airport. The cost of changing this alignment to provide a direct connection to Basildon station appear to be significant and therefore option 3 would appear to have negligible benefits.

The introduction of the airport express rail link in option 4 is predicted to reduce the loadings on HS1 by around 10%, and only slightly reduce the loadings on Crossrail (by 1%), the Network Rail services (by 1%) and the Waterloo stopper (by 8%). The loadings on the AEX service itself are predicted to be between 27%-34%. Thus the AEX does not significantly reduce the loadings on the other services which are close to (Crossrail 91%) or over capacity (Waterloo stopper 136%). What it does do is to provide a premium, direct, high quality service to Waterloo. It therefore represents an "optimal option" in terms of passenger level of service. Furthermore, if 4tph paths are not available on HS1, an alternative premium service to Central London would be required.

In 2050, while the predicted loadings on HS1 are between 61%-67% in option 1, this option does not provide sufficient capacity for background demand plus airport-related demand on other key links. The loadings due to background demand on the central sections of Crossrail are predicted to be over capacity (106%) and the addition of the ITE airport demand increases the loadings to 115%. The loading due to background demand on the key London-bound section of the Chatham Main Line (Rochester -Swanley) is also predicted to be overloaded (at up to 125%) and the addition of the ITE airport demand is predicted to increase this loading to

133%. Thus option 1 is not feasible in 2050. Neither is option 2, unless (as in 2030) additional capacity is provided between Bromley and Central London. The comments for option 3 stated above in 2030 apply equally well in 2050 and option 3 provides negligible benefits.

Thus in 2050, we would recommend that option 4 is the best solution. Loadings of between 38%-42% are predicted on HS1 and 38%-48% on AEX. However, the central section of Crossrail is still predicted to be overloaded (at over 110%) and the Rochester-Swanley section of the Chatham Main Line is also predicted to be overloaded (at up to 130%), primarily due to the growth in background demand as London grows as a city.

Our analysis also suggested that Options 1 and 4 provided shorter average rail journey times than Options 2 and 3. However, the overall average rail journey time weighted by forecast passenger demand in all four options ranged between 80 and 90 minutes, and the analysis indicated that the average rail passenger would have a shorter rail journey to Heathrow in 2030 than they would to the ITE (accounting for the trip distribution/mode share assumptions and rail options tested for the ITE as part of this study) – this included trips from many key locations such as Westminster and Kensington & Chelsea. This simply reflects the fact that in general terms, Heathrow is likely to be located closer to key population and employment centres across the UK in 2030 and 2050 than the ITE. A test was also run to calculate rail journey times to the ITE using the Heathrow 2030 distribution of rail passengers, which indicated that in this instance average rail time would be even longer to the ITE, reflecting the potential transitional impacts that may be experienced at the ITE immediately after opening.

Thus in summary, while rail Option 1 would accommodate predicted demand in 2030, it is dependent on 4 rail paths per hour being available on HS1 and a significant proportion of ITE passengers (around 45%) would experience crush capacity loadings of above 90% on the central sections of Crossrail. The rail elements of this option would cost around £5bn, rising to around £10bn with rail and optimism bias included.

In comparison, rail Option 4 would provide an additional express rail service to London (the AEX), which would both improve the resilience on relying on available HS1 train paths, and provide faster connections to south and west central London. The predicted Crossrail sub mode share of this option reduces to 27%, so fewer ITE airport users would have to experience Crossrail crush capacities in the core sections. However, the rail elements of this option would cost around £13bn, rising to around £27bn with rail and optimism bias included. By 2050, rail option 4 is the only credible option, due to the predicted growth of London, and even then some capacity issue still remain.

Roads assessment

The roads assessment involved using a route assignment model to forecast the impact of road trips to the ITE accounting for the impacts on capacity related purely to expected growth in background traffic. The costs of mitigating for these background traffic-related impacts have not been assigned to the airport.

The analysis detailed the following road widening requirements due to the ITE airport, covering works required in both 2030 and 2050 – our model indicated that these links exceed 100% of capacity as a result of airport-related traffic:

- 88km widening of the M25 (73km single lane widening and 15 km double lane widening);
- 17km single lane widening of the M2;
- 17km widening of the A2 (2km single lane widening and 15km double lane widening);
- Around 30km single lane widening of the A12/A127/A13 roads on their approach to the M25 from outside London.

Additionally, the construction of the ITE airport brings the predicted Volume/Capacity Ratios (VCRs) above the critical 85% threshold on the following links, and additional road widening may be required as follows:

- 20km single lane widening of the M25;
- 3km single lane widening of the M2;
- Around 55km single lane widening of the A12/A127/A13 in various locations.

Engineering costs

A summary of the costs calculated for each of the rail options is shown in the table below, and a summary of the methodology used to develop these costs is provided in Chapter 6 of this report.

Summary scheme costs for rail packages (£)

Scheme	Option 1 Do minimum	Option 2 Waterloo Stopper	Option 3 Crossrail Northern extension but not AEX	Option 4 AEX but no Crossrail Northern extension
Common Tracks into Airport	920,000,000	920,000,000	920,000,000	920,000,000
Shuttle to Strood	100,000,000	100,000,000	100,000,000	100,000,000
Shuttle to Grays Station	1,600,000,000	1,600,000,000	1,600,000,000	1,600,000,000
Waterloo Stopper		510,000,000	510,000,000	510,000,000
Southern Crossrail Extension	1,710,000,000	1,710,000,000	1,710,000,000	1,710,000,000
Northern Crossrail Extension			1,030,000,000	
HS1 Extension	235,000,000	235,000,000	235,000,000	235,000,000
Additional HS1 platform at St Pancras	110,000,000	110,000,000	110,000,000	110,000,000
Airport Express				7,660,000,000
Rail costs total	**4,675,000,000**	**5,185,000,000**	**6,215,000,000**	**12,845,000,000**
Risk and optimism bias	5,140,000,000	5,700,000,000	6,840,000,000	14,130,000,000
RAIL TOTAL (inc. risk and optimism bias)	**9,820,000,000**	**10,890,000,000**	**13,050,000,000**	**26,970,000,000**

Note: excludes land costs

For highway costs, overall out-turn unit road widening costs of £35m-£50m per km were used to estimate total costs associated with the ITE of between £4.8bn and £8.2bn. As well as the range in unit costs, this variation also accounted for the criteria applied to identify whether capacity issues could be related to airport traffic (links where demand exceeded 100% capacity as opposed to those where it exceeded 85% capacity). These costs excluded risk and optimism bias, which when included bring the total estimate up to between £10.1bn and £17.2bn.

In addition, if the DfT took the decision to adopt Lower Thames Crossing Option A, and subsequently the ITE airport is approved, the location of the LTC at Option A would be sub-optimal. Under this scenario, the case might be made for the ITE airport to include the incremental cost of LTC Option C over Option A. This incremental cost is estimated to be £2bn.

In terms of engineering feasibility and overall deliverability, there would be significant challenges to overcome to provide a successful rail package for the ITE airport, especially for option 4. For example, the four-tracking of the Abbey Wood to Hoo Junction line to accommodate a southern branch Crossrail extension would present significant issues in terms of land acquisition, while the AEX scheme (if required) would involve providing four new subterranean stations (connected via an underground tunnel around 18km in length), three of which would need to be connected to existing heavily used underground stations. The feasibililty of the HS1 spur is also dependent on securing 4 train paths on the line (which has been identified as unfeasible by HS1 Ltd although consultation elsewhere in the rail industry suggests it could be achieved) and would require the construction of an additional platform at St. Pancras. In addition to these major strategic challenges, a range of more local issues would need to be addressed, some of which (such as the provision of new platform capacity at central London termini and resolving line utilisation issues in the Medway area) are likely to require costly solutions.

Environmental impacts

The new transport links would introduce new impacts on international and nationally designated sites in addition to the ITE airport itself. All of the surface transport access requirements for the ITE airport are likely to lead to significant additional environmental impacts.

All of the rail options are generally similar in terms of their overall potential impact on the environment within the Hoo Peninsula. This is because all have the same new routes proposed through this location. There are also additional impacts arising from the Crossrail Northern Extension and the Airport Express in other locations.

There is very little difference between the potential environmental risks and impacts associated with the two road improvement scenarios, related to the aforementioned core and extended baselines. This is because the differences in the roads likely to be upgraded in the core baseline compared with the extended baseline are limited to two road lengths. The main differences are the number of additional carriage ways that would need to be constructed on existing roads in the core baseline without the impact of the LTC Option C alignment and the effects of widening would need to be considered at a later stage of assessment if the ITE option is taken forward as a fourth short-listed option.

The Thames Estuary and Marshes and Medway Estuary and Marshes SPA and Ramsar sites, internationally designated sites, would be directly affected by rail access routes involving habitat loss, severance and fragmentation. This could include for example, up to 4km of new rail within the Thames Estuary Ramsar site. There are likely to be additional disturbance impacts as a result of construction and operation where both road and rail run adjacent to designated areas. Compliance with the Conservation of Habitats and Species Regulations would need to be demonstrated. This would involve undertaking a Habitats Regulations Assessment (HRA). This would include an appropriate assessment of the in-combination effects of the surface access routes. The effects of the surface access routes are likely to increase the total area of compensatory habitat that would need to be provided for the airport development. This would add to the costs of the scheme.

In addition, there would be potential impacts on nationally designated sites including SSSIs. Routes running through a small number of sites including the SSSI designations which also form the internationally designated sites identified above. Compliance with National Planning Policy Framework would need to be demonstrated regarding nature conservation, heritage and other environmental planning constraints including AQMA objectives for the road improvements and planning policy relating to AONB.

Mitigation measures for ecological purposes would be required to minimise potential impacts on designated sites, this would include detailed routing and option design, increased tunnelling lengths, potentially restrictions on construction, screening and other measures to reduce disturbance such as noise barriers. Compensatory habitat would also be required and together these requirements could add significantly to the cost of the proposals.

Even with mitigation the proposed surface transport access routes would generate new environmental impacts and increase the cumulative effects from the development of a hub airport in the ITE. In particular, there would be wider ranging impacts extending long distances from the proposed airport development.

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs is to assess surface access to a future airport in the Inner Thames Estuary in accordance with the scope of services set out in the contract between Jacobs and the Airports Commission (AC). That scope of services, as described in this report, was developed with the AC.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the AC and other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the AC and key stakeholders and that available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, the AC, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the AC. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

1.1 Background

1.1.1 The Airports Commission (AC) was established in 2012 by the UK Government to examine the need for additional UK airport capacity and to recommend how any additional capacity requirements can be met in the short, medium and long term. The Commission is due to submit a Final Report to the UK Government by summer 2015 assessing the environmental, economic and social costs and benefits of various solutions to increase airport capacity, considering operational, commercial and technical viability.

1.1.2 A key milestone in the AC's operational life was the delivery in December 2013 of an Interim Report. Following a general call for evidence, this report detailed the results of analysis of the capacity implications of forecast growth in UK aviation demand and a preliminary appraisal on a long-list of proposals put forward by scheme promoters to address the UK's long-term aviation connectivity and capacity needs. This appraisal process identified three short-listed options, two focussed on expanding Heathrow Airport and one on expanding Gatwick. These short-listed options are to be further developed and appraised in the run-up to the submission of the Final Report.

1.1.3 The report also indicated that additional analysis was required to establish the credibility of a new hub airport in the Inner Thames Estuary (ITE) (identified as the most viable of the Thames Estuary options) as a potential fourth option on the short-list.

1.1.4 Shortly after its inception, the AC issued tenders for support contracts to engage independent technical advice on a range of aspects of the Commission's work. Jacobs together with sub-consultants Leigh Fisher and Bickerdike Allen Partners were appointed as the sole supplier on the Airport Operations, Logistics and Engineering Support Contract (ref: RM1082), which runs throughout the AC's lifespan up until the summer of 2015.

1.2 Study scope

1.2.1 This report details the aforementioned additional analysis undertaken on the ITE option by Jacobs on behalf of the AC with respect to surface transport. The work was undertaken under the terms of the RM1082 support contract, and focusses specifically on four key elements as follows:

- Estimating airport passenger and employee surface transport demand;
- Identifying surface transport measures to meet airport-related demand, accounting for capacity implications related to background growth and non-airport travel demand;
- Assessing the engineering feasibility and high-level cost of the surface transport measures identified to meet forecast travel demand;
- Assessing the environmental cost of the identified surface transport measures.

1.2.2 The ultimate aim of the study was to provide guidance to the AC on the feasibility and likely issues associated with the most viable packages of surface transport measures. The terms of reference for these packages were defined as follows:

- An 'opening year' (2030) package consisting of surface access elements designed to provide a reasonable degree of service for airport passengers at a minimum cost;
- A 'mature year' (2050) package consisting of elements designed to provide a high quality degree of service for airport passengers, befitting a world-class 21st century hub airport operating at full capacity.

1.2.3 The AC and key surface transport stakeholders including the Department for Transport (DfT), the Highways Agency (HA), Network Rail (NR), and Transport for London (TfL) were consulted throughout the study to inform the findings.

1.2.4 Together with separate work-streams focussed on environmental impacts (Study 1), airport operations (Study 2) and socio-economic impacts (Study 3), this analysis (referred to as Study 4) underpins the decision that will be taken by the AC on whether to include the ITE as a fourth option on the short-list for long-term additional UK airport capacity.

Inner Thames Estuary airport proposals

1.2.5 To aid the additional assessment of the ITE option, the AC announced another general call for evidence on feasibility in January with a deadline of the 23rd May. Over 170 responses were received from interested parties both in favour and against a new hub airport in this location, including significant submissions from the following organisations:

- Mayor of London/Greater London Authority (GLA)/Transport for London (TfL);
- Foster + Partners;
- Metrotidal Tunnel and Thames Reach Airport Ltd (MTTRA).

1.2.6 Each of these submissions built upon initial proposals put forward by the same organisations in the run-up to the December 2013 Interim Report, and were centred on the provision of an airport in the ITE that would effectively replace Heathrow as the UK's aviation hub and would be designed to handle up to 150 million passengers per annum (mppa) once fully operational. However, the submissions differed significantly both in terms of key assumptions and proposed surface access measures, and these differences are explored in the following chapter of this report. A fourth organisation, the Independent Aviation Advisory Group (IAAG), submitted a significant proposal for a London Gateway Airport in the ITE in the run-up to the December 2013 Interim Report but did not revise or update their proposal in May. As a result, the surface access measures included in the 2013 IAAG proposal have been compared with the revised submissions from the other three organisations in this report.

1.2.7 The assessment detailed in this report was undertaken independently by Jacobs but has been compared at every stage with the submissions, and meetings were held with MTTRA and Foster + Partners to better understand their approach to planning a new airport in the ITE. The relative merits of each submission in terms of surface access were compared with the ultimate aim of providing guidance to the AC on the feasibility of the most attractive surface transport packages.

1.2.8 An important point to note is that the packages identified by Jacobs did not have to be identical to any one option presented in an individual submission. The 'opening year' (2030) and 'mature year' (2050) options identified included elements from the submissions in hybrid packages that Jacobs considered to be the most viable options based on the analysis undertaken.

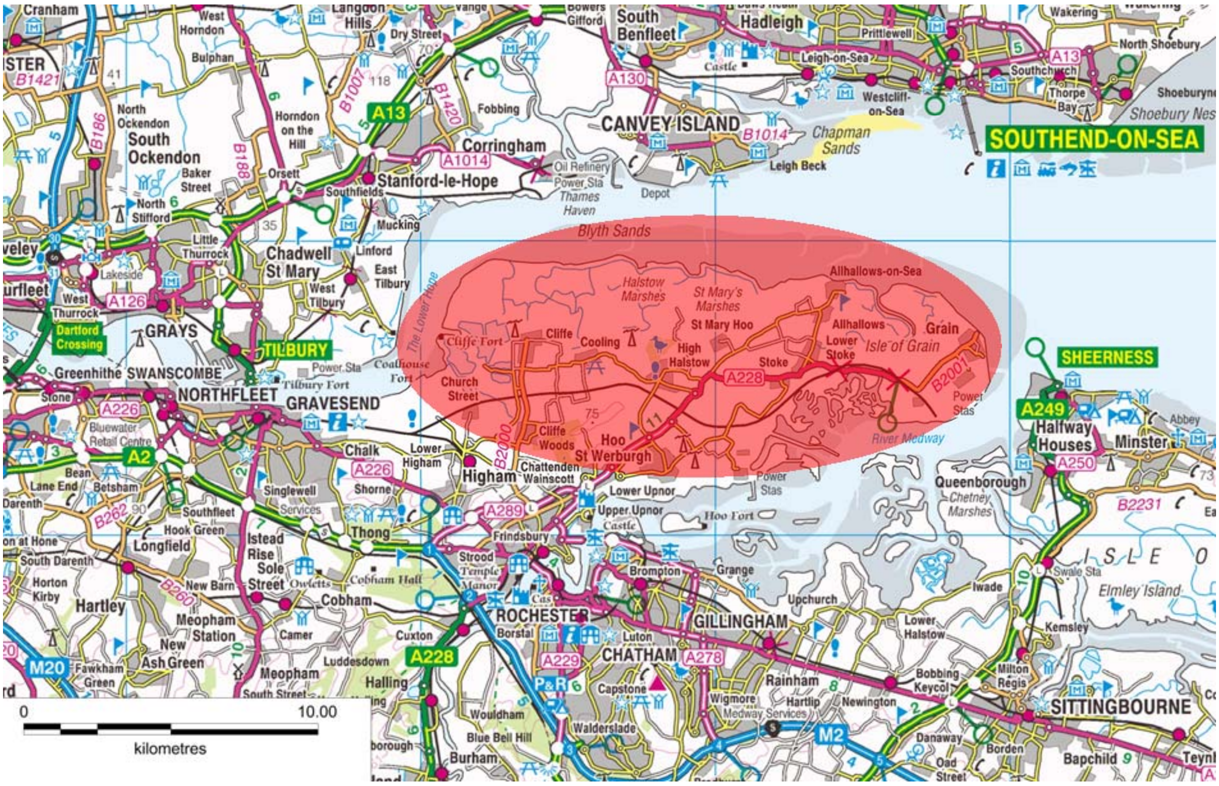
1.3 Context

1.3.1 In the context of this report, the ITE location refers to the Hoo Peninsula, a spur of land in the Thames Estuary between the Medway towns to the south and Southend-on-Sea and Canvey Island to the north on the opposite bank of the river, as shown in Figure 1. The area is currently predominantly marshland and includes a number of small settlements such as the villages of Cliffe, High Halstow, Grain, Lower Stoke and All Hallows. Immediately to the south of the village of Grain is a significant industrial area that includes Grain Power Station, a Liquefied Natural Gas (LNG) import facility, the Thamesport container port terminal, and other industrial and warehousing land-uses. A second power station, at Kingsnorth, is located on the River Medway some 6km to the south-west of Thamesport.

1.3.2 The site is located some 56km (35 miles) from central London, as shown in Figure 2, and is connected to the strategic road network via the A228/A289, which links to the A2/M2, the principal road corridor in north Kent, at junction 1. This in turn provides access to the M25 at junction 2, just south of the Dartford crossing.

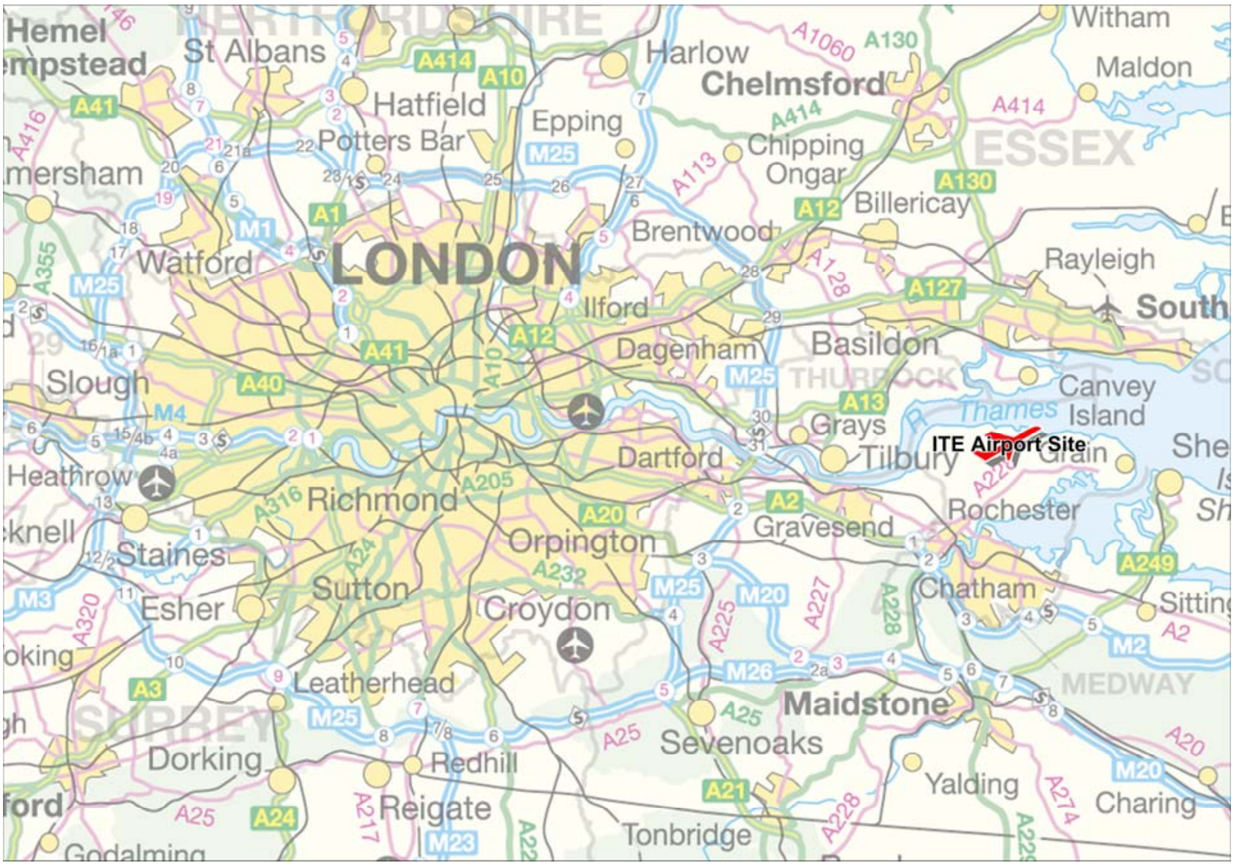
1.3.3 The closest passenger rail stations of note are at Gravesend, Strood and Rochester, all within 15km of the site. These stations together provide connections to a number of central London termini; locations in south-east London including Bromley; and destinations in Kent including Maidstone, Canterbury, Margate and Ramsgate. A single-track rail line runs through the site connecting Thamesport with Hoo Junction to the east of Gravesend, although this is currently a freight-only route. The High Speed 1 (HS1) Channel Tunnel Rail Link from St. Pancras International and Stratford also passes close to the site, running parallel to the A2/M2 from south-west of Gravesend to south of Chatham and parallel to the M20 from east of Maidstone to the Kent coast. HS1 includes stops in Kent at both Ebbsfleet and Ashford, the former approximately 20km from the site.

Figure 1: Inner Thames Estuary local environs



Contains Ordnance Survey data © Crown copyright and database right 2014

Figure 2: Inner Thames Estuary Airport location and context



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1.4 Report structure

1.4.1 The remainder of this report is structured as follows:

- Chapter 2 summarises the assumptions made in the four main ITE proposals received by the AC and compares the surface transport measures included in each;
- Chapter 3 summarises the approach to forecasting passenger and employee-related surface transport demand to an airport on the ITE, and describes how this demand was then used to assess capacity, level of service, and journey time issues for road and rail on key corridors;
- Chapter 4 details the subsequent assessment of a number of rail options to the airport, based on the methodology summarised in Chapter 3, and includes a high-level overview of rail deliverability issues;
- Chapter 5 summarises the strategic road network capacity enhancements that would be required to meet forecast traffic demand, again based on the methodology described in Chapter 3;
- Chapter 6 provides a high-level assessment of the cost of the surface transport rail options and road enhancements identified in the two previous chapters;
- Chapter 7 summarises the environmental impact of the identified surface access options;
- Chapter 8 summarises the conclusions of the study.

2. ITE proposals

2.1 Overview

2.1.1 This chapter summarises the assumptions and surface transport elements of the three main proposals for the ITE option received by the AC on the 23rd May as well as the IAAG proposal received in 2013, which was not updated or revised in May. Throughout the remainder of this report, elements of the four submissions have been compared with, and in a number of cases challenged by, the independent analysis undertaken by Jacobs.

2.1.2 All three submissions received in May assumed the provision of a hub airport replacing Heathrow and handling up to 150 million passengers per annum (mppa) once fully operational, but differed in terms of the headline assumptions used and the surface access measures proposed. Where gaps were evident in the 23rd May submissions, it was assumed that elements contained in the initial 2013 submissions assessed in the AC's Interim Report were still applicable. The IAAG's 2013 submission did not include any details regarding annual passenger or employee assumptions but did include a number of surface access schemes that have been summarised in this chapter.

2.1.3 The remainder of this chapter is divided into two sections comparing the differences in headline assumptions and proposed surface transport measures in each submission.

2.2 Headline assumptions

2.2.1 The headline assumptions made in each of the proposals with regard to airport passengers are summarised in Table 1, indicating that the Mayor of London provided the most comprehensive breakdown of assumptions. A key assumption of note made in three of the proposals was a high passenger public transport mode share of 60-65%. Foster + Partners and MTTRA stated explicitly in their 2013 submissions that the rail mode share would be 60% while the Mayor of London indicated that for testing purposes it was assumed that the assumed 65% public transport mode share would all use rail.

2.2.2 Table 2 summarises the headline assumptions made in each of the proposals with regard to airport employees. As with passengers, all the proposals included bold assumptions regarding employee public transport mode share to the airport, ranging from 60% using rail (identified in both the MTTRA and Foster + Partners proposals) to an overall 75% public transport mode share (identified by the Mayor of London). As with passengers, the Mayor's submission indicated that for testing purposes, all employee public transport trips would be made by rail.

Table 1: ITE proposals – headline surface transport assumptions for passengers

Parameter	Mayor of London	Foster + Partners	Metrotidal Tunnel and Thames Reach Airport Ltd (MTTRA)	Independent Aviation Advisory Group (IAAG)
Opening year (2030) MPPA	90	110	115	~ (no assumption indicated)
Peak capacity (2050) MPPA	150	150	150	~
Transit passengers (interliners)	20%-50% (35%-37% during peak hour)	38%	~ (no assumption indicated)	~
Daily surface access 'to-from' factor	50% to, 50% from	~	~	~
Busy day factor	Based on BAA Annual Patterns of Traffic 2010	~	~	~
Peak hour - time	0700-0800	~	~	~
Peak hour - % daily trips	Based on hourly flight profiles for a peak month	15%	~	~
Peak-hour two-way trips	20,200 (150mppa)	~	~	~
Main mode split: Private v Public	35% private, 65% public	60% use rail for last/first mode to/from the airport	60% rail use	~
PT sub mode split: Bus/Coach v Rail	All PT trips (65%) assumed to be rail for testing	~	~	~
Car occupancy factor	1	~	~	~
% Meet and Greet by rail	Not quoted for rail (total meet and greet demand 10% of passenger demand)	10% of airport passenger rail demand	~	~

Sources: Atkins (July 2013), 'Mayor of London's Aviation Work Programme, Surface Access Technical Report';
Atkins (May 2014), 'Mayor of London's Aviation Work Programme, Technical Note – surface access demands and impacts';
Foster + Partners (July 2013), 'THAMES HUB AIRPORT, Outline proposal to the Airports Commission'
Foster + Partners (May 2014), 'INNER THAMES HUB ESTUARY, Feasibility Studies';
Thames Reach Airport Consortium (July 2013), 'Air Rail Hub, Submission to the Sir Howard Davies Commission';
METROTIDAL TUNNEL AND THAMES REACH AIRPORT (April 2014), 'TRANSPORT CONNECTIONS'.

Table 2: ITE proposals – headline surface transport assumptions for employees

Parameter	Mayor of London	Foster + Partners	Metrotidal Tunnel and Thames Reach Airport Ltd (MTTRA)	Independent Aviation Advisory Group (IAAG)
Total Employees	130,000	100,000	~ (no assumption indicated)	~ (no assumption indicated)
% Employees at work on a given day	70%	63%	~	~
% Employees travelling to/from airport during peak hour	15% (19,000 two-way trips)	15%	~	~
AM peak main mode split: Private v Public	25% private, 75% public	60% will use rail	60% rail use	~
PT Sub mode split Bus/Coach vs Rail	All PT trips (75%) assumed to be rail for testing	~	~	~
Staff car occupancy factor	1.5	~	~	~

Sources: Atkins (July 2013), 'Mayor of London's Aviation Work Programme, Surface Access Technical Report';
Atkins (May 2014), 'Mayor of London's Aviation Work Programme, Technical Note – surface access demands and impacts';
Foster + Partners (July 2013), 'THAMES HUB AIRPORT, Outline proposal to the Airports Commission'
Foster + Partners (May 2014), 'INNER THAMES HUB ESTUARY, Feasibility Studies';
Thames Reach Airport Consortium (July 2013), 'Air Rail Hub, Submission to the Sir Howard Davies Commission';
METROTIDAL TUNNEL AND THAMES REACH AIRPORT (April 2014), 'TRANSPORT CONNECTIONS'.

2.3 Surface transport elements

2.3.1 The surface transport packages proposed in each of the four submissions are summarised in turn in this section. It should be noted that the rail elements of the proposed packages, notably that put forward by MTTRA, incorporate some complex assumptions regarding service patterns and required infrastructure works. In the interests of brevity, Jacobs has sought to provide an overview of the key elements of the proposed packages in this section.

Mayor of London

2.3.2 The Mayor of London's submission indicates that surface access for all the AC's short-listed options and the ITE should be compared using a framework based on the categorisation of surface transport packages as either low, intermediate, high or optimum, depending on the level of performance they deliver.

2.3.3 The submission focusses on the proposed elements of an optimum scenario for the ITE option to handle 150mppa, which is summarised in Figure 3 – the submission indicates that a workable surface access package for the airport during the opening year (2030) would not need to include all of the proposed elements associated with this scenario.

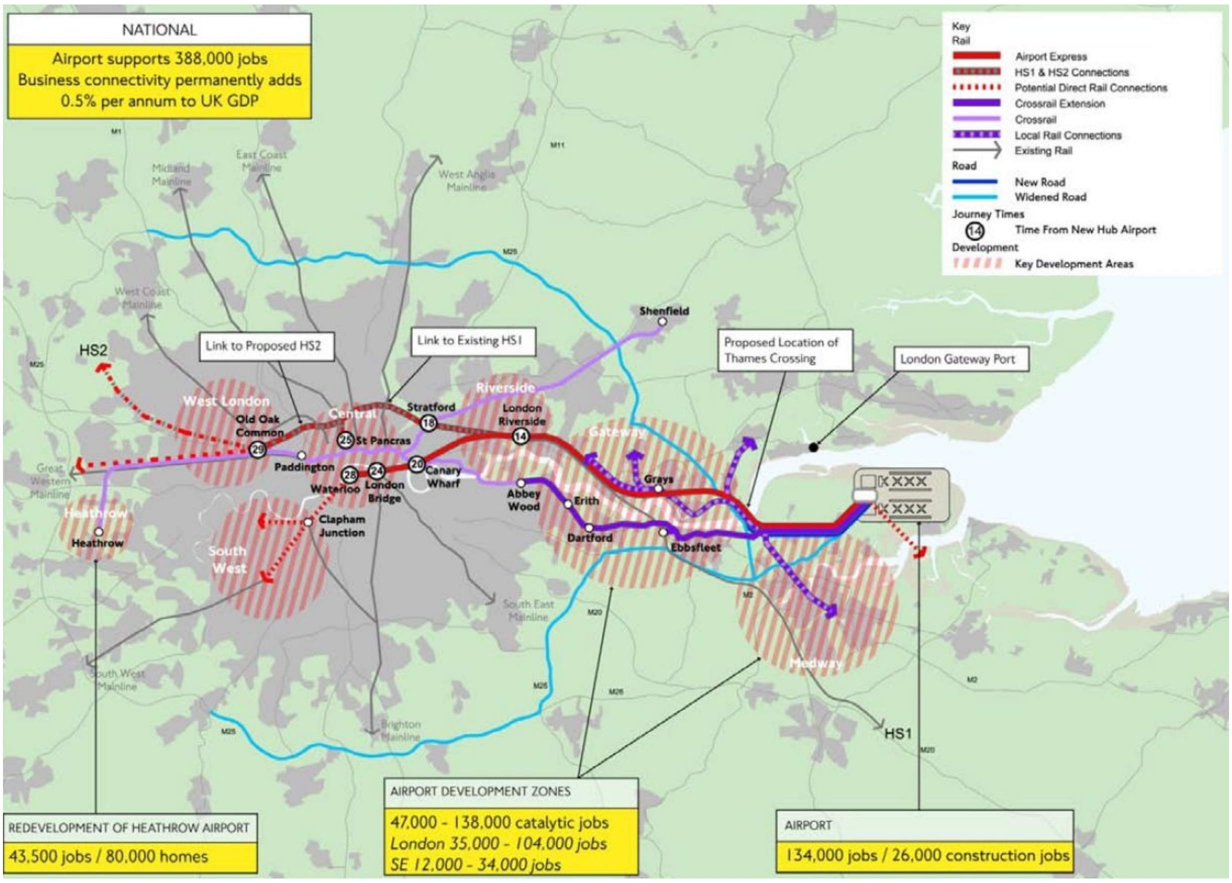
2.3.4 The rail components of the optimum scenario can be summarised as follows:

- Central London Airport Express providing high speed connectivity to Barking Riverside (14mins), Canary Wharf (20mins), London Bridge (24mins), and Waterloo (28mins) – the Mayor of London's submission does not include detailed information about the nature of the alignment for this service so for the purposes of this study, Jacobs has made the following assumptions:
  - The sections between Waterloo and Barking Riverside, and through the Thurrock area around Grays, would operate along new tunnelled links;

- The service would operate at surface level between Barking and Rainham (either sharing or alongside the existing HS1 alignment in this area);
- The river crossing east of Grays would be via a multi-modal bridge on the current LTC Option C alignment;
- The service would then run between the LTC and the airport at surface level via the existing Hoo Junction;

- HS1-HS2 link providing direct high speed connections to St Pancras, Old Oak Common (29 minutes) and onward connectivity via HS2 to Birmingham and the North – this has been assumed to have the same configuration as the proposed spur that was recently dropped from the core HS2 proposal by the government;
- Crossrail extension from Abbey Wood via Dartford and Gravesend to provide an additional rail alternative to/from Central London – this is assumed to be provided on new tracks alongside the existing route through Dartford and Gravesend (this corridor has already been safe-guarded for potential eastward Crossrail extensions);
- Local rail connections to South Essex (via the Thames Crossing), North Kent and South East London, including radically enhanced connectivity to growth and regeneration areas such as the City and Fringe, Riverside and Thames Gateway – these connections are assumed to primarily utilise existing track with some area-specific enhancements (for example at key junctions) and the provision of the current LTC Option C alignment as indicated above.

Figure 3: Mayor of London ITE surface access proposal



Source: Atkins (July 2013): 'Mayor of London's Aviation Work Programme Surface Access Technical Report' – page 14

2.3.5 The road components of the optimum scenario are as follows:

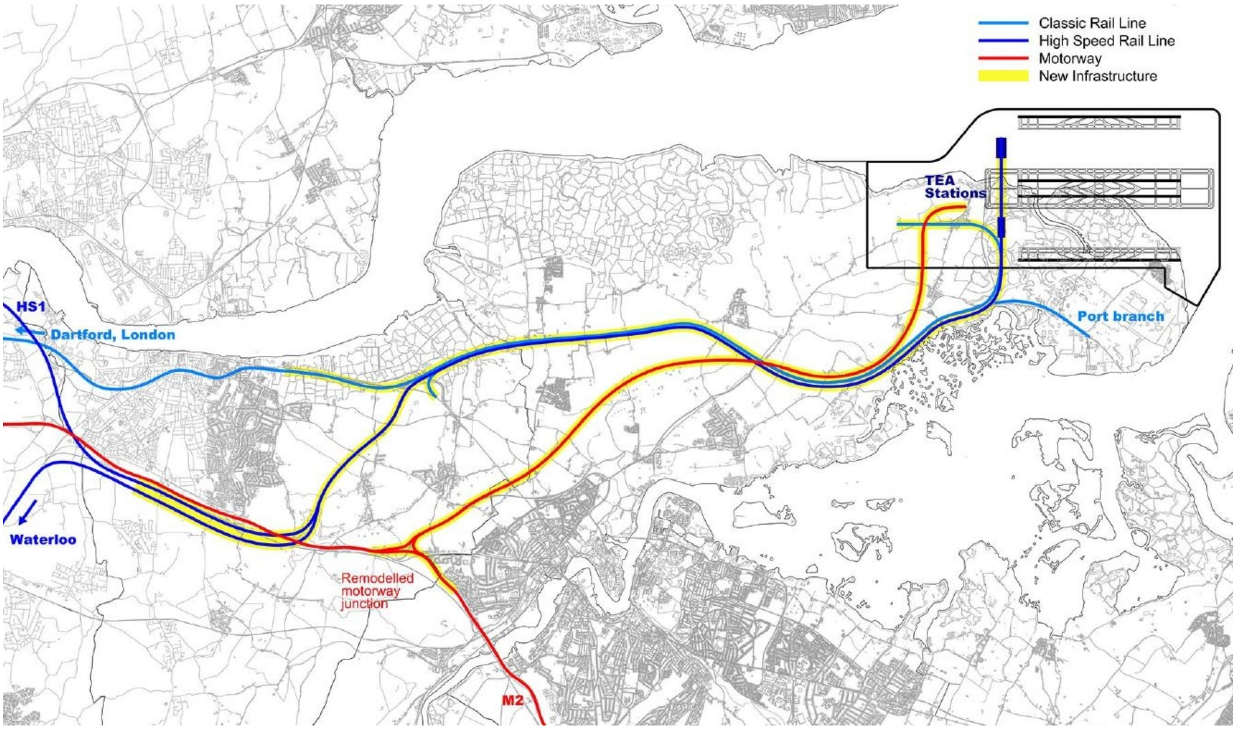
- Airport access roads – new access roads and widening of existing roads, to provide efficient access, with two links to provide resilience;

- Lower Thames Crossing (LTC) – building on existing proposals for LTC (Option C) to ensure sufficient capacity for peak airport demand;
- Capacity enhancements to the M25 and the A2 – widening and enhancement to mitigate against delay and congestion for airport and non-airport users.

Foster + Partners

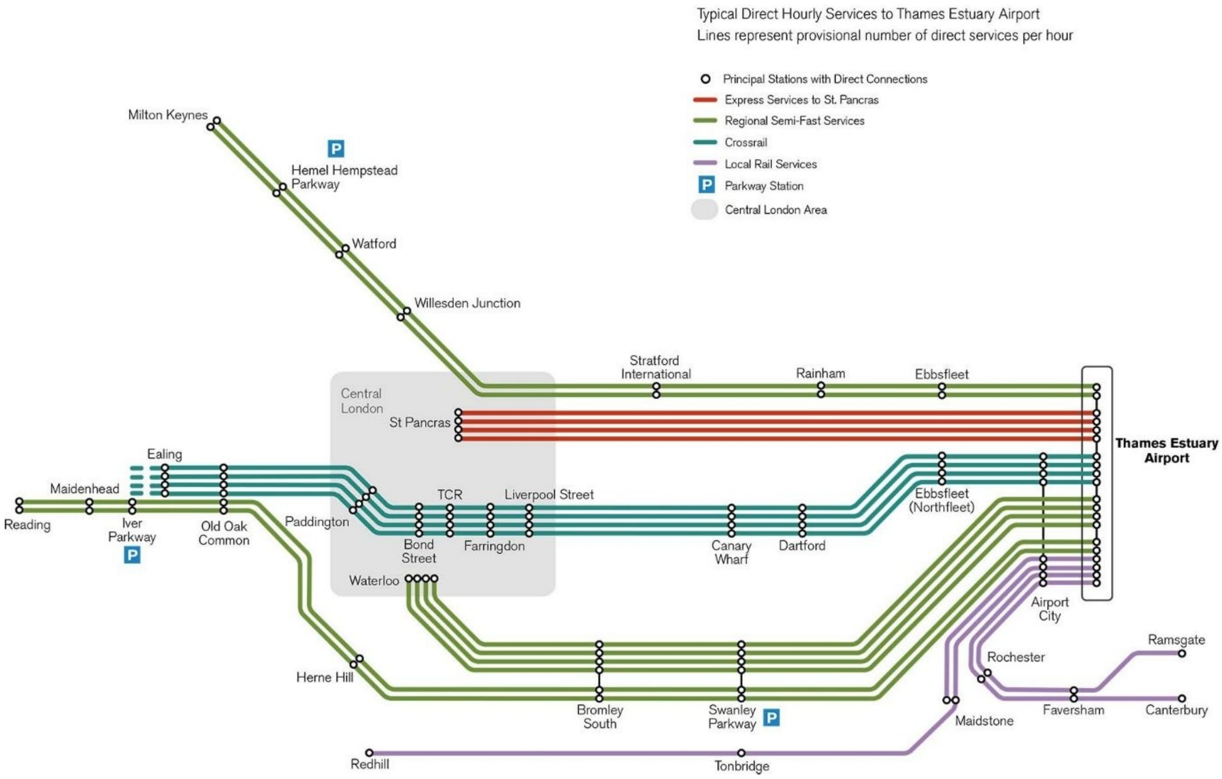
2.3.6 Foster + Partners proposed two surface transport packages in their submission, the first for the opening year (2030) and then a higher level of intervention for a mature year (2050) when the airport is expected to handle up to 150mppa. The opening year (2030) package is summarised in Figure 4 with the rail elements detailed in Figure 5.

Figure 4: Foster + Partners ITE surface access proposal – opening year (2030)



Foster + Partners (May 2014): 'INNER THAMES HUB ESTUARY Feasibility Studies' – page 63

Figure 5: Foster + Partners ITE direct rail access proposal – opening year (2030)



Source: Foster + Partners (May 2014): 'INNER THAMES HUB ESTUARY Feasibility Studies' – page 65

2.3.7 The opening year (2030) rail package differs from the Mayor of London's submission in that it does not include a new express link from Waterloo or a direct link to the north of the UK via an HS1-HS2 spur. Foster + Partners also proposes a number of direct rail links utilising existing track to locations around London including Milton Keynes and Reading, which are not included in the Mayor of London's submission although the latter suggests that it may be possible to run direct services to some destinations via Clapham Junction.

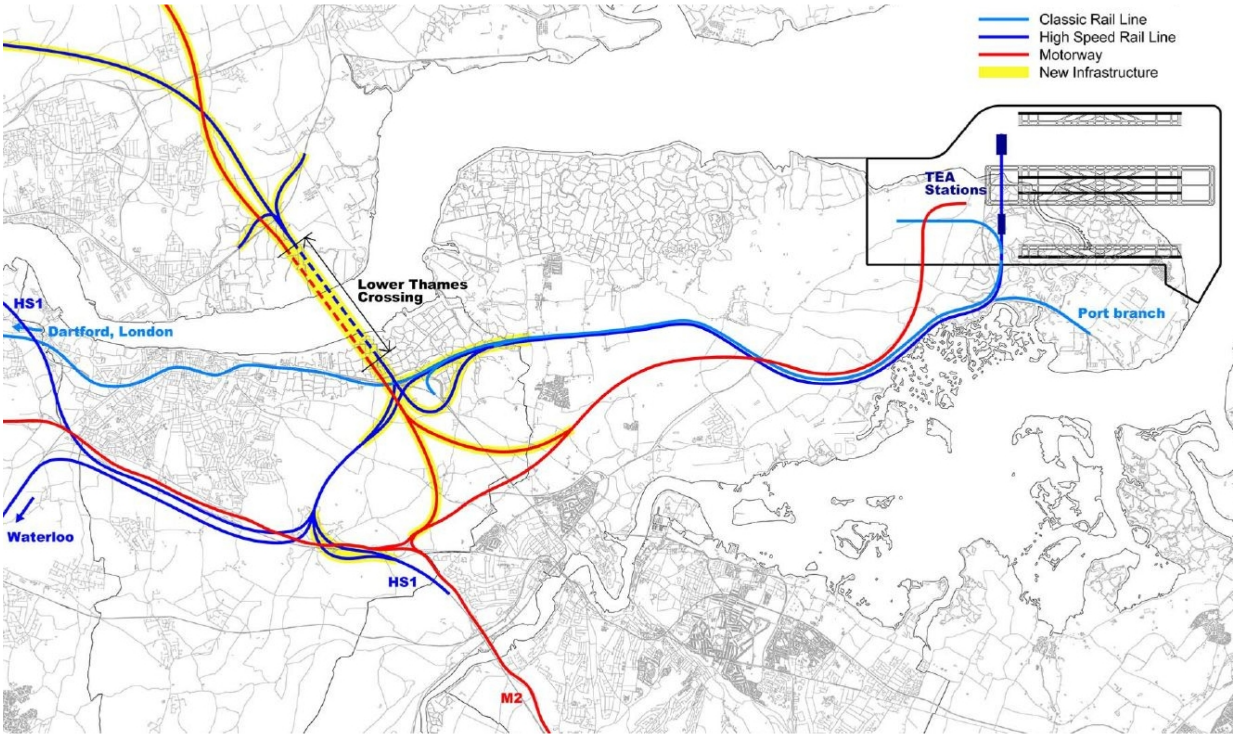
2.3.8 However, a number of other rail elements are similar to the Mayor of London's proposals, including a direct link from St. Pancras utilising spare capacity on HS1 with a spur to the airport from Hoo Junction, the extension of the southern branch of Crossrail and local rail connections to North Kent and South London.

2.3.9 In terms of road enhancements, a dual four-lane motorway would be provided between the airport and the A2/M2 corridor via an upgrade of junction 1, and the A228 would be upgraded to dual-two to provide enhanced access from the Medway Towns via the Medway Tunnel. Foster + Partners also identify that widening is likely to be needed in the following locations:

- A2 between M25 junction 2 and M2 junction 1 (from 4 to 5 lanes);
- M25 between junction 2 and junction 3 (from 4 to 5 lanes);
- M25 between junction 3 and junction 6 (from 3 to 4 lanes); and
- M25 between junction 30 and junction 27 (from 4 to 5 lanes).

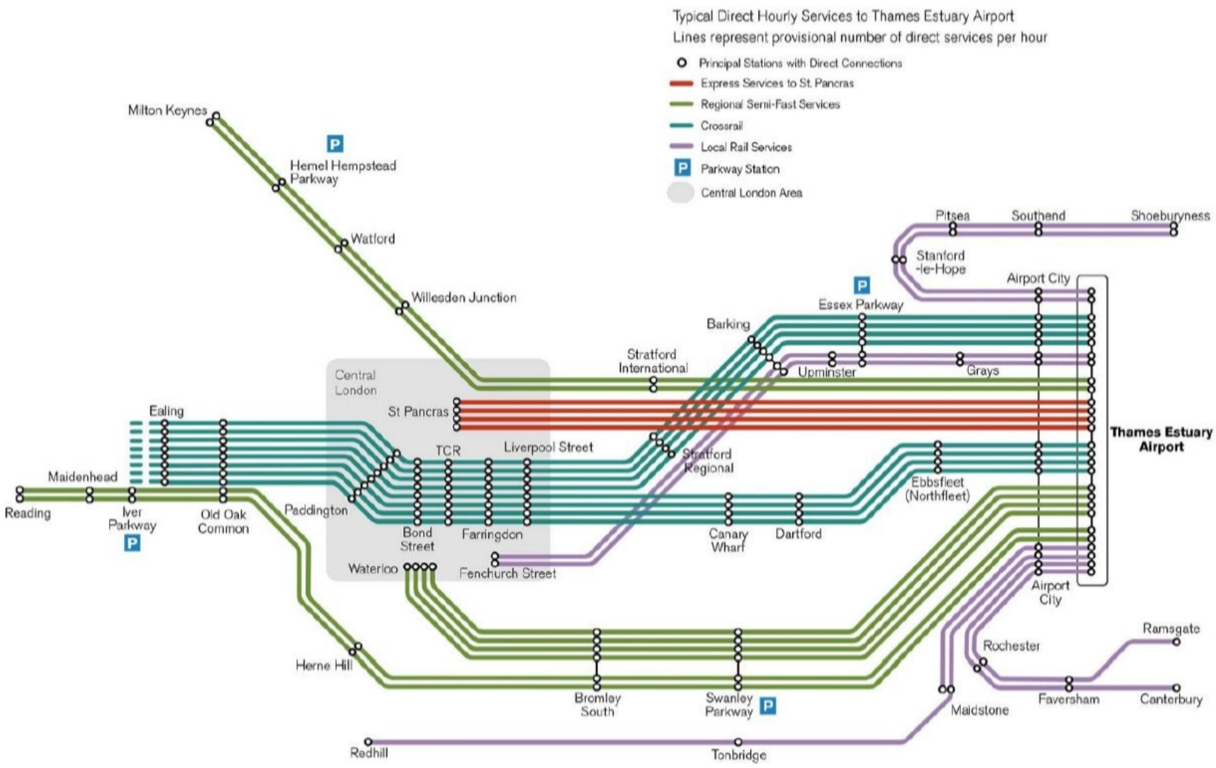
2.3.10 The mature year (2050) package is shown in Figure 6 with the rail elements summarised in Figure 7. Additional rail connections are provided over a new multi-modal LTC including an extension of the northern branch of Crossrail and local rail links to Fenchurch Street and South Essex. The Mayor of London's submission also includes a proposal for direct rail links to South Essex via the LTC. A similar road connection is included in the AC's extended baseline (see Appendix A) so it has therefore been assumed for the purposes of this study that such a connection, if committed, would be in place by 2030, well in advance of the mature year (2050) scenario outlined by Foster + Partners.

Figure 6: Foster + Partners ITE surface access proposal – mature year (2050)



Source: Foster + Partners (May 2014): 'INNER THAMES HUB ESTUARY Feasibility Studies' – page 74

Figure 7: Foster + Partners ITE direct rail access proposal – mature year (2050)



Source: Foster + Partners (May 2014): 'INNER THAMES HUB ESTUARY Feasibility Studies' – page 75

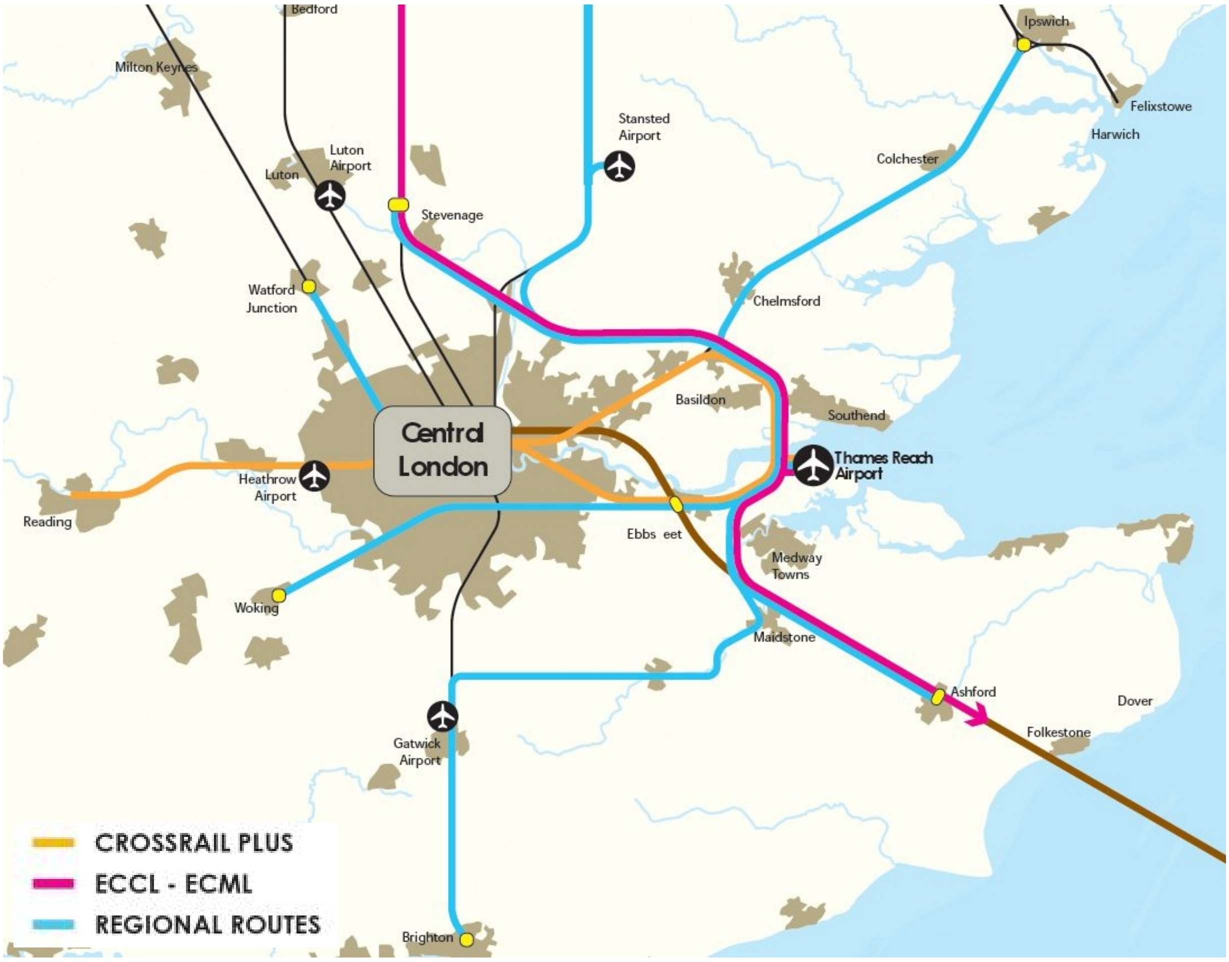
2.3.11 Foster + Partners also indicated that further road widening may be needed on the strategic highway network to accommodate airport demand in the mature year (2050) scenario, including:

- A2 between M25 junction 2 and M2 junction 1 (from 5 to 6 lanes);
- M25 between junction 2 and junction 3 (from 5 to 6 lanes);
- M25 between junction 3 and junction 6 (from 4 to 5 lanes);
- M25 between junction 6 and junction 7 (from 4 to 6 lanes);
- M25 between junction 7 and junction 9 (from 4 to 5 lanes);
- M25 between junction 29 and junction 27 (from 5 to 6 lanes); and
- M25 between junction 27 and junction 21 (from 4 to 5 lanes).

Metrotidal Tunnel and Thames Reach Airport Ltd (MTTRA)

2.3.12 MTTRA's proposal for surface access to a new airport in the ITE included some rail elements common to both the Mayor of London and the Foster + Partners submissions, notably a direct link to St. Pancras via a spur to the HS1 link, the extension of the southern branch of Crossrail from Abbey Wood, and a connection to the Fenchurch Street line via a rail river crossing. In addition, the MTTRA submission included a direct express connection to Waterloo similar to the Foster + Partners semi-fast proposal via Bromley South, and an extension of the northern branch of Crossrail from Shenfield, which was also included in the Foster + Partners 'mature year' (2050) proposal. Each of these proposals is indicated on the plans in Figure 8 to Figure 10.

Figure 8: MTTRA ITE strategic rail access proposal

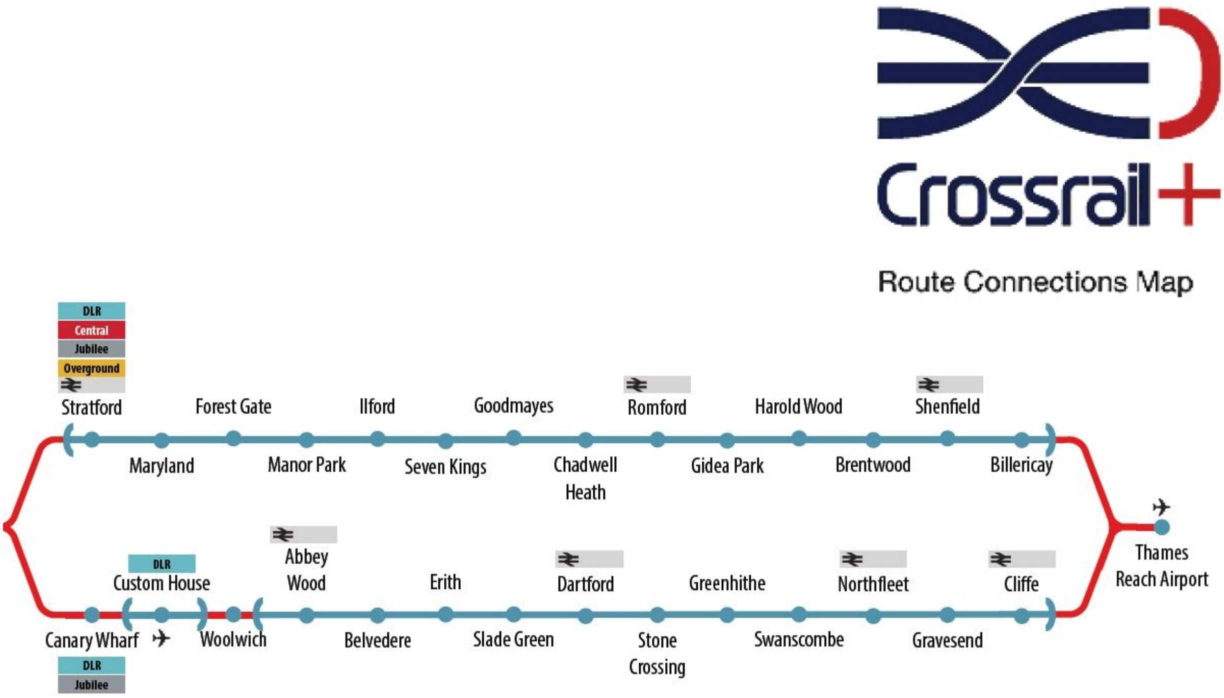


Source: MTTRA (May 2014), 'METROTIDAL TUNNEL AND THAMES REACH AIRPORT SUMMARY PRESENTATION' – p3

Figure 9: MTTRA TRAX (Thames Reach Airport Express) proposal

Source: MTTRA (May 2014), 'METROTIDAL TUNNEL AND THAMES REACH AIRPORT SUMMARY PRESENTATION' – p9

Figure 10: MTTRA Crossrail Plus proposal



Source: MTTRA (May 2014), 'METROTIDAL TUNNEL AND THAMES REACH AIRPORT SUMMARY PRESENTATION' – p6

2.3.13 However, as illustrated on the plans above, the MTTRA submission also included a wide range of additional rail elements, which included the following:

- All proposed rail river crossings would be via a new multi-modal Canvey to Hoo tunnel from the airport emerging on the north bank in the vicinity of Canvey Island – this would be delivered in lieu of the LTC alignment referenced by the Mayor of London and Foster + Partners – it was noted that MTTRA put this forward as their preferred river crossing option from a short-list of three identified alignments that included the current LTC Option C route included in the Mayor of London and Foster + Partners submissions;
- A new 'HS3' providing direct services to Ashford International and Europe to the south and Stevenage, Peterborough, Newcastle and Edinburgh to the north via the East Coast Main Line (ECML);
- Direct airport express services to additional London termini including Victoria, London Bridge (via Kent lines), and Liverpool Street;
- Direct regional services from Ipswich, Cambridge, Stansted, Watford Junction, Woking, and Brighton via Gatwick.

2.3.14 In terms of road enhancements, MTTRA proposed the following key elements:

- An outer orbital route across the estuary via a dual-two link in the aforementioned tunnel, linking the A289 (upgraded to dual-three where required) to a dual-two extension of the A130;
- Upgrading the A13 between Orsett and Pitsea to dual-three where required, with the provision of new sections of road to relieve local capacity constraints;
- A new dual-two East London Crossing between the A406 and A2016.

2.3.15 MTTRA indicate in their submission that long-term capacity enhancements on the outer orbital link would enable the LTC proposals to be dropped and avoid the need for another lane upgrade around the eastern half of the M25.

London Gateway Airport – IAAG

2.3.16 IAAG's 2013 submission indicated that a new airport in the ITE would take advantage of extensive improvements that have already been made to existing road infrastructure in the vicinity of the airport site, particularly affecting the A13, the A2 and the A20. The submission pointed out that Dubai World is already improving road transport links through South Essex to serve the new London Gateway port, and that plans for a new Lower Thames Crossing have been much discussed, including the identification of the A13 junction that would provide a key access route to the new crossing. The connections provided by the M25 are also highlighted, and the proposal suggests the extension of the M2 to the airport site, with a number of alternative route configurations referenced. A summary plan of the IAAG road proposal is shown in Figure 11.

Figure 11: IAAG proposal for road access to a London Gateway Airport

Source: IAAG/Met Studio (2013), 'London GatewayAirport – A New Beginning' – page 5

2.3.17 In terms of rail access, the IAAG 2013 proposal includes a number of key elements as follows:

- Establishing Gravesend as a critical interchange hub serving the airport;
- Providing an express service from Gravesend to St Pancras via Ebbsfleet in 25 minutes, thus providing good onward connections to the midlands and north of England;
- Enhancing connections to Liverpool and Fenchurch Street through Essex via the LTC (which would be a multi-modal tunnel carrying road and rail traffic);
- Using the former international terminal at Waterloo to provide enhanced connections via Ebbsfleet and Gravesend;
- Providing connections on existing track to London Bridge, Victoria, Charing Cross, and Clapham Junction.

2.3.18 These rail connections are illustrated on the plan in Figure 12, and would serve the airport and communities in the Medway area, providing improved links to London.

2.3.19 The submission also highlights the river as a means of transporting air passengers to and from London, references Hong Kong to Macau ferry services as an exemplar, and indicates that high speed ferry links could also be provided to Southend (for staff) and to northern Europe. The proposal also highlights how links across the estuary to the London Gateway could remove commercial traffic from the M25, the Dartford Crossing, the M2 and the M20.

Figure 12: IAAG proposal for rail access to a London Gateway Airport

Source: IAAG/Met Studio (2013), 'London GatewayAirport – A New Beginning' – page 6

3. Surface transport demand forecasting methodology

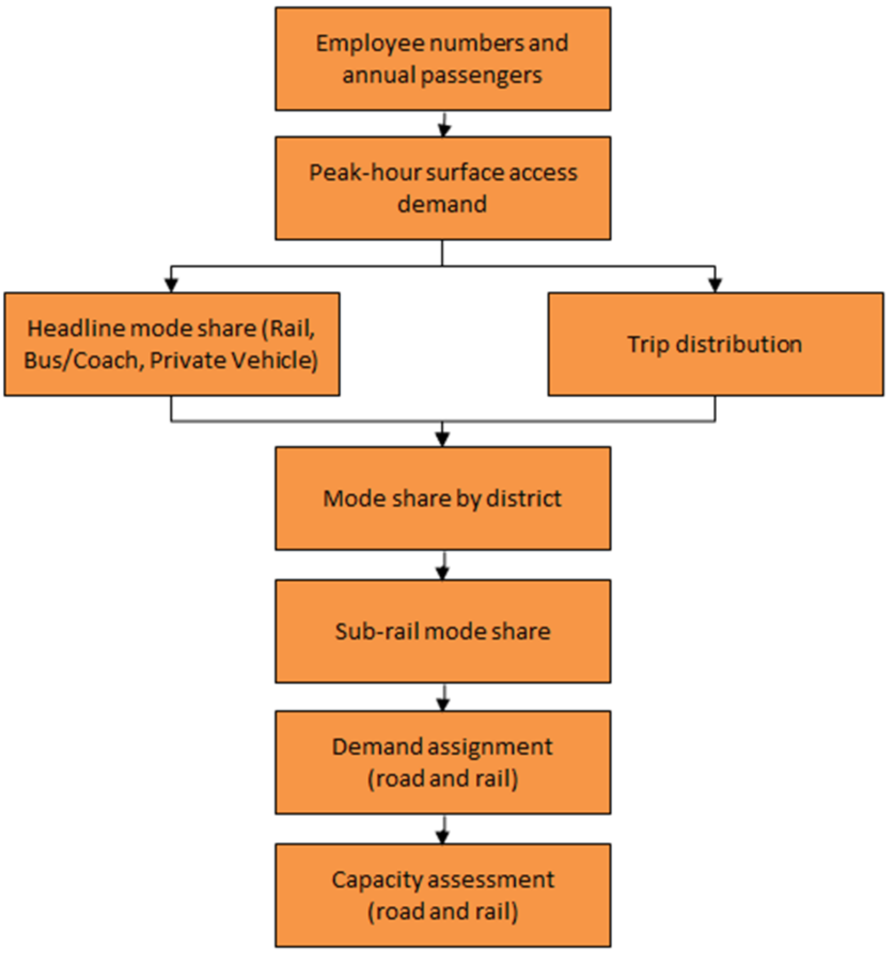
3.1 Overview

3.1.1 The approach to forecasting surface transport demand for an airport in the ITE was broken down into a number of key stages as follows:

- Estimating total peak-hour demand to and from the airport by main mode of surface transport (either private vehicle, bus/coach, or rail);
- Allocating total peak-hour trips to and from the airport to geographic regions in the UK;
- Assigning rail trips from different geographic regions to different rail corridors – a number of options for rail access to the airport were tested consisting of different combinations of schemes;
- Assigning road-based trips to the airport to the strategic road network in the south-east.

3.1.2 This methodology is summarised graphically in Figure 13.

Figure 13: ITE Airport surface transport demand forecasting methodology overview



3.1.3 Surface transport demand in this context was considered to include trips made to and from the airport by both air passengers and employees based on-site and in direct airport-related employment in the immediate vicinity of the airport. Passengers and employees were considered separately before being combined for the analysis of rail mode choice and road routes.

Future year scenarios and baselines

3.1.4 Surface transport demand to and from the airport was forecast for two future-year scenarios – an airport opening year in 2030, and a subsequent 2050 scenario to allow for an assessment of the impacts of background growth and a gradual ramping-up of airport operations.

3.1.5 Surface transport baselines for the future years were defined by the AC in accordance with its Appraisal Framework, the final version of which was published on the 2nd April 2014. The baselines identified the likely state of surface transport infrastructure and operations in the future without consideration of any airport expansion, and were used to assess all three short-listed options and the potential fourth ITE option identified in the December 2013 Interim Report to ensure consistency when testing the implications of new airport capacity.

3.1.6 Two separate baselines were identified as follows:

- **Core Baseline** – consisting of existing infrastructure and services plus enhancements whose delivery the AC considered to be inevitable or close to inevitable – this included schemes with a firm Government commitment and funding plan such as the main HS2 line (excluding spurs); the NR Control Period (CP) 4 rail infrastructure plan; almost all of the CP5 infrastructure plan (excluding Western Rail Access to Heathrow); and other road, rail and underground schemes for which there was firm policy and funding support;
- **Extended Baseline** – consisting of infrastructure and service improvements that were not firmly committed, but which the AC considered likely to be required to support background demand – this included some schemes (Western Rail Access to Heathrow and some planned capacity improvements to the Brighton Main Line) where the delivery probability appeared very high in addition to more speculative schemes.

3.1.7 The AC indicated that Core Baseline schemes were not to be included in the costs associated with airport-related schemes, and that Extended Baseline schemes relevant to expansion proposals would be considered on a case-by-case basis to determine whether the proposal in question would affect the likelihood of an enhancement being required or the timing within which it was required. This would allow the AC to reach a judgement on whether some or all of the enhancement costs should be included within the assessment of the airport proposal costs.

3.1.8 The full contents of the core and extended baselines are detailed in Appendix A of this report.

3.2 Benchmarking

Heathrow Airport

3.2.1 A central assumption behind the forecasting undertaken on the ITE option was that it would effectively serve as a direct replacement for Heathrow Airport as the UK's primary aviation hub. As a result, many of the headline assumptions on surface access, summarised in the following section of this report, are based on the current travel behaviour of staff and employees at Heathrow, adapted where necessary to account for the change in geographic location of the airport to the ITE and likely future changes related to travel behaviour and demand management.

3.2.2 It should be noted that in the context of this report, employee travel behaviour refers to trips made by direct airport employees (both on-site and off-site in the immediate vicinity). This equates with the scope of the Heathrow employee travel survey undertaken in 2008/9 and updated by Ipsos Mori in 2013/4. In a summary report of the latter survey, Heathrow employment is defined as being within 'the boundaries of Heathrow', which includes "*airport terminals, Northern Area/Compass Centre, Southern Area, EBP/Eastern Area/Compass Centre and the Waterside area*"[2]. The report indicates an overall estimate of 75,780 staff based at Heathrow in 2013/4 (similar to the reported figure of 76,500 in 2008/09 survey) defined as "*anyone in active employment in the Heathrow area; within the airport itself and the business parks and industrial areas around its perimeter*".

3.2.3 The analysis summarised in this surface access report does not include a quantitative assessment of the transport impacts of indirect and induced employment in the local area, or catalytic job growth across London and the rest of the UK as a result of an airport in the ITE. Further discussion of the rationale for this is provided in section 3.3.

3.2.4 Direct airport employee travel behaviour is related to the distribution of employee home locations, and it was assumed for the purposes of this study that the distribution of such employees at an airport in the ITE would be similar to that observed at Heathrow in terms of sensitivity to travel time from place of work. It is acknowledged that this assumption may not represent the most favourable scenario for the ITE, since analysis of Heathrow data suggests that many employees are highly sensitive to travel time and tend to live in close proximity to the airport. Applying similar assumptions to ITE airport employees results in a forecast where high numbers are allocated to areas such as the Medway Towns, Maidstone, Southend and Basildon, where car is at present typically the dominant mode of transport.

3.2.5 As mentioned in Chapter 1, a separate study on the socio-economic impacts of an airport on the ITE was undertaken by PwC in parallel to this study on surface access. The socio-economic study reviewed a number of spatial growth scenarios for the airport and indicated that a range of alternative distributions for direct airport employees may be possible, including one for example where high numbers cluster around Crossrail stations to benefit from cheap rail access to the site. In addition to the provision of transport infrastructure in the opening year (2030) and mature year (2050), the distribution of employees will also be influenced by variables such as the availability of housing.

3.2.6 However, due to the many variables identified and the long-term timescales involved, the PwC socio-economic study indicated that there was a significant degree of uncertainty on how direct airport employees would distribute around a site in the ITE in both the opening year (2030) and the mature year (2050) scenarios. As a result of this uncertainty, the assumptions related to Heathrow employees' sensitivity to travel time have been maintained for the surface access analysis detailed in this report. Implicit within this is the assumption that direct airport employees at a site in the ITE in the two future-year scenarios would be similar to their present-day Heathrow counterparts in terms of socio-economic and demographic characteristics.

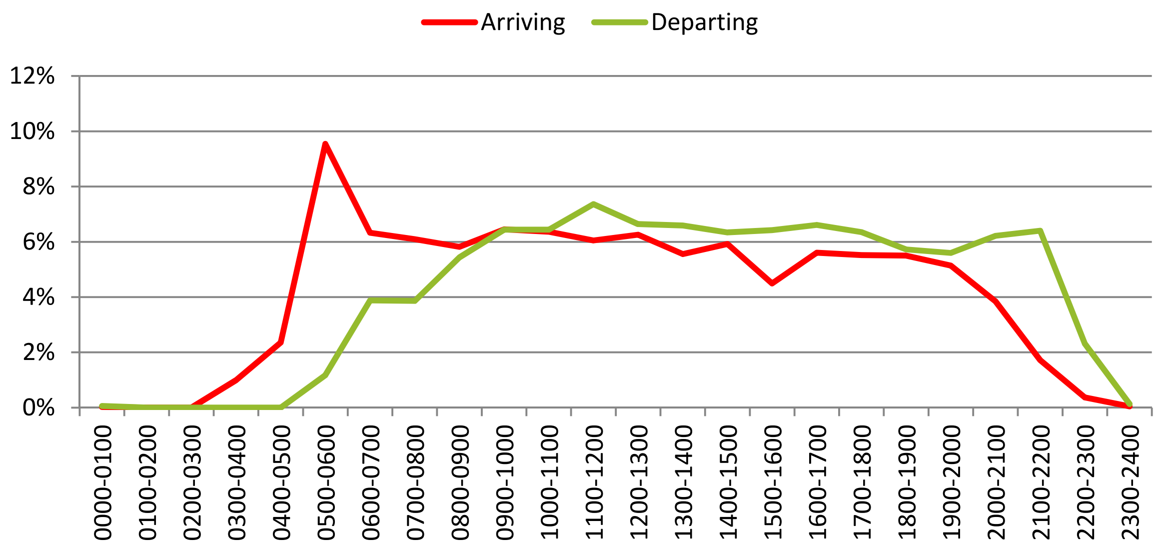
3.2.7 A summary of key Heathrow facts and figures for 2013 is published on the airport website[3], which indicated the following with regard to passenger-related surface access:

- 46.3m non-connecting (i.e. surface access) passengers passed through the airport during the year (72.3m less 26m transferring);
- 238,949 passengers (including transfers) passed through on the busiest day (0.33% of the annual total);
- 191,200 passengers (including transfers) passed through on an average day (0.26% of the annual total);
- The split of arriving and departing passengers was 50-50.

[2] Ipsos Mori (2014), 'Heathrow Employment Survey 2013'
[3] http://www.heathrowairport.com/static/HeathrowAboutUs/Downloads/PDF/heathrow-factsheet-2014.pdf

3.2.8 More detailed information on passenger travel was obtained from a number of other sources. A 2010 report by the British Airports Authority (BAA) provided a daily profile of air passenger flight departure and arrival times, averaged for the peak month in the year (July). This data is summarised in Figure 14, indicating that the peak hour for arrivals was between 0500 and 0600 (accounting for close to 10% of the daily total), with 1100-1200 identified as the peak hour for departing passengers.

Figure 14: Heathrow Airport hourly distribution of terminal passengers (average for July 2010)



Source: BAA (2010), 'http://www.heathrowairport.com/static/Heathrow/Downloads/PDF/Patterns_of_Traffic-2010.pdf' (page 24)

3.2.9 An estimate of surface transport arrivals and departures was derived from this data, assuming that passengers arrived at the airport on average 2 hours before flight departures and left the airport on average 1 hour after flight arrivals. This analysis indicated that the peak surface transport hour for passengers is 0700-0800, accounting for 6% of daily trips to the airport and 8% of trips from the airport.

3.2.10 The main source of detailed passenger data for Heathrow used during this study was the annual Civil Aviation Authority (CAA) survey of passengers. The latest data-set available was from 2012 and included 40,220 interview records primarily collected while passengers were waiting to board aircraft. The CAA apply scaling factors to the interview records to factor up to the total annual number of non-transfer passengers handled by the airport, which in 2012 was 43.95m. A summary report of the survey findings is published online[4].

3.2.11 The raw CAA data was used throughout the forecasting process, in particular as a basis for calculating likely passenger trip distribution to an ITE airport and assessing sub-rail mode choice. Summary statistics are provided in Table 3 to Table 5 below.

[4] http://www.caa.co.uk/docs/81/2012CAAPaxSurveyReport.pdf

Table 3: Annual non-transfer Heathrow passengers by country of residence and journey purpose (2012)

Type	Annual passengers	%
Foreign	**19,065,000**	**43%**
Business	6,478,000	15%
Leisure	12,587,000	29%
UK	**24,885,000**	**57%**
Business	7,814,000	18%
Leisure	17,071,000	39%
Total	**43,950,000**	**100%**

Source: CAA (2012), 'Raw Heathrow Passenger Survey data'

Table 4: Annual non-transfer Heathrow passengers by final mode of surface transport to the airport (2012)

Final mode	Annual passengers	%
Private vehicle/taxi	**25,918,000**	**59%**
Bus/coach	**5,618,000**	**13%**
Rail	**12,172,000**	**28%**
Heathrow Connect	273,000	1%
Heathrow Express	3,938,000	9%
Rail Unspecified	18,000	0%
Tube	7,942,000	18%
Other (including walk/cycle)	**90,000**	**0%**
Did not respond	**152,000**	**0%**
Total	**43,950,000**	**100%**

Source: CAA (2012), 'Raw Heathrow Passenger Survey data'

Table 5: Annual non-transfer Heathrow passengers by trip origin region and final mode of surface transport to the airport (2012)[5]

Trip origin	Private vehicle/ taxi	Bus/ coach	Rail	Total	Private vehicle/ taxi	Bus/ coach	Rail	Total
Inner London	5,805,000	540,000	8,303,000	**14,648,000**	40%	4%	57%	100%
Outer London	5,198,000	699,000	1,723,000	**7,620,000**	68%	9%	23%	100%
South East	7,746,000	2,036,000	488,000	**10,270,000**	75%	20%	5%	100%
East Midlands	883,000	199,000	188,000	**1,270,000**	70%	16%	15%	100%
East of England	2,708,000	420,000	486,000	**3,614,000**	75%	12%	13%	100%
North East	40,000	23,000	36,000	**99,000**	40%	23%	36%	100%
North West	154,000	35,000	103,000	**292,000**	53%	12%	35%	100%
Scotland	44,000	13,000	42,000	**99,000**	44%	13%	42%	100%
South West	1,730,000	872,000	302,000	**2,904,000**	60%	30%	10%	100%
Wales	416,000	309,000	95,000	**820,000**	51%	38%	12%	100%
West Midlands	749,000	308,000	140,000	**1,197,000**	63%	26%	12%	100%
Yorkshire and the Humber	191,000	103,000	170,000	**464,000**	41%	22%	37%	100%
TOTAL	**25,664,000**	**5,557,000**	**12,076,000**	**43,297,000**	**59%**	**13%**	**28%**	**100%**

Source: CAA (2012), 'Raw Heathrow Passenger Survey data'

[5] Excluding other modes (including walk and cycle) and interviewees not providing accurate trip origin or mode information

3.2.12 Before any analysis was undertaken, all trips in the database that were tagged with an Olympic-related journey purpose were removed so as not to skew the results with the inclusion of atypical trips. In total, the raw database included 416,352 Olympic trips, 0.9% of all surface transport trips recorded at the airport in 2012.

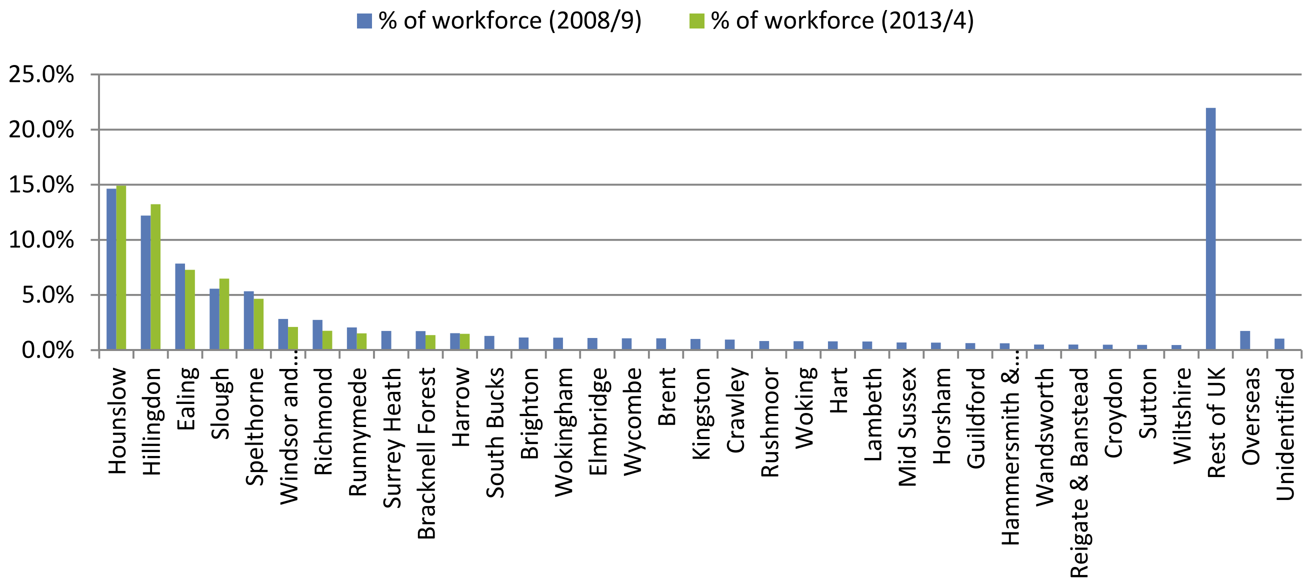
3.2.13 Of particular relevance to this study is the headline passenger mode share of 59% private vehicle, 13% bus/coach and 28% rail. Of the rail passengers, approximately 64% used Piccadilly Line London Underground services to reach the airport. The vast majority of the remaining rail trips used the premium Heathrow Express service from Paddington.

3.2.14 Also of note is how the majority of rail trips, some 83% of the total, to the airport were made by people with trip origins within the Greater London area, with 25% of all rail trips originating from Westminster alone and a further 9% from Kensington & Chelsea and 7% from Camden. Total rail mode share for trips originating outside London was only 10% compared to 45% within Greater London, and 57% within the Inner London boroughs of Camden, Greenwich, Hackney, Hammersmith & Fulham, Islington, Kensington & Chelsea, Lambeth, Lewisham, Southwark, Tower Hamlets, Wandsworth, Westminster, and the City of London. Within Inner London, the City of London had the highest overall rail mode share at 68% of all trips to the airport, with Islington at 66%, Tower Hamlets at 62% and Westminster at 59%.

3.2.15 In terms of geographic distribution, 51% of non-transfer passengers originated in the London area, with 24% from the rest of the South East and the remaining 25% from the rest of the UK. GLA growth forecasts for London indicate that the capital's population is expected to grow by 18% between 2012 and 2030 and by 30% between 2012 and 2050. This compares with figures of 11% and 21% for the rest of the UK. In terms of total employment, the GLA figures for London suggest growth of 25% and 42% compared to figures of 8% and 17% for the rest of the UK over the same time periods. These trends suggest that over time, an increasing proportion of airport passengers would travel to Heathrow from the Greater London area if the airport continues to operate as it does at present, assuming that the characteristics of passengers at the airport remains broadly consistent over the timescales identified.

3.2.16 When compared with passengers, data on surface access by Heathrow employees was more difficult to obtain and the only sources used for this study were the aforementioned summary reports for on-airport employment surveys undertaken in 2008/9 and 2013/4, with the latter undertaken by Ipsos Mori on behalf of the airport operator. All Heathrow employee home locations recorded during these surveys are summarised at district level in Figure 15 – data was only provided in the 2013/4 report for the top 10 districts, which included Bracknell Forest and Harrow but excluded Surrey Heath.

Figure 15: All Heathrow employees by district of residence (2013/4)

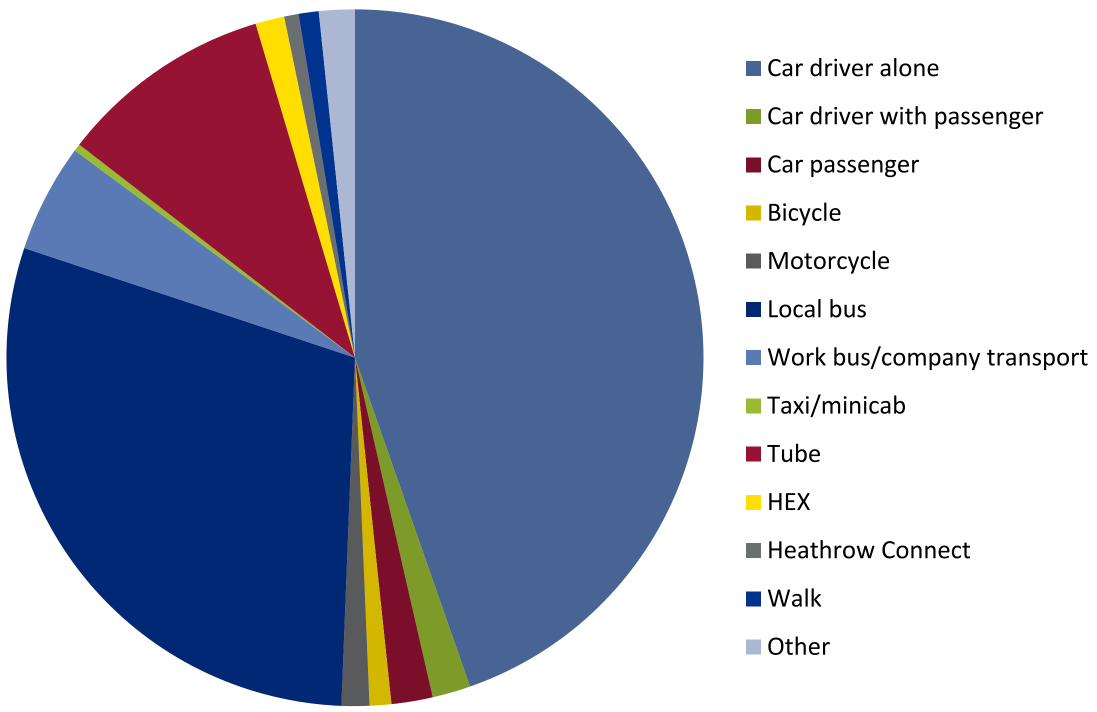


Sources: HAL (2009), 'Heathrow: On-airport Employment Survey, 2008/09 - Summary report';
HAL (2014), 'Taking Britain further, Heathrow's plan for connecting the UK to growth TECHNICAL SUBMISSION VOLUME 2' (p315)

3.2.17 The graph indicates that 35,557 of the 73,440 Heathrow staff (48%) referenced in the 2008/9 survey lived in Hillingdon (the district where the airport is located) or in a neighbouring district (Hounslow, Harrow, Ealing, Spelthorne, Slough and South Bucks). Residential areas within these districts are almost all within 20km of the airport, suggesting that staff are generally very sensitive to travel time to their place of work. The 2013/4 survey results suggests a similar concentration of staff in areas a short distance from the airport. No 2013/4 data was available for South Bucks but the proportion of staff resident in the other 6 districts referenced above increased slightly from 47.1% in 2008/9 to 48.1%.

3.2.18 As shown in Figure 16, the updated Heathrow staff travel survey in 2013/4 also indicated that car (including motorcycle and taxi) remains the main mode of transport for employees to the airport, accounting for 50% of all surface access trips, with the vast majority of those undertaken as single occupancy car trips. Bus (including work bus/company transport) accounted for a further 35% with rail accounting for 12% (10% by tube, 1% by Heathrow Express and 1% by Heathrow Connect).

Figure 16: Heathrow employee main mode of travel to work (2013/4)



Source: HAL (2014), 'Taking Britain further, Heathrow's plan for connecting the UK to growth TECHNICAL SUBMISSION VOLUME 2' (page 334)

3.2.19 As mentioned earlier in this section, the Heathrow employee characteristics summarised above have been used as a basis for forecasting employee travel behaviour at an airport in the ITE.

International comparators

3.2.20 As well as sourcing data on Heathrow, information on surface access was also investigated for a range of international comparators. The general focus was on European airports, since it was felt that passenger surface transport characteristics would be the most similar with the UK when compared to other regions. National hub airports handling high volumes of passengers were prioritised, and data from other high profile international exemplars such as Hong Kong and Singapore was also sourced along with information for airports specifically referenced in the ITE proposals.

3.2.21 Numerous sources provided the basis of the information, including the following:

- Charles de Gaulle Airport, Paris press information[6];
- Frankfurt Airport 2013 facts and figures[7];
- Amsterdam Schiphol Airport 2012 facts and figures[8];
- Madrid Airport 2012 annual report[9];
- Zurich Airport 2013 facts and figures[10] and 2012 Annual Report[11];

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6 http://www.aeroportsdeparis.fr/ADP/pages/presse/Aeroports_de_Paris_Press_Kit.pdf
7 http://www.fraport.com/favicon.ico
8 http://www.schiphol.nl/web/file?uuid=c4d122ec-7c7d-47c3-b944-9a237c83a7d3&owner=15363697-6095-4e98-9d9a-d34f50101ab2
9 http://www.aena-aeropuertos.es/csee/ccurl/474/547/RESUMEN%20EJECUTIVO%20AENA%20INGLES%20WEB.pdf

- Copenhagen Kastrup 2013 annual report[12];
- Oslo Airport 2012 annual report[13];
- Hong Kong Airport annual report 2012/13[14];
- Singapore Changi Airport 2014 facts and statistics[15].

3.2.22 In addition to airport-specific information, a range of other more general sources were referenced, notably a 2008 US study sponsored by the Federal Aviation Authority on surface public transport to major airports[16].

3.2.23 A summary of the headline information for the international benchmark airports is shown in Table 6. In terms of surface access to the airport, the highest public transport passenger mode share achieved by any of the comparators was 63%, recorded at Oslo in 2012 and Hong Kong in 2008.

3.2.24 The report on Copenhagen Airport indicated 58% of passengers travelled to the airport by rail in 2013 (37% using standard train services and 21% using the Copenhagen Metro), the highest rail mode share among the international comparators by some distance. This can be explained by the close proximity of the airport to both Copenhagen city centre (less than 10km away) and Malmo city centre (less than 20km) and the provision of direct rail links to both. The second highest rail mode share was recorded at Zurich Airport in 2008 at 42%, also explained by the airport's close proximity to the city centre (approximately 7km away) connected by a high-speed rail link.

3.2.25 At larger airports further from city centres. the rail mode share was generally lower – even at Hong Kong Airport, which has a dedicated express link providing city centre check-in facilities, rail mode share in 2008 was only 28%.

3.2.26 The data also indicated a range of annual passengers per employee ratios across the airports, from 1,600 at Singapore Changi Airport in 2012 to 716 at Charles de Gaulle in Paris in the same year. Some caution should be exercised when quoting these figures however, since the definition of an airport employee is likely to differ between locations.

[10] http://www.zurich-airport.com/~/media/FlughafenZH/Dokumente/Das_Unternehmen/Flughafen_Zuerich_AG/Broschuere_Zahlen_Fakten_2013_en.pdf
[11] http://www.zurich-airport.com/~/media/FlughafenZH/Dokumente/Das_Unternehmen/Investor_Relations/FHZAG_GB_2012_e_Komplett.pdf
[12] http://rapporter.cph.dk/CPH/groupannualreport2013/
[13] http://www.osl.no/tridionimages/Annual%20report%202012_tcm181-157877.pdf
[14] http://www.hongkongairport.com/eng/pdf/media/publication/report/12_13/E_Annual_Report_Full.pdf
[15] http://www.changiairport.com/our-business/about-changi-airport/facts-statistics
[16] http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_004.pdf

Table 6: International airports key statistics

Country	Airport	Mppa	Connecting passengers (%)	Daily passenger movements	Surface Transport Mode Share (Passengers)	Employees	High Speed Rail Links	Additional relevant data	Year of data
France	Paris Charles de Gaulle	61.6	31%	170,000	40% PT – 27% rail, 13% bus (2008)	86,000	Yes (TGV)	27,000 parking spaces	2012
Germany	Frankfurt International	57.5	55%	201,380	33% PT – 27% rail, 6% bus (2008)	78,000	Yes	60% of employees live within 35 km 14,000 public parking spaces	2012
Netherlands	Amsterdam Schiphol	51.0	41%		PT 38%	64,000		38,326 parking spaces (22,776 for visitors, 15,550 for staff). 44,728 employees (70%) live in Schiphol Centre	2012
Spain	Madrid Barajas	45.2	~	123,000	~	~			2012
Switzerland	Zurich	24.9	34%	68,124	47% PT – 42% rail, 5% bus (2008)	25,379	Yes	Peak hour to airport 1100-1200: 4,014 passengers; from airport1200-1300: 4,863 passengers Daily PT patronage of close to 70,000 17,100 parking spaces 37%-63% business-leisure split	2013
Denmark	Copenhagen Kastrup	22.4	~	~	60% PT (37% train, 21% metro, 2% bus)	23,000	Yes	>10,000 parking spaces	2013
Norway	Oslo Gardermoen	22.1	~	~	63% PT (2012) – 39% rail, 25% bus (2008)	15,000			2012
China	Hong Kong International	56.5	~	~	63% PT – 28% rail, 35% bus (2008)	65,000	Yes		2012
Singapore	Changi	51.2	30%	136,738	~	32,000			2012
UK	Heathrow	72.3	36%	238,949 (busiest day)	41% PT – 28% rail, 13% bus	77,000	Yes		2012/3

Source: see footnotes on page 32 – "~" = figure not available

3.3 Headline assumptions

3.3.1 The benchmarking work summarised in the previous section of this report was compared with information in the ITE proposals to develop a number of headline demand forecasting assumptions for the ITE airport option. These assumptions are summarised for passengers and employees in Table 7 and Table 8.

3.3.2 The AC provided the key input of 103.2mppa in the opening year of 2030 rising to 143mppa by 2050, while the headline figures used for airport employees are sourced from the 2011 Optimal Economics[17] report. For the purposes of this study it has been assumed that 2030 airport employment would equate to the figure provided in the 2011 report for direct on- and off-airport local jobs, which comes to 84,300. In 2050 it was assumed that this figure would have grown in line with the projected increase in MPPA to 117,000. All the subsequent analysis detailed in this report was based on these headline figures for passengers and employees.

3.3.3 As mentioned in the previous section of this report, a key point to note is that as well as direct airport-related employment (both on-site and off-site in the immediate vicinity), an airport in the ITE is likely to result in some indirect and induced employment in the local area (i.e. Kent and Essex) as well as catalytic growth leading to additional jobs further afield in London and the rest of the UK.

3.3.4 The 2011 Optimal Economics study estimated that local indirect and induced employment would amount to some 29,700 additional jobs, bringing the total local employment estimate including direct airport employees up to 114,000. The socio-economic workstream presents evidence showing that catalytic growth for an ITE could result in the creation of additional jobs in a range between 50% and 150% of the total local employment generated by the airport[18]. This suggests that wider area catalytic growth could create between 57,000 and 171,000 additional jobs as a result of an airport in the ITE, based on the 2011 Optimal Economics local employment estimate.

3.3.5 This additional job growth would obviously add to the pressure on the transport network serving the airport to some degree, but given the high level of uncertainty surrounding the development scenarios associated with the ITE option (both in terms of absolute impact and also how that impact would be spatially distributed) it is not possible at this stage to account for this growth in any meaningful quantitative way. Local indirect and induced employment and jobs created by wider area catalytic growth would generate trip patterns quite distinct from those generated by airport passengers and on-site employees, and the airport itself would not be an origin or destination for many such trips.

3.3.6 As a result, the analysis described in this report should be understood in the context of the potential for additional but as yet undefined transport network impacts created by local indirect and induced employment and wider area catalytic growth. Additional analysis and modelling would be required to account for the transport impacts of such growth, firstly to define its nature, scale and location more accurately, and secondly to incorporate it in the background demand forecasts for road and rail provided by the DfT, TfL and Network Rail that have been used in this study.

3.3.7 In many respects the assumptions used are similar to those used in the ITE proposals discussed in Chapter 2. The total peak-hour two-way passenger trip calculation of 20,020 in 2050 is for example almost identical to the 20,200 assumed by the Mayor of London, while the 2050 assumption of 114,000 employees also falls between the Foster + Partners estimate of 100,000 and the Mayor of London's estimate of 130,000.

[17] Source: http://www.heathrowairport.com/static/Heathrow/Downloads/PDF/Heathrow-Related-Employment-Report.pdf
[18] Oxford Economics & Ramboll, Impact of new hub locations on business locations, FDI and alignment with strategies, 2013

3.3.8 The key way in which the Jacobs assumptions differ from the ITE proposals is in terms of public transport, and more specifically rail, mode share. For airport passengers, the Mayor of London tested a scenario where the public transport mode share was 65% and all were assumed to use rail, whereas both Foster + Partners and MTTRA indicated a mode share of 60% rail. In contrast, the Jacobs assumptions underpinning the analysis undertaken in this study were 40% rail for passengers and 25% rail for employees.

Table 7: ITE airport passenger surface transport demand – headline assumptions

Parameter	**Jacobs assumption**	**Jacobs source**
MPPA on opening	103 (2030)	Demand forecasts provided by the AC
Peak capacity MPPA	143 (2050)	Demand forecasts provided by the AC
Proportion of connecting (transfer) passengers	36% (26m/72.3m)	Heathrow Airport Traffic Stats 2013[19]
To/From airport factor (split of surface trips by direction of travel)	0.5	Assumption that surface access trips on a busy day are split evenly by direction (to or from the airport)
Busy day factor	0.31% (1/320)	Based on estimated 85th percentile day using Heathrow Airport Traffic Stats 2013 data
Peak hour - time	0700-0800	Patterns of Traffic at BAA Airports 2010[20] – assumption that passengers arrive at airport 2 hours before departure and leave airport 1 hour after arrival
Peak hour - % daily trips	7%	Patterns of Traffic at BAA Airports 2010 – analysis indicated 8% from/6% to but flattened to 7% in both directions to account for reduced curfew.
Peak-hour two-way trips (max mppa)	20,020	7% of busy day based on 143 mppa
Peak-hour two-way trips (opening)	14,444	7% of busy day based on 103 mppa
Main mode split: Car/Taxi vs Bus/Coach/Rail	52% PT	Assumed 40% rail mode share based on qualitative review of benchmarking accounting for potential impact of new rail connections and demand management measures (current Heathrow rail mode share is 28%) – 12% bus/coach derived from split of road-based modes in Heathrow 2012 CAA data
Car occupancy factor	1.6	Based on current Heathrow data
% Meet and Greet by rail	1% business, 3% leisure	Heathrow 2012 CAA passenger survey data

Source: consultant assumptions based on a range of data

[19] http://www.heathrowairport.com/static/HeathrowAboutUs/Downloads/PDF/heathrow-factsheet-2014.pdf
[20] http://www.heathrowairport.com/static/Heathrow/Downloads/PDF/Patterns_of_Traffic-2010.pdf (page 24)

Table 8: ITE airport employee demand – headline assumptions

Parameter	Jacobs assumption	Jacobs source
Total employees (2030)	84,300 (76,600 on-site and 7,700 off-site)	Direct on- and off-airport local employment estimate derived from the 2011 Optimal Economics report
Total employees (2050)	117,000	Direct local employment as per 2011 Optimal Economics study, factored up from 2030 using change in MPPA
% Employees at work on a given day	57%	Heathrow 2008/9 employee survey
% Employees travelling to/from airport during passenger peak hour	12% to, 1% from	Stansted Employment Strategy 2012 (Heathrow data unavailable)
PT Sub mode split Bus/Coach vs Rail	25% rail, 10% bus/coach	Analysis based on effectiveness of travel demand measures (current Heathrow rail mode share is 12% - low bus/coach mode share assumed to assess conservative case for employee road impacts)
Staff car occupancy factor	1.2	Current data at existing airports plus assumption about greater car sharing

Source: consultant assumptions based on a range of data

3.3.9 Following the benchmarking of international exemplars described earlier in this report, Jacobs concluded that the rail mode share assumptions used in the ITE proposals were overly optimistic, and the forecasting was subsequently based on a core assumption of a 40% rail mode share for passengers. This represented an uplift from the current rail mode share of 28% at Heathrow to account for the impact of improved rail services and the potential for demand management measures to limited private vehicle use, but also reflected the fact that no major hub airport in the world currently achieves a rail mode share higher than this.

3.3.10 Even more so than with passenger mode share, the assumptions regarding employee rail mode share used in the ITE proposals (ranging from 60% in the Foster + Partners and MTTRA submissions up to 75% in the Mayor of London's submission) were concluded to be extremely optimistic. The current staff rail mode share at Heathrow is 12% and the analysis of the distribution of Heathrow employees suggests that many staff at an airport in the ITE would be clustered within a 20km radius of the site, in locations such as the Medway Towns, Gravesend, Maidstone and (partially dependent on the introduction of a new Thames Crossing) areas to the north of the river such as Southend and Basildon. These areas currently have a lower level of public transport accessibility than the Heathrow catchment.

3.3.11 However, a new airport in the ITE could benefit from improved traffic management measures and rail services (potentially including dedicated links from new towns accommodating airport workers), and a general shift towards 24-hour public transport to the airport. To account for these impacts, Jacobs assumed a 25% employee rail mode share for the ITE analysis.

3.3.12 The flowcharts in Figure 17 and Figure 18 summarise the process and the assumptions used to develop peak-hour surface transport demand forecasts by main mode for the 2030 and 2050 future-year scenarios. The remainder of this section summarises how this process was developed and the sources on which key assumptions were based.

Figure 17: ITE airport surface transport demand – 2030 headline assumptions

PASSENGER ASSUMPTIONS

Interliners	36%

Busy day factor	0.31%

	TO airport	FROM airport
Direction factors	50%	50%

	TO airport	FROM airport
Day-to-peak-hour factor	7%	7%

Headline mode split	TO airport	FROM airport
Car/taxi	48%	48%
Bus/coach	12%	12%
Rail	40%	40%
TOTAL	100%	100%

Meet and greet	TO airport	FROM airport
Rail	2.41%	2.41%

Passenger vehicle occupancy	1.6

PASSENGERS

Total mppa	103.2

Surface access mppa	66.0

Daily surface transport ODs	206,355

	TO airport	FROM airport
Daily surface trips	103,178	103,178

	TO airport	FROM airport
Peak-hour surface trips	7,222	7,222

Passengers by mode	TO airport	FROM airport
Car/taxi	3,495	3,495
Bus/coach	856	856
Rail	2,871	2,871
TOTAL	7,222	7,222

Meet and greet	TO airport	FROM airport
Rail	69	69

Total passengers + meet and greet	TO airport	FROM airport
Car/taxi	3,495	3,495
Bus/coach	856	856
Rail	2,941	2,941
TOTAL	7,292	7,292

Total passenger vehicles	TO airport	FROM airport
Car/taxi	2,184	2,184

EMPLOYEES

Total	84,300

Total employee daily two-way trips	48,051

	TO airport	FROM airport
Peak-hour surface trips	5,766	481

Employees by mode	TO airport	FROM airport
Car/taxi	3,748	312
Bus/coach	577	48
Rail	1,442	120
TOTAL	5,766	481

Total employee vehicles	TO airport	FROM airport
Car/taxi	3,123	260

EMPLOYEE ASSUMPTIONS

Employees at work per day	57%

	TO airport	FROM airport
Day-to-peak-hour factor	12%	1%

Headline mode split	TO airport	FROM airport
Car/taxi	65%	65%
Bus/coach	10%	10%
Rail	25%	25%
TOTAL	100%	100%

Employee vehicle occupancy	1.2

TOTALS

Total trips by mode	TO airport	FROM airport
Car/taxi	7,243	3,807
Bus/coach	1,433	904
Rail	**4,382**	**3,061**
TOTAL	13,058	7,772

Total vehicles	TO airport	FROM airport
Car/taxi	**5,308**	**2,445**

Source: consultant assumptions based on a range of data

JACOBS

Figure 18: ITE airport surface transport demand – 2050 headline assumptions

PASSENGER ASSUMPTIONS

Interliners	36%
Busy day factor	0.31%

	TO airport	FROM airport
Direction factors	50%	50%

	TO airport	FROM airport
Day-to-peak-hour factor	7%	7%

Headline mode split	TO airport	FROM airport
Car/taxi	48%	48%
Bus/coach	12%	12%
Rail	40%	40%
TOTAL	**100%**	**100%**

Meet and greet	TO airport	FROM airport
Rail	2.41%	2.41%

Passenger vehicle occupancy	1.6

PASSENGERS

Total mppa	143.0
Surface access mppa	91.5
Daily surface transport ODs	286,000

	TO airport	FROM airport
Daily surface trips	143,000	143,000

	TO airport	FROM airport
Peak-hour surface trips	10,010	10,010

Passengers by mode	TO airport	FROM airport
Car/taxi	4,802	4,802
Bus/coach	1,174	1,174
Rail	4,034	4,034
TOTAL	**10,010**	**10,010**

Meet and greet	TO airport	FROM airport
Rail	97	97

Total passengers + meet and greet	TO airport	FROM airport
Car/taxi	4,802	4,802
Bus/coach	1,174	1,174
Rail	4,131	4,131
TOTAL	**10,107**	**10,107**

Total passenger vehicles	TO airport	FROM airport
Car/taxi	3,001	3,001

EMPLOYEES

Total	116,836
Total employee daily two-way trips	66,597

	TO airport	FROM airport
Peak-hour surface trips	7,992	666

Employees by mode	TO airport	FROM airport
Car/taxi	5,195	433
Bus/coach	799	67
Rail	1,998	166
TOTAL	**7,992**	**666**

Total employee vehicles	TO airport	FROM airport
Car/taxi	4,329	361

EMPLOYEE ASSUMPTIONS

Employees at work per day	57%

	TO airport	FROM airport
Day-to-peak-hour factor	12%	1%

Headline mode split	TO airport	FROM airport
Car/taxi	65%	65%
Bus/coach	10%	10%
Rail	25%	25%
TOTAL	**100%**	**100%**

Employee vehicle occupancy	1.2

TOTALS

Total trips by mode	TO airport	FROM airport
Car/taxi	9,997	5,235
Bus/coach	1,973	1,240
Rail	**6,129**	**4,298**
TOTAL	18,099	10,773

Total vehicles	TO airport	FROM airport
Car/taxi	**7,330**	**3,362**

Source: consultant assumptions based on a range of data

3.4 Trip distribution

3.4.1 The headline rail passenger and employee trips to and from the ITE airport described in the previous section were then distributed across the UK using a gravity model calibrated with Heathrow 2012 CAA survey passenger data and Heathrow 2008/9 employee survey data.

3.4.2 This analysis was undertaken at district level, including the 33 London boroughs and the remaining 328 districts and unitary authority areas in the UK. The CAA passenger data and employee data already contained fields identifying trip and home location at this level, which facilitated the process. The CAA data also included two fields related to passenger country of residence (categorised as either ‘UK’ or ‘foreign’) and overall journey purpose (categorised as either ‘business’ or ‘leisure’), allowing the data to be sub-divided into these four categories to refine the analysis.

3.4.3 An initial analysis was undertaken using the journey purpose split without consideration of country of residence. However, as one would expect, significant differences were evident in the distribution of leisure passengers depending on whether they were UK or foreign residents and as a result, leisure passengers were sub-divided into these categories in the gravity model. This seemed a logical assumption since the drivers of UK leisure and foreign leisure airport trip origins are likely to be quite different. For example, for the former group, home location and place of work are likely to be key drivers while in contrast, foreign leisure trip origins are likely to be influenced by places of interest for tourists.

3.4.4 For business passengers, the initial analysis indicated that the model could be calibrated to a satisfactory extent without the need to sub-divide by country of residence and as a result, business passengers were retained as one discrete group. This was also viewed as a logical approach since areas with a high number of jobs that generate high volumes of UK-based business air trips also tend to generate high numbers of foreign business passenger trips as well.

Identifying variables influencing airport passenger trip origins

3.4.5 In any gravity model, accessibility to and from the destination is a key determining factor of trip origin. Ideally this would be represented by the generalised cost of a journey to the airport from each district, weighted by key variables such as car ownership. However, such a detailed assessment was outside the scope of this study and as a result, crow-fly distance to the airport from a central point in each district was used as a proxy for accessibility.

3.4.6 In addition, passenger and employee trip origins are influenced by different population-based variables depending on the trip purpose and passenger characteristics. For example, districts with a high resident population or a high number of jobs may be expected to generate significant numbers of airport trips by UK residents, with location of jobs a more important factor influencing the origin of business trips due to the propensity of passengers to travel directly between the airport and their place of work. In contrast, foreign leisure passenger trip origins are unlikely to be influenced by resident population distribution and are more likely to be related to the distribution of, for example, hotel rooms.

3.4.7 As with the calculation of accessibility, an ideal gravity model would take into account a range of other variables associated with population-based factors, including for example socio-economics (which would account for the likelihood of financial service jobs in the City of London/Canary Wharf generating more airport business passenger trips than blue collar jobs in outer London, or affluent areas generating more trips than those in poorer areas). The parallel workstream on socio-economic impacts undertaken by PwC and mentioned earlier in this report provides more information on the factors influencing spatial location decisions.

3.4.8 However, developing a model to this level of complexity was outside the scope of this study and as a result, three population-based variables were assessed as determining factors influencing passenger and employee trip origins:

- Total resident population – mid-year population estimates for 2009 and 2012 were sourced from the Office of National Statistics (ONS) Nomis website, to match the year of the CAA survey and the Heathrow employment survey data;
- Total employee jobs – sourced from the ONS Annual Business Inquiry for 2009 and 2012, also available on the ONS website;
- Total employee jobs in the hospitality sector – assumed as a proxy variable influencing foreign leisure trips, and also sourced from the ONS Nomis website.

3.4.9 In the future year 2030 and 2050 models, population and job forecasts provided by the GLA (for London) and DfT Tempro (for the rest of the UK) replaced the base-year numbers described above. The proportion of total jobs in the hospitality sector was assumed to remain constant in the base and future-year models.

Defining gravity model formulae

3.4.10 Each trip origin group was tested against a range of different combinations of the variables described above, and the following formulae were derived for each group to calculate a function of attraction, f(a), for each district to Heathrow Airport:

Business passengers: $$f(a) = \frac{\alpha J \times \beta P}{D^{\gamma}}$$

UK leisure passengers: $$f(a) = \frac{\alpha J \times \beta P}{D^{\gamma}}$$

Foreign leisure passengers: $$f(a) = \frac{\delta H}{D^{\gamma}}$$

Employees: $$f(a) = \frac{\beta P}{D^{\gamma}}$$

Where: D = crow-fly distance to the airport;
J = total jobs;
P = total population; and
H = hospitality jobs

3.4.11 Business and UK leisure passenger trip origins were effectively related to the spread of both population and total jobs, while foreign leisure trips were related only to the spread of hospitality jobs and employees only to the spread of population. It should be noted that 2012 population data was used for passenger trips while 2009 population was used for employees, to match the respective dates of the survey data.

Base model calibration

3.4.12 The constants identified in the formulae above were then adjusted using the MS Excel Solver tool to achieve the highest possible R-Square value for f(a) when compared with the relevant Heathrow passenger and employee trip origins by district. The final constant values and corresponding R-Squares, assuming an intercept of 0, are summarised in Table 9.

Table 9: Co-efficients and RSQ values for calculation of function of accessibility for Heathrow trip categories

Trip category	Variables/coefficents for f(A)				Resultant RSQ value
	β (population)	α (jobs)	δ (hospitality jobs)	γ (distance)	
Business	0.75	4.00		0.61	0.64
UK leisure	1.60	2.52		0.61	0.77
Foreign leisure			10.00	0.50	0.83
Employees	1.00			2.15	0.89

3.4.13 The constant values shown in the table indicate that the distribution of both business passengers and UK leisure passengers was more closely related to the spread of total jobs than of resident population, with jobs being more of a determining factor for business trips. In addition, the low values of the constant for distance related to passenger distribution generally reflect the fact that passenger distributions are spread across a large area of the UK. In contrast the distance factor for employees is much higher, reflecting a higher level of clustering around the airport site.

3.4.14 The graphs in Figure 19 to Figure 22 illustrate the strength of the relationship derived with f(a) for each of the four trip types, demonstrating a close correlation in the case of employees and foreign leisure trips but a weaker relationship for business passengers. In the latter case the overall R-Square value is reduced by significant outliers such as Westminster and Kensington & Chelsea, which generate significantly higher volumes of business trips than predicted using the gravity model formula based purely on population, jobs and distance from the airport. If these two boroughs are removed, the R-Square value for business increases to 0.72.

Figure 19: Trip origin v accessibility for Heathrow business passengers (2012), by UK district

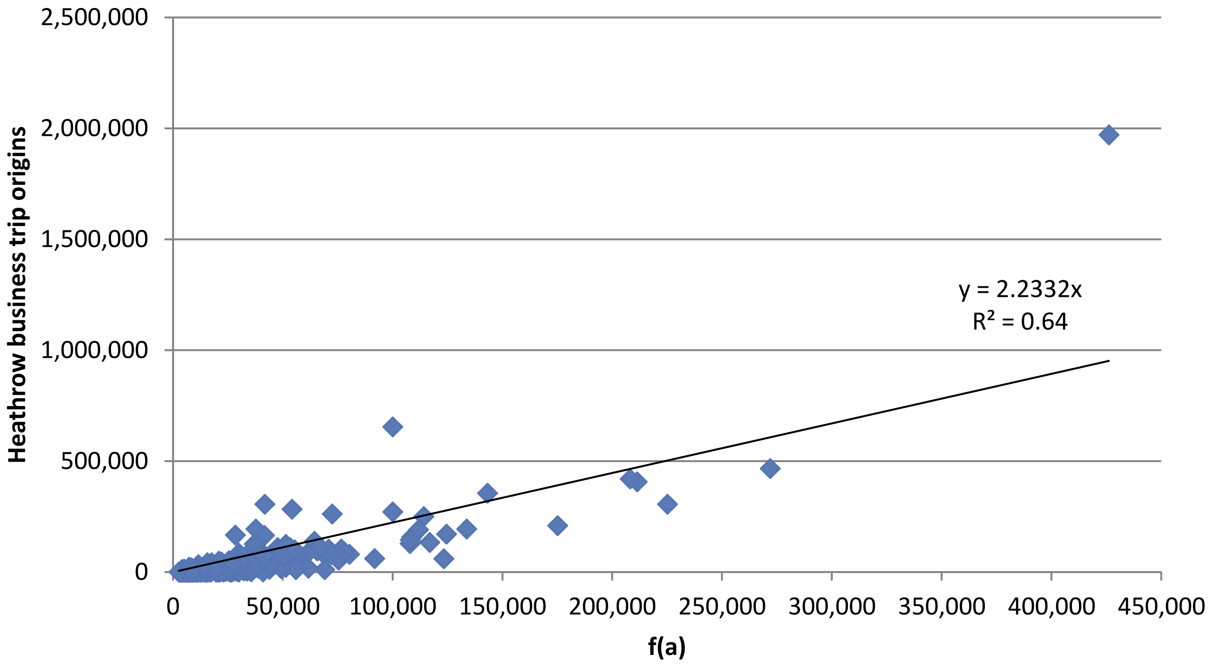


Figure 20: Trip origin v accessibility for UK resident Heathrow leisure passengers (2012), by UK district

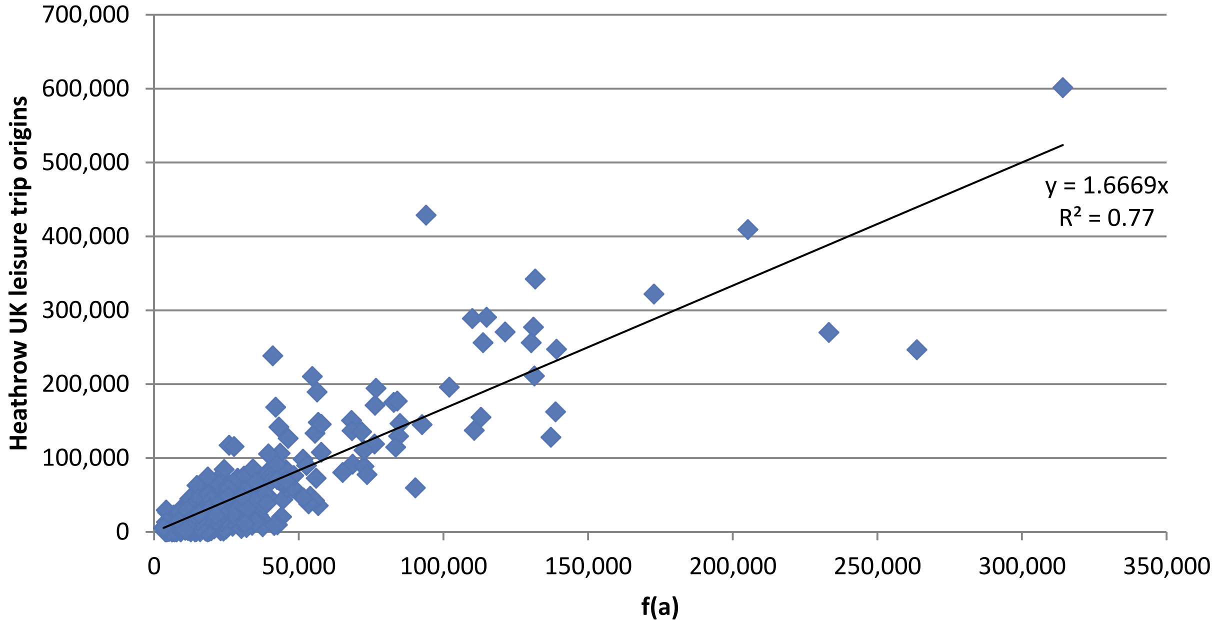


Figure 21: Trip origin v accessibility for foreign resident Heathrow leisure passengers (2012), by UK district

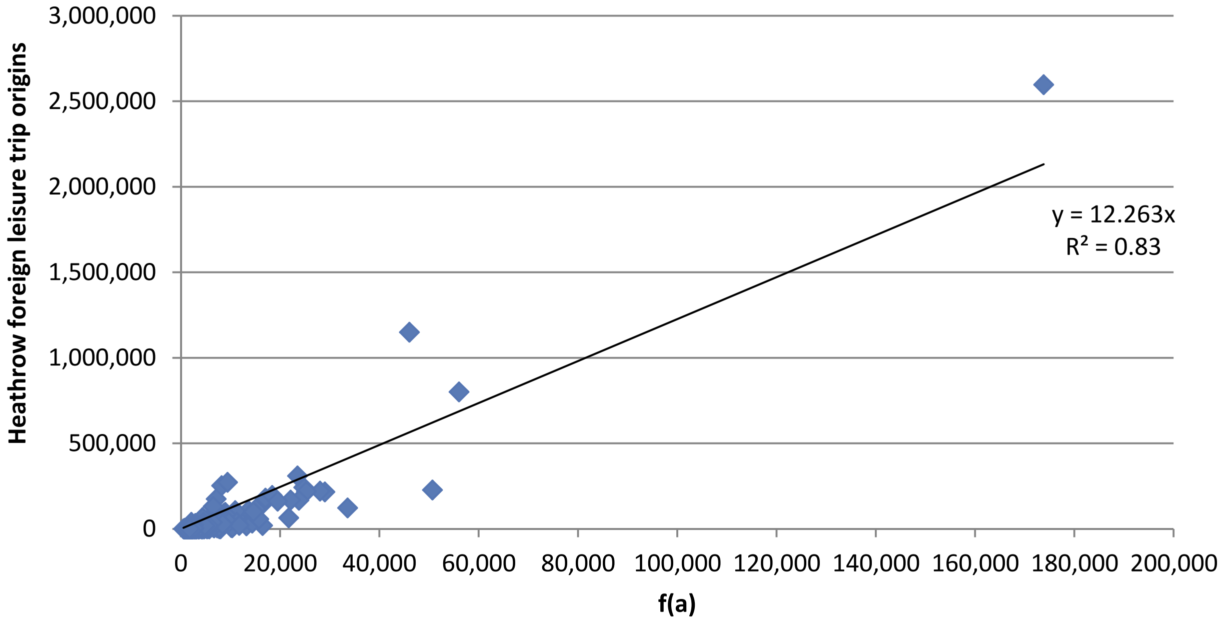
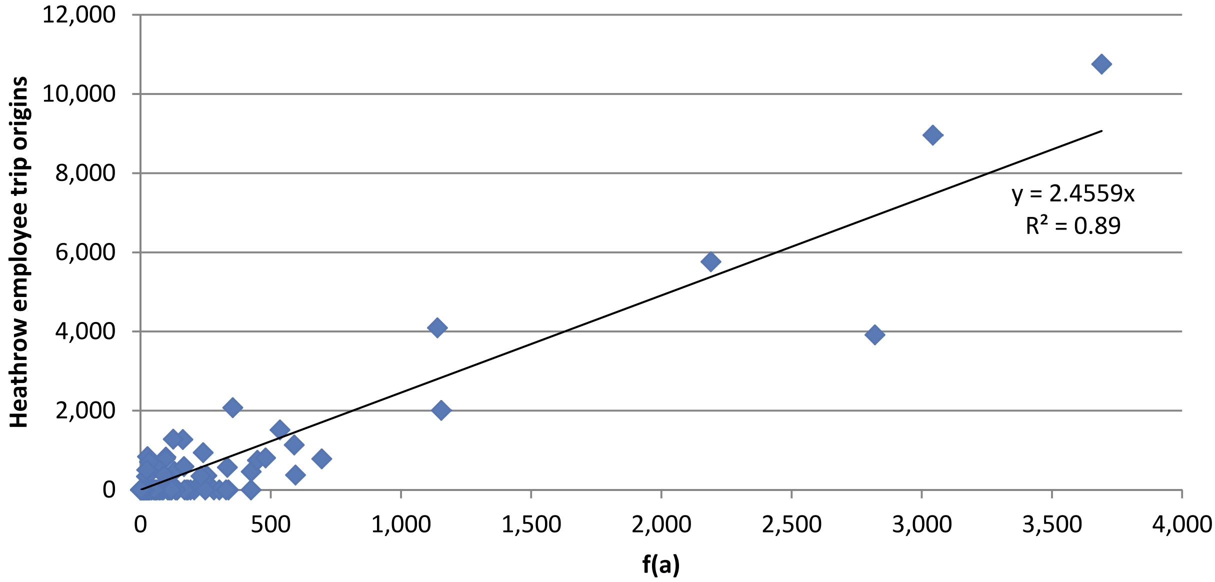


Figure 22: Trip origin v accessibility for Heathrow employees (2008), by UK district



3.4.15 To account for the outliers in the passenger relationships derived, residual values for each of the districts were calculated using the equations identified on the graphs. These values were then re-applied to each district in the ITE forecasts. For example, 271,714 business passenger trips were recorded in the 2012 survey originating in Richmond, 22% higher than the predicted value of 223,410 using the formula derived above. As a result, the business passenger forecasts between an ITE Airport and Richmond in 2030 and 2050 were both uplifted by 22% to account for this discrepancy.

3.4.16 In the case of business passenger trips originating in boroughs such as Richmond, Westminster and Kensington & Chelsea, higher observed volumes are likely to be explained by the concentration of high value jobs and affluent resident populations in those boroughs. An assumption implicit in applying residual values calculated from a 2012 Heathrow model to the 2030 and 2050 ITE forecasts is that the characteristics of districts that influence air passenger volumes will remain relatively similar in future.

3.4.17 In contrast to passengers, residual values could not be applied to employee forecasts for the ITE, since employees are more tightly clustered around the airport site – for example, 27% of all Heathrow employees live in either Hounslow or Hillingdon, and none were recorded in the survey breakdown living in areas in close proximity to the ITE site, such as the Medway towns, Kent, Southend, Basildon or Thurrock. As a result, residual values could not be calculated for many of the locations where the gravity model forecast a high volume of employee trip origins for the ITE.

3.4.18 The relationships calculated above to explain passenger and employee trip origins are considered sufficiently robust for the purposes of forecasting trip distribution to an airport in the ITE, particularly so given the use of residual values to account for outlying districts in terms of passenger trip generation.

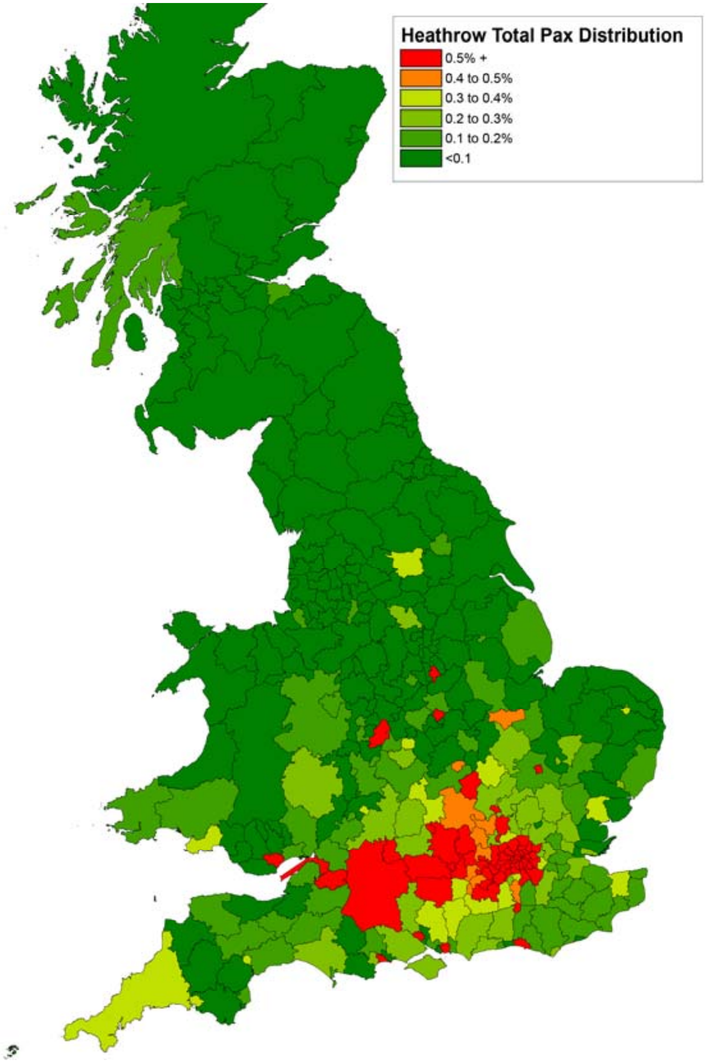
Forecasting passenger and employee distribution to the Inner Thames Estuary

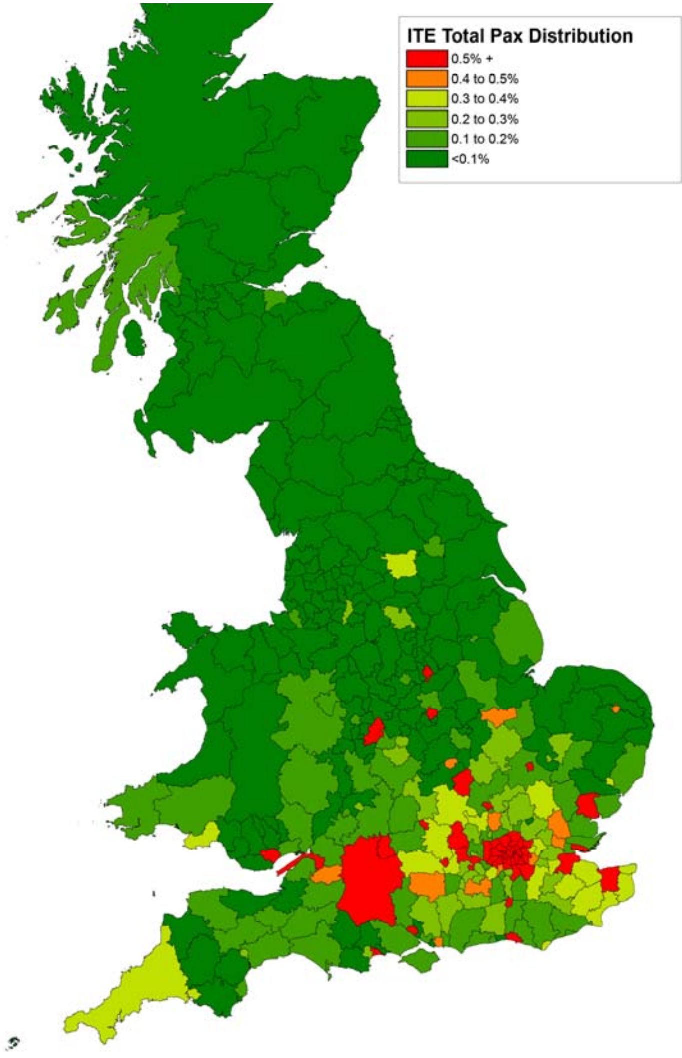
3.4.19 The formulae and residual calculations described above were then applied to generate trip distribution forecasts for passengers and employees to a new ITE airport site. Crow-fly distance to the site was calculated for each district using GIS software, and 2030/50 population and job estimates by district were derived. DfT Tempro population and job growth factors were applied to the base numbers to generate forecasts for districts outside London while within London, GLA population and job estimates were used. It was assumed that in both future years, the proportion of total jobs in the hospitality sector remained similar to the 2012 proportion in each district.

3.4.20 The initial resulting forecasts of passenger and employee trips for the ITE derived from this process were based on the total number of passenger and employee trips recorded during the Heathrow surveys. As a result, they were then converted to percentages and multiplied by the peak-hour ITE trip forecasts described in the previous section of this report. During this process, it was assumed that the proportion of business, UK leisure and foreign leisure passengers at the ITE in both future years would be similar to that recorded at Heathrow in 2012.

3.4.21 The map in Figure 23 illustrates the resulting change in trip distribution for passengers forecast by the model for an ITE airport site in 2030 when compared with the Heathrow 2012 data.

Figure 23: Comparison of Heathrow 2012 and forecast ITE 2030 total passenger distribution



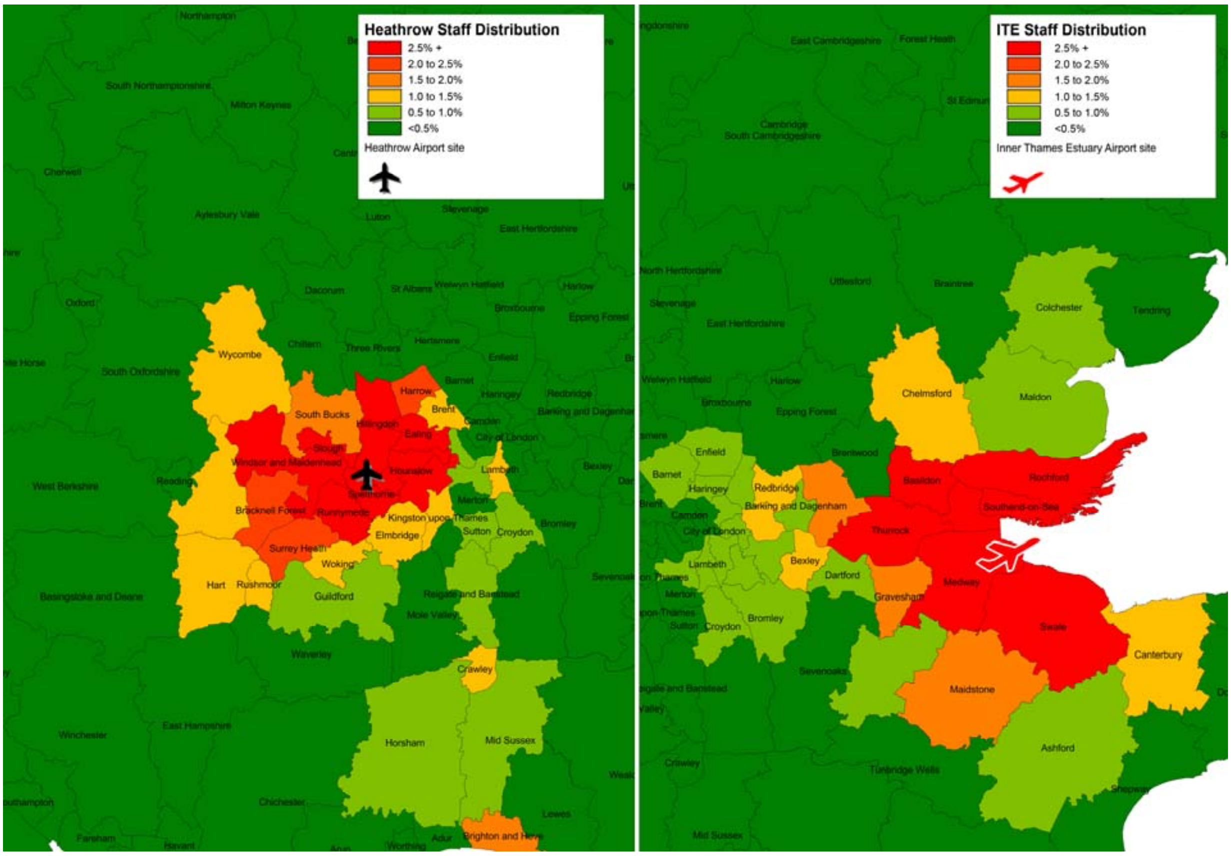


3.4.22 The plan above highlights the continuing importance of London as a surface access origin location for airport trips, although the model does forecast a reduction in the proportion of total passenger trips coming from London, from 51% observed at Heathrow in 2012 down to 45% at the ITE in 2030. This reflects the expectation that over time, some residents and businesses that make regular use of Heathrow Airport at present will gradually re-locate to areas in closer proximity to the ITE to benefit from shorter journey times and better accessibility if a new hub airport is delivered there.

3.4.23 The plan also highlights an expected shift eastward in passenger origin locations, with an increased proportion of trips originating in districts in Essex and Kent and decreases evident in many districts to the west of London.

3.4.24 Figure 24 illustrates the forecast distribution of employees at the ITE in 2030 when compared with Heathrow in 2008/9. As described earlier in this report, Heathrow employees are generally clustered tightly around the airport, with around half living either in Hillingdon or in an adjacent borough. Applying parameters calibrated to the Heathrow data to the ITE results in a similar clustering of employees around the new airport, with high numbers resident in Medway, Swale, Thurrock, Basildon, Southend and Rochford.

Figure 24: Comparison of Heathrow 2008/9 and forecast ITE 2030 employee distribution

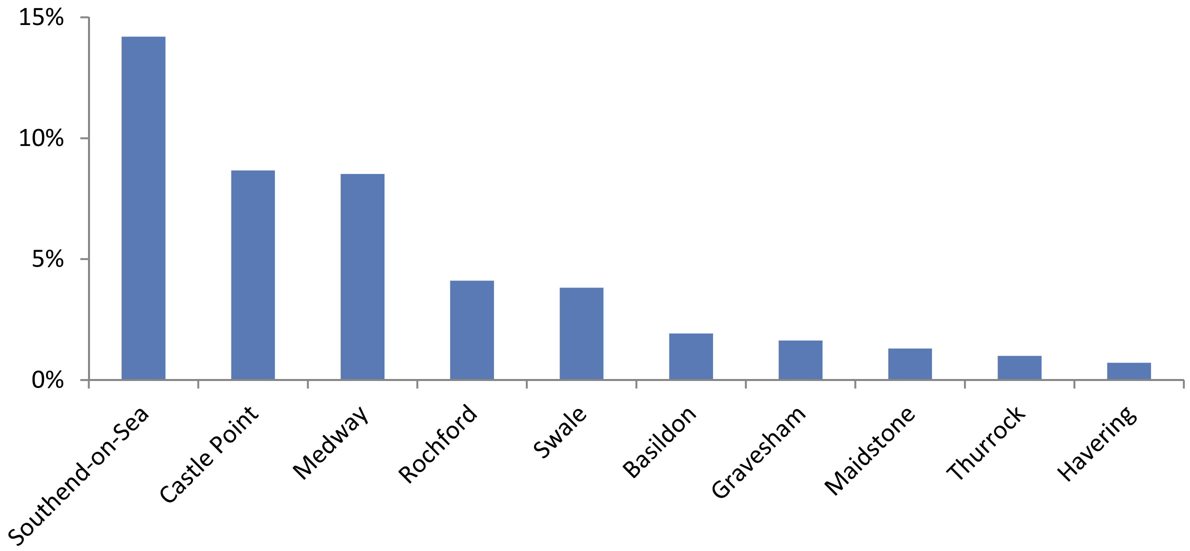


Contains Ordnance Survey data © Crown copyright and database right 2014

3.4.25 It should be noted that the employee distribution forecast for the ITE illustrated on the plan above was calculated based purely using the parameters assessed in the gravity model, and did not consider factors such as the size of the local labour market or the availability of housing. The assumption was that if an airport was delivered in the ITE, the relevant infrastructure would be put in place and local planning regulations would be relaxed if necessary to accommodate future airport employees in an ‘end-state’ scenario, not accounting for the impact of a gradual transition from Heathrow.

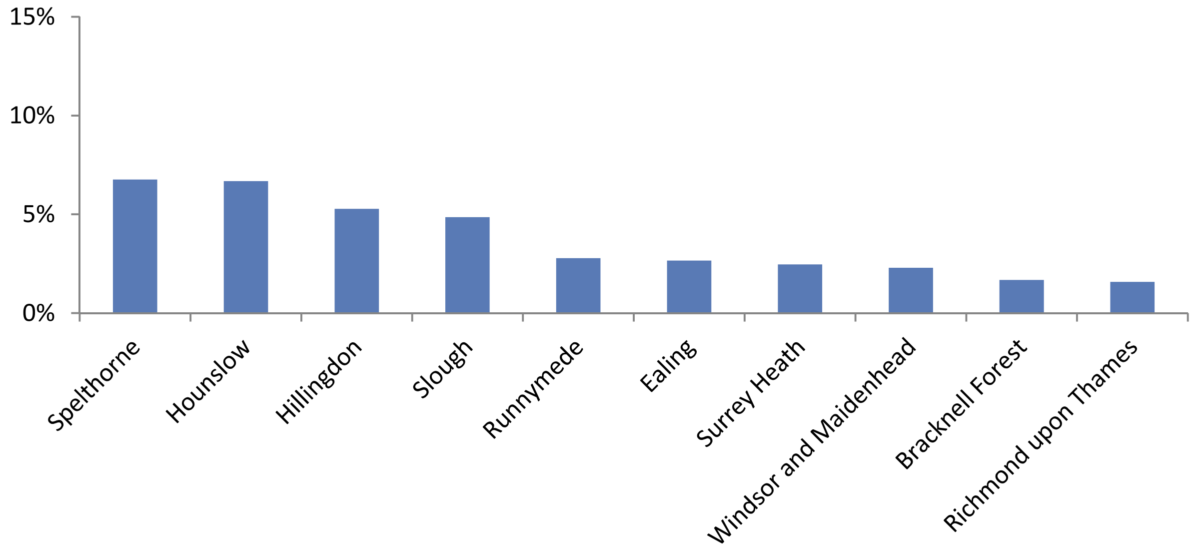
3.4.26 However, the employee forecasts were compared with the DfT and GLA forecasts of population in each district in 2030 referenced earlier in this chapter, assuming that the proportion of the population that is working age remained static. The result of this analysis is summarised for key districts around the ITE site in Figure 25, indicating that in Southend-on-Sea, ITE employees would account for just over 14% of the working age population based on the assumptions described above. In Castle Point and Medway the forecast suggested around 8 to 9% of the working age population would be employed in jobs directly related to the airport.

Figure 25: 2030 forecast ITE employees by district as a % of working age (16-64) population



3.4.27 These figures can be compared with a similar calculation for Heathrow using 2008 employee travel survey data, summarised for key districts in Figure 26. The graph indicates that in Hounslow, the borough with the highest concentration of Heathrow staff, under 7% of the working-age population in 2008 were in employment directly related to the airport.

Figure 26: 2008 Heathrow employees by district as a % of working age (16-64) population



3.4.28 The analysis demonstrates that the existing forecast population around the ITE is unlikely to be able to support direct employment at the airport, and this situation would be exacerbated if indirect and induced employment was considered as well. If a job/working-age population ratio cap was applied to the ITE employee analysis based on the Heathrow 2008 data, this would lead to an increased dispersal of employees around the ITE, which in turn would result in more employees making longer commutes to the airport. This would likely have an increased detrimental impact on the transport network serving the site.

Trip distribution by headline mode share

3.4.29 Once passenger and employee trip distribution had been established as described above, the headline mode share could be applied to geographic areas. As described earlier in this chapter, an overall passenger headline mode share target of 40% rail and 12% bus/coach was defined initially based on benchmarking of Heathrow data and international comparators against assumptions used in the main ITE proposals received by the AC, accounting for an assumed increase in public transport mode share as a result of changing future travel behaviour and demand management measures.

3.4.30 However, analysis of the Heathrow 2012 CAA passenger survey data also indicated wide variations in headline mode share for trips originating in different geographic regions. This was highlighted particularly by the fact that over 80% of all Heathrow passenger rail trips originated in the Greater London area, which only accounted for just over 50% of all trips to the airport.

3.4.31 An initial assessment of rail options to the ITE Airport, developed in consultation with Network Rail and discussed in more detail in a later chapter of this report, indicated that services bypassing London were unlikely to generate the necessary background demand to make them viable. Rail options assessed in detail as part of this demand forecasting process were therefore focussed on provision of access to and from London.

3.4.32 If the ITE is short-listed as a fourth potential option for addressing long-term UK aviation capacity issues, further analysis could be undertaken to assess the demand and capacity implications of direct rail connections to other areas of the UK outside London if such options are considered to be appropriate taking into account other considerations impacting on feasibility. This analysis could involve a dynamic assessment of the impact of new rail services from areas outside London on headline mode share, which was outside the scope of this study.

3.4.33 As a result, the variation in headline mode share by region was assumed to remain constant when testing ITE options, with rail mode share from each region scaled up from the initial Heathrow survey % until an overall target rail mode share of 40% was achieved. The outcome of this process is summarised in Table 10. It should be noted that some UK-based journeys to and from an airport in the ITE would be made by air on domestic flights, as is currently the case at Heathrow, but in the context of this study they are counted as interliners and are excluded from the analysis.

Table 10: Assumed passenger headline mode share by region to/from ITE Airport (2030) – overall target of 40%

Region	Private vehicle/ taxi	Bus/coach	Rail
Inner London	14%	1%	85%
Outer London	58%	8%	34%
South East (not London)	74%	19%	7%
East Midlands	63%	14%	22%
East of England	69%	11%	20%
North East	29%	17%	54%
North West	38%	9%	53%
Scotland	28%	8%	63%
South West	56%	28%	16%
Wales	47%	35%	17%
West Midlands	58%	24%	18%
Yorkshire and the Humber	29%	16%	55%

Source: consultant assumptions based on CAA 2012 Heathrow passenger survey data

3.4.34 The rail mode share scaling factor applied to each region was 1.5, and thus Inner London rail mode share increased from its Heathrow base of 57% to 85% in the ITE 2030 model. It should be noted that this factor does not match exactly the overall increase in rail mode share (from 28% at Heathrow to the target of 40% for the ITE Airport) since passenger trip distribution for the two airports are not identical as a result of the gravity modelling process described above.

3.4.35 Since no data on headline mode share by region was available for employees at Heathrow or at any of the international comparators, the headline figures of 25% rail, 10% coach, 65% private vehicle were applied to all districts generating employee trips to the ITE airport.

3.5 Rail demand

3.5.1 Following the allocation of headline mode share by district described in the previous section, a logit model was then developed to allocate rail passenger volumes to proposed rail services to the ITE site. A range of options for rail access were developed and these are described in more detail in a subsequent chapter of this report, but the first task involved in this process was the development of a base 2012 Heathrow rail mode choice logit model, which was calibrated to the CAA passenger survey data to provide a robust set of parameters with which to forecast ITE rail mode share. As indicated earlier in this report, Olympic-related trips were removed from the CAA database before this analysis was undertaken to minimise the risk of the results being skewed by travel choices related to atypical journeys.

3.5.2 The development of a logit model for this purpose was considered particularly important due to the likely difference in rail fare that would apply to a dedicated airport express service when compared with standard rail options. The Mayor of London submission to the AC for example identified a mix of such options and calculated rail mode share using the Railplan model, which forecast a high proportion of passengers using a dedicated express rail link from Waterloo and London Bridge. However, the Railplan model does not include fare as a determining variable when it allocates rail trips to particular services and it is therefore likely to over-estimate the proportion of passengers who would choose to use express services over alternatives with longer journey time assumptions.

3.5.3 The observed CAA data for Heathrow, which was used to calibrate the base Heathrow model, reinforces the importance of fare. In total only 32% of rail passengers used the Heathrow Express service to access the airport compared to 65% using the tube. In addition, a significantly higher proportion of business rail passengers (51%) used Heathrow Express when compared with leisure passengers (23%).

3.5.4 Further evidence on the importance of travel time and fare was provided by Medway Council in response to the 23rd May call for evidence. The Council commissioned ComRes to undertake a survey on airport expansion in London and the south-east, which covered 2,034 British adults resident in that area interviewed between 4th-6th April 2014. The survey found that:

- The average maximum acceptable travel time to a new airport from central London on public transport is just under an hour – any proposal not taking into account this upper limit is unlikely to be popular with passengers;
- The cost of investing in new airport infrastructure can only be borne by passengers to a certain degree – on average, British adults would be willing to pay less than £10 extra for the cost of travelling or flying to or from a new or existing airport where investment has taken place, suggesting that cost should be a key concern when considering airport expansion options.

Model structure

3.5.5 The base logit model was developed at a district level to ensure consistency with the trip distribution model described previously that fed into it. The Heathrow CAA data was analysed and an initial sift was undertaken to remove districts that generated less than 20,000 total annual rail passenger trip origins, or were based on less than 20 survey records. This was to ensure that the model calibration was focussed on the key rail trip generators and was not hampered by observed mode share data based on very few interview records, which could skew the results.

3.5.6 The resulting districts and observed rail mode shares by journey purpose are shown in Table 11 and provided the framework for the development of the model. As indicated, the data revealed that a significant number of trips made on Heathrow Express used taxi as a secondary mode, and these were separated from trips with secondary public transport modes due to significant differences in the cost of the secondary trip in each case. A small number of trips by Heathrow Express did not indicate a secondary mode (including some within walking distance of Paddington Station) and these were allocated to PT and Taxi proportionally in each borough – consideration was given to splitting Westminster into two zones to account for the Paddington walk catchment but it was felt that this would not significantly impact on the model outputs and so Westminster was retained as a single zone.

3.5.7 Hillingdon was removed from the data-set following analysis that indicated a high proportion of trips originating in the borough were already at the airport and were using Heathrow Express services to move between terminals, thus skewing the overall rail mode share from the borough. Following the removal of Hillingdon and the exclusion of origins based on less than 20 survey records described above, a total of 10.6m rail trips were left in the base model, which amounted to 87% of all rail trips recorded in the CAA survey.

3.5.8 Once the district-level framework was established, a representative 'busy' station was then identified in each borough based on a qualitative high-level assessment. Wherever possible, a prominent tube station was selected as a representative station in London boroughs, while in other districts, the main railway station in the district was identified.

Table 11: Heathrow rail passenger trip origins by final mode and journey purpose (2012)

Origin District	Area	Business				Leisure			
		Tube	Heathrow Connect	HEX (PT)	HEX (Taxi)	Tube	Heathrow Connect	HEX (PT)	HEX (Taxi)
Barking and Dagenham	London	86%	0%	14%	0%	97%	0%	3%	0%
Barnet	London	68%	0%	27%	5%	91%	0%	3%	6%
Bexley	London	44%	0%	56%	0%	42%	21%	37%	0%
Brent	London	52%	2%	30%	16%	74%	5%	14%	7%
Bromley	London	33%	4%	63%	0%	99%	0%	1%	0%
Camden	London	47%	2%	30%	22%	76%	1%	10%	13%
City of London	London	26%	1%	46%	28%	58%	1%	32%	9%
Croydon	London	67%	0%	33%	0%	93%	0%	7%	0%
Ealing	London	77%	22%	1%	0%	82%	16%	2%	0%
Enfield	London	55%	0%	45%	0%	100%	0%	0%	0%
Greenwich	London	38%	0%	35%	27%	71%	0%	29%	0%
Hackney	London	65%	2%	19%	14%	78%	1%	17%	4%
Hammersmith and Fulham	London	92%	1%	5%	3%	96%	0%	3%	1%
Haringey	London	57%	0%	32%	12%	97%	1%	1%	1%
Harrow	London	71%	0%	29%	0%	100%	0%	0%	0%
Havering	London	87%	0%	0%	13%	95%	5%	0%	0%
Hillingdon	London	0%	0%	0%	0%	0%	0%	0%	0%
Hounslow	London	81%	7%	0%	12%	93%	1%	6%	0%
Islington	London	55%	0%	18%	27%	81%	1%	9%	9%
Kensington and Chelsea	London	71%	0%	14%	15%	80%	1%	8%	11%
Kingston upon Thames	London	66%	0%	34%	0%	100%	0%	0%	0%
Lambeth	London	60%	0%	29%	12%	88%	1%	8%	3%
Lewisham	London	53%	5%	31%	11%	88%	1%	10%	1%
Merton	London	90%	0%	9%	1%	93%	0%	7%	0%
Newham	London	80%	0%	6%	14%	89%	3%	8%	0%
Redbridge	London	77%	0%	23%	0%	92%	1%	7%	0%
Richmond upon Thames	London	86%	0%	8%	6%	95%	2%	2%	1%
Southwark	London	41%	3%	40%	17%	82%	0%	12%	6%
Sutton	London	88%	0%	12%	0%	55%	0%	45%	0%
Tower Hamlets	London	44%	0%	47%	9%	78%	2%	16%	4%
Waltham Forest	London	59%	0%	41%	0%	95%	0%	3%	2%
Wandsworth	London	61%	0%	31%	8%	94%	0%	5%	1%
Westminster	London	30%	2%	30%	39%	53%	4%	17%	26%
Nottingham	Rest of UK	61%	0%	39%	0%	86%	0%	14%	0%
Cambridge	Rest of UK	78%	0%	22%	0%	79%	8%	11%	1%
Colchester	Rest of UK	66%	0%	34%	0%	88%	0%	12%	0%
Peterborough	Rest of UK	75%	0%	10%	15%	90%	2%	8%	0%
Manchester	Rest of UK	58%	10%	0%	32%	53%	33%	9%	4%
Brighton and Hove	Rest of UK	100%	0%	0%	0%	98%	0%	0%	2%
Canterbury	Rest of UK	72%	0%	28%	0%	97%	0%	3%	0%
Crawley	Rest of UK	100%	0%	0%	0%	85%	0%	4%	11%
Oxford	Rest of UK	28%	16%	53%	4%	47%	7%	46%	0%
Bath and North East Somerset	Rest of UK	10%	0%	90%	0%	10%	16%	74%	0%
Bristol, City of	Rest of UK	4%	0%	96%	0%	55%	9%	36%	0%
Exeter	Rest of UK	0%	0%	100%	0%	45%	0%	55%	0%
Plymouth	Rest of UK	7%	0%	93%	0%	4%	1%	95%	0%
Cardiff	Rest of UK	36%	8%	56%	0%	35%	2%	63%	0%
Swansea	Rest of UK	17%	0%	83%	0%	23%	0%	77%	0%
Birmingham	Rest of UK	63%	0%	25%	11%	78%	0%	22%	0%
Leeds	Rest of UK	89%	0%	11%	0%	50%	0%	48%	1%
York	Rest of UK	82%	0%	7%	11%	85%	0%	15%	0%

Source: CAA 2012 Heathrow passenger survey data, analysed by consultant

3.5.9 Generalised Costs (GCs) were then calculated from each representative station to Heathrow Airport for each of the mode options identified in the table. This calculation was based on a number of key data inputs, as follows:

- In-train times were estimated using the National Rail and TfL journey planner websites, and were divided by category of service for each leg of the journey (i.e. tube, commuter rail, long-distance rail etc);
- The number of interchanges required to make each journey was counted, and a flat 5 minutes clock time was assumed per interchange;
- Platform wait times at stations were based on half the rail frequency sourced from the National Rail website for trips from outside London, with generic times applied for journey legs beginning in London based on the category of service being used;
- Taxi wait times were assumed to be a flat 2 minutes;
- Train fares were based on an assumed single ticket to Zone 9 for London trips, with the National Rail website used to estimate fares from areas outside London;
- Taxi journey times and fares were estimated to Paddington using Google Maps and information from the Public Carriage Office on average taxi fare by distance – an assumed congestion factor was then applied based on information on delay in TfL's Travel in London Report 6, with a manual adjustment to account for use of bus lanes by black cabs;

3.5.10 The following parameters were then applied to calculate GC for each mode choice based on the inputs described above – the values derived for these parameters are described in the following section on model calibration:

- Comfort factors were applied to in-vehicle time to reflect the different quality of the services available, with low factors applied for perceived high-quality options such as Taxi and Heathrow Express;
- A factor was applied to wait times and interchange times;
- Values of time of 69p per minute for business trips and 27p per minute for leisure trips were applied to convert total fare estimates for each journey to generalised minutes – these values were sourced from research developed to understand potential rail passenger trips to airports using HS2;
- Mode Constants were applied to the total GC derived for each mode by journey purpose to account for variables not included in the modelling.

3.5.11 The resulting GCs derived for each mode by district were then used to predict mode shares using a standard multinomial logit model formula, with a lambda value calibrated to determine the sensitivity of passengers to GC.

Base model calibration

3.5.12 A number of tests were used in the process of calibrating the base logit model, which was undertaken with the assistance of the MS Excel Solver tool. The first was to ensure that the relationships between modelled and observed annual passenger numbers by mode and journey purpose, expressed in R-Square values, were as high as possible. In addition, the approach focussed on keeping the differences between the total forecast and observed number of trips by each mode to a minimum.

3.5.13 Some of the factors used to calculate GC by different modes were held constant during the calibration process to ensure that the final parameters applied to sub-rail mode share in the ITE 2030 and 2050 models could be justified based on sense checks. These included the following:

- Comfort factors applied to in-vehicle journey time, which were held as follows:
  - 1.0 for Tube, Overground, DLR, Heathrow Connect, and other London commuter rail services;
  - 0.8 for long-distance rail services;
  - 0.65 for Heathrow Express;

   - 0.5 for Taxi;
- Platform wait time factor: 2.0;
- Interchange time factor: 2.0;

3.5.14 The values assigned for platform wait times and interchange times are within standard ranges often used to calculate GC and are referenced in DfT WebTAG documentation. The comfort factors were defined by assuming a reference value of 1 for rail options identified as offering a standard level of service (such as tube and commuter rail), and then reducing values relative to this benchmark for 'premium' services assumed to offer a more attractive level of service. For example, taxi was assumed to be the most comfortable and therefore the most attractive mode due to the direct, door-to-door nature of the journey and the space provided for luggage. Heathrow Express was assumed to be the next most comfortable mode, with long-distance rail identified as the third most comfortable option.

3.5.15 The key variables that were therefore changed during the calibration process were the lambda values in the logit model formula and the mode constants. The Solver tool was used to maximise R-Square values and minimise errors in total passenger numbers by mode by firstly adjusting lambda values. Mode constants were then subsequently adjusted to account for any significant residual errors.

3.5.16 The final derived lambda values were 0.028 for business passengers and 0.026 for leisure passengers (which are typical values for a logit model of this nature and are within ranges identified in WebTAG), and the mode constants applied are summarised in Table 12.

Table 12: Mode constants applied in calibrated 2012 Heathrow rail mode choice logit model

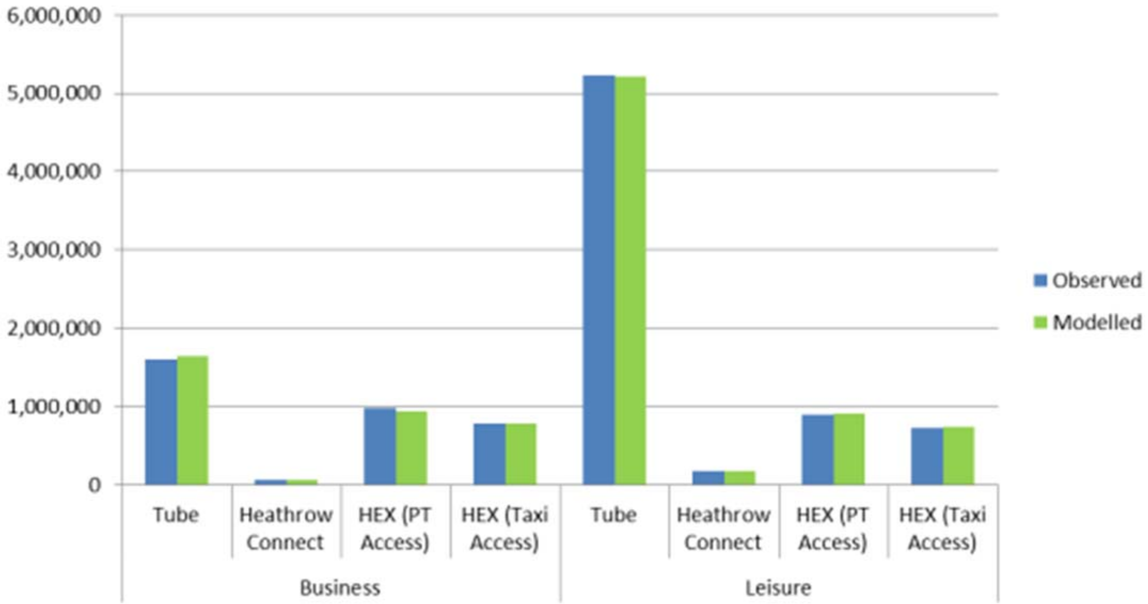
Mode Factors	Business	Leisure
Tube	1	1
Heathrow Connect	1.46	1.26
HEX (PT Access)	1	1
HEX (Taxi Access)	0.96	0.91

3.5.17 The mode constant values indicate two key elements of the observed mode shares that the GC calculations could not fully explain. The first was the popularity of taxi trips linking to Heathrow Express, particularly among leisure passengers, and so the mode constant lowered GC for these trips to make them more attractive. An implicit assumption in mode share modelling is that passengers are aware of all the options available to them to make a particular journey. Taxis were particularly well used by foreign leisure passengers who may not be fully aware of all the rail options available to them, or who may place a higher value on a direct, door-to-door journey than UK leisure passengers. In addition, some visitors to London may view black cabs as an experience as well as a mode of transport, and the mode constants for taxis were applied to account for the impact of such factors.

3.5.18 In contrast, the second element was the low observed use of Heathrow Connect services, particularly among business passengers. Anecdotal evidence suggests that there is little knowledge of the existence of Heathrow Connect services among airport passengers as the service is not widely advertised. As a result, the mode constants were adjusted to reduce the attractiveness of these trips.

3.5.19 Figure 27 summarises the differences between observed annual passenger trips to Heathrow by rail mode and the outputs from the calibrated 2012 base model. The graph indicates that overall, the model forecast for total trips by mode is very close to the observed, with the biggest difference being for business trips by Heathrow Express (secondary PT mode) – the model forecast overall was 4.4% lower than the observed.

Figure 27: Modelled v observed total annual rail passenger trips to Heathrow by mode and journey purpose (2012)



3.5.20 The graphs in Figure 28 to Figure 31 summarise the other element of the calibration process – the relationship between modelled and observed passenger forecasts by district for each mode. The graphs illustrate a very strong correlation between modelled and observed with R-Square values of 0.94 or above for all relationships with the exception of those derived for Heathrow Connect services.

Figure 28: Modelled v observed annual tube passengers to Heathrow (2012)

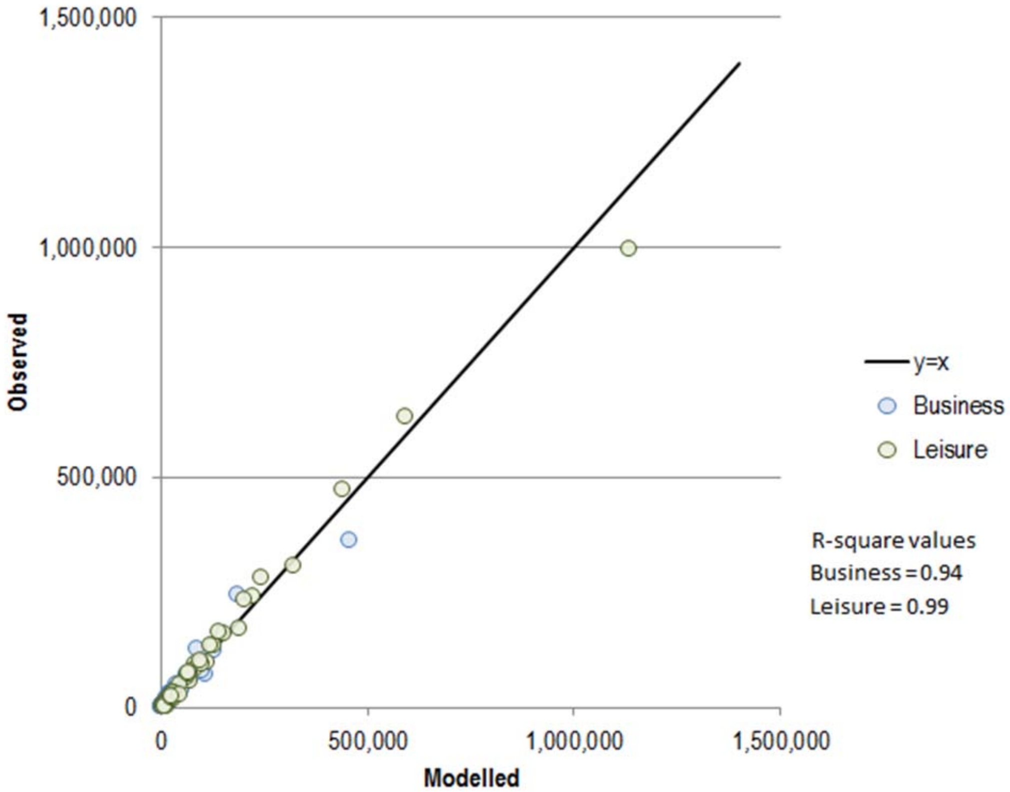


Figure 29: Modelled v observed annual Heathrow Connect passengers to Heathrow (2012)

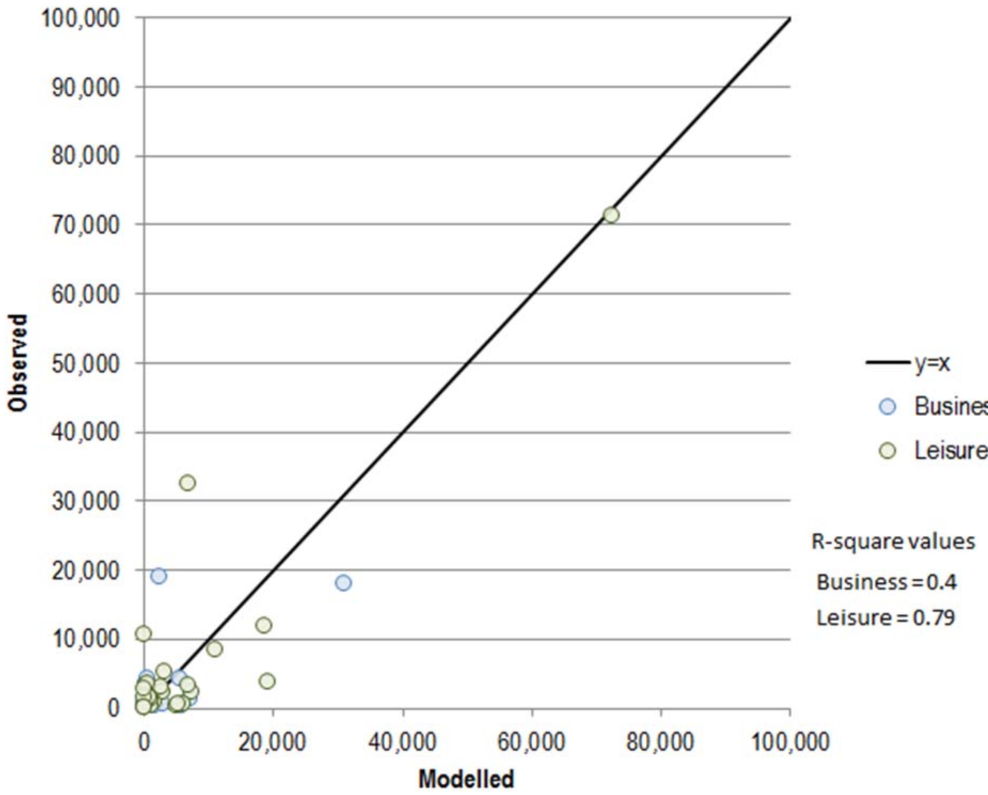


Figure 30: Modelled v observed annual Heathrow Express passengers (with secondary PT) to Heathrow (2012)

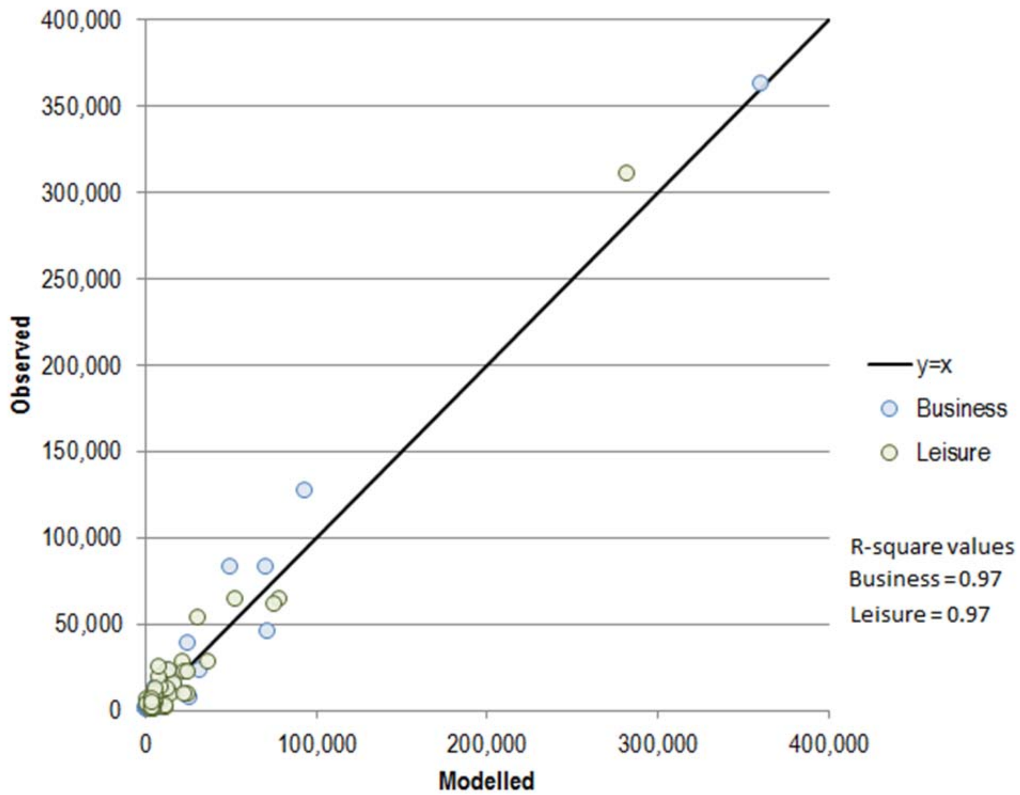
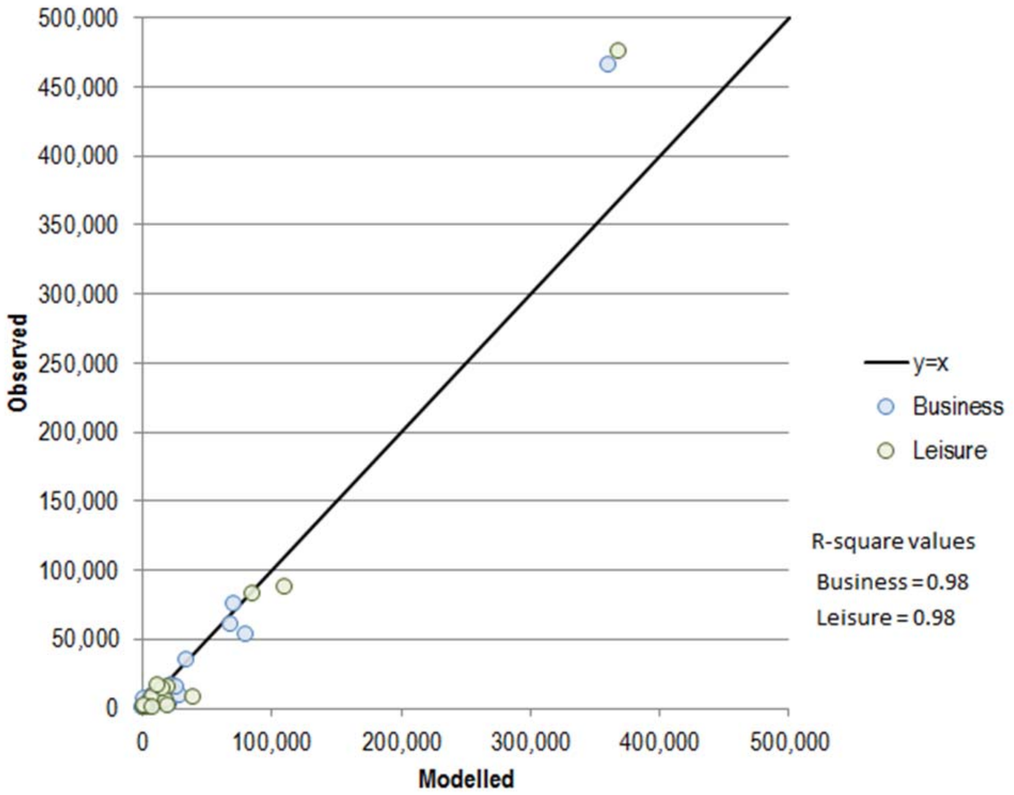


Figure 31: Modelled v observed annual Heathrow Express passengers (with secondary taxi) to Heathrow (2012)



3.5.21 The poor relationship derived for Heathrow Connect was partly due to the limited number of districts that generated observed trips, particularly for business purposes. This appears in itself linked to a general lack of awareness of the service among many passengers – no districts generated more than a 3% mode share for Heathrow Connect among business rail passengers. Only 3% of business passengers from Westminster used the service compared to 38% who used the Tube, despite Paddington being located within Westminster and the two route options having similar clock times and fares from many parts of the borough.

3.5.22 The fare for Heathrow Connect trips is considerably lower than Heathrow Express for trips to the airport from Paddington – an average of £9.90 was assumed in the modelling compared to £21 for Heathrow Express. In contrast an assumed journey time of 41 minutes and an average service frequency of 30 minutes compares poorly with equivalent values of 15 minutes for both journey time and service frequency for Heathrow Express.

3.5.23 An initial analysis of the Generalised Cost of both options from Paddington using a leisure value of time of 27p per minute, a factor of 2 for average wait time, and no factors applied for comfort suggests that both services should be equally attractive for leisure passengers. Even accounting for an enforced interchange at Terminals 1, 2 and 3 for Heathrow Connect passengers travelling to Terminals 4 and 5 and a reduced comfort factor, the analysis of Generalised Cost included in the modelling does not generate a mode share forecast as low as the observed for Heathrow Connect.

3.5.24 Due to the low number of passengers using Heathrow Connect, it was felt that the poor relationship derived for the service in the base logit model was not a significant issue in the context of the strength of the relationships derived for other modes. Furthermore, Heathrow Connect services are due to be discontinued when Crossrail services begin operating to and from Heathrow, which is due to happen regardless of whether an airport in the ITE replaces Heathrow or whether Heathrow itself is expanded or otherwise. Also, no directly equivalent service to the ITE was identified in any of the four submissions summarised in Chapter 2 of this report.

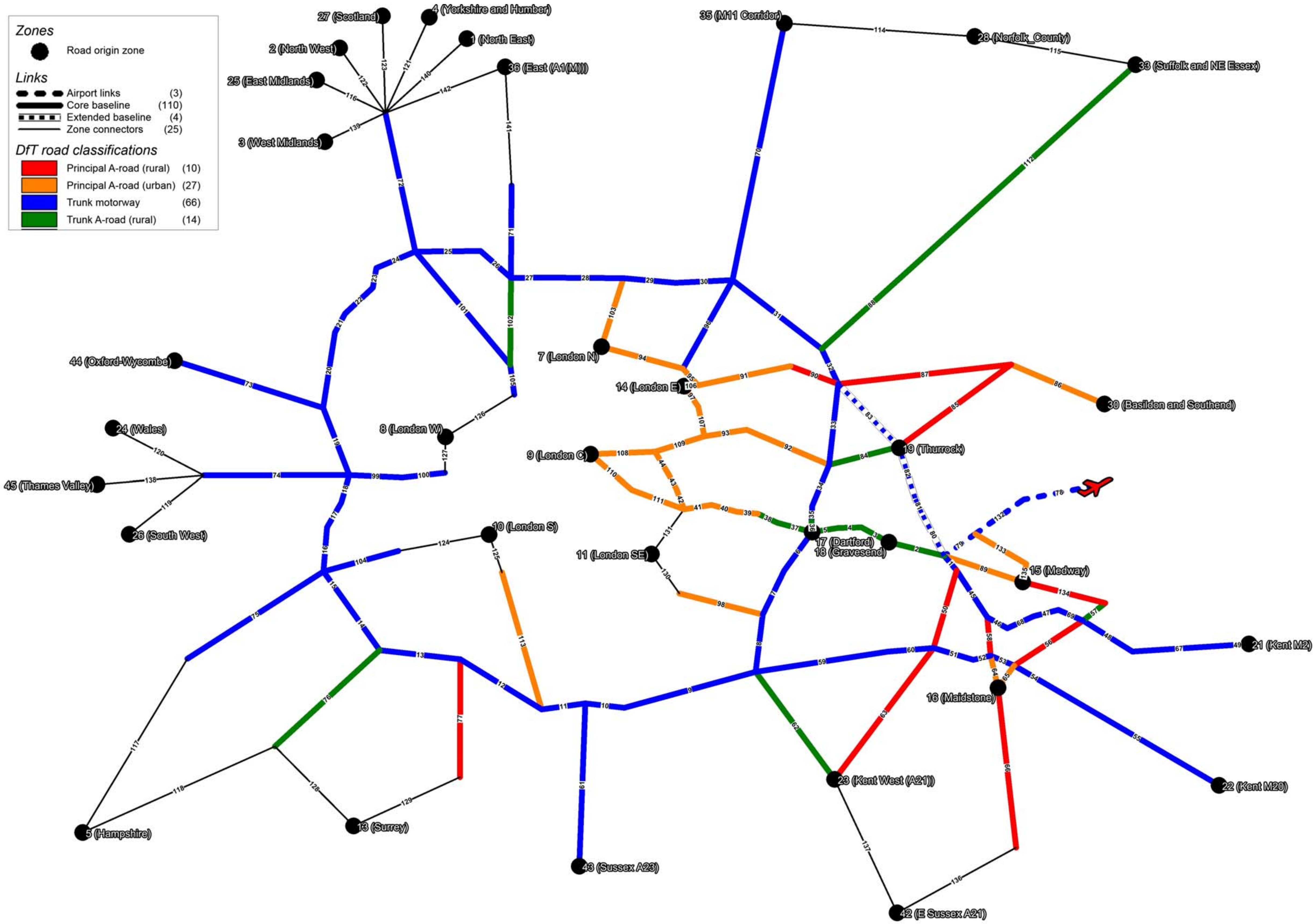
3.5.25 The parameters developed for the Heathrow model were subsequently applied to GC calculations developed for potential rail options to the ITE to estimate rail mode share for each option. The development and testing of these options is described in a later chapter of this report.

3.6 Road demand and capacity

3.6.1 Road capacity was assessed by firstly identifying the strategic road network links that would serve an airport in the ITE and that were likely to carry a significant level of airport-related traffic. These links are shown in Figure 32. It was assumed that beyond the south-east region, airport-related road traffic would dissipate to the extent that there would be a negligible impact on road capacity. Within the south-east, all key motorway links on the M25, the motorway approaches to the London orbital, and the M2 and M20 in Kent were included in the model, along with other major roads on key corridors linking the airport to key destinations. In addition, links representing the Lower Thames Crossing Option C were also included in the extended baseline road network, connecting the M25 via the A13 to the existing M2/A2 junction 1. In both baselines, a trunk-motorway category link was also assumed to be provided linking junction 1 to the airport itself

3.6.2 A zone system was then defined to allocate airport-related traffic to the road network. As described earlier, the trip distribution analysis (split by headline mode share) was undertaken at a district level for both airport passengers and employees. An initial assessment of the strategic road network serving the airport in the south-east region indicated that trips between many districts and the airport would likely enter or leave the network at similar points and as a result, the zone system was established by grouping districts accordingly. For example, all road trips between the airport and districts in Scotland, the North West and the Midlands were assumed to enter or leave the defined network along the M1, while all trips between districts in Wales and the airport were assumed to use the M4.

Figure 32: ITE road network (core and extended baselines)



Source: network developed by consultant for this study

3.6.3 Once the zone system and road network had been established as described above, road trips were then allocated to network links as follows:

- Assumed headline mode share by private vehicle (split by broad geographic region for passengers, as indicated in Table 10) was applied to the district-level trip distribution figures calculated for passengers and employees to and from the airport using the gravity modelling approach described earlier – for the purpose of this analysis, all private vehicle users were assumed to be car users;

- Car person trips were then converted to car vehicle trips using the headline car occupancy factors for passengers and employees;

- Car vehicle trips by district were then summed by zone, based on the zone system illustrated in the figure above;

- Two sets of routing options between each zone and the airport were then defined manually, one for the core baseline (the existing road network) and one for the extended baseline (similar to the core but with the addition of the LTC Option C links as described above) – in many cases, there was only one self-evident route that the vast majority of drivers would take in each baseline (for example, trips between zones assigned to the M11 and the airport were assumed to use the M25 Dartford Crossing and the A2 in the core baseline and the new LTC in the extended baseline), while in others, multiple routes were identified (for example north and south around the M25 for trips between the airport and the zones allocated to the M4);

- Car vehicles trips calculated by zone were then allocated to network links cumulatively in each baseline, based on the route assignment process described above – where multiple route options were identified, demand between the zones in question and the airport were allocated equally to each route option.

3.6.4 The plans in Figure 33 and Figure 34 illustrate the result of the methodology described above for all passenger and employee-related car trips ***to*** the airport in 2030 in the core and extended baselines. Trips ***from*** the airport were allocated in the same way but had a lower overall total, as more employees travelled to the airport in the peak hour than from it. Airport-related car trips to and from the airport in 2050 were also allocated in the same way, with the total number of car trips to the airport increasing to just over 7,300 in 2050.

3.6.5 The plans illustrate the impact of the LTC in removing airport-related traffic from the M25 in the vicinity of the Dartford Crossing and on the A2 between the M25 and its junction with the M2 in the extended baseline. In both baselines, the sections of road that would be impacted the most by airport traffic included the northern section of the M25 back to its junction with the M1, and to a lesser extent the southern sections of the M25 round to its junctions with the A23 and A3. In addition, a significant level of airport traffic is evident on the A13 from Southend and Basildon as a result of the allocation of employees to these districts by the gravity model.

Figure 33: Forecast peak-hour vehicle demand to the ITE Airport in 2030 (core baseline)

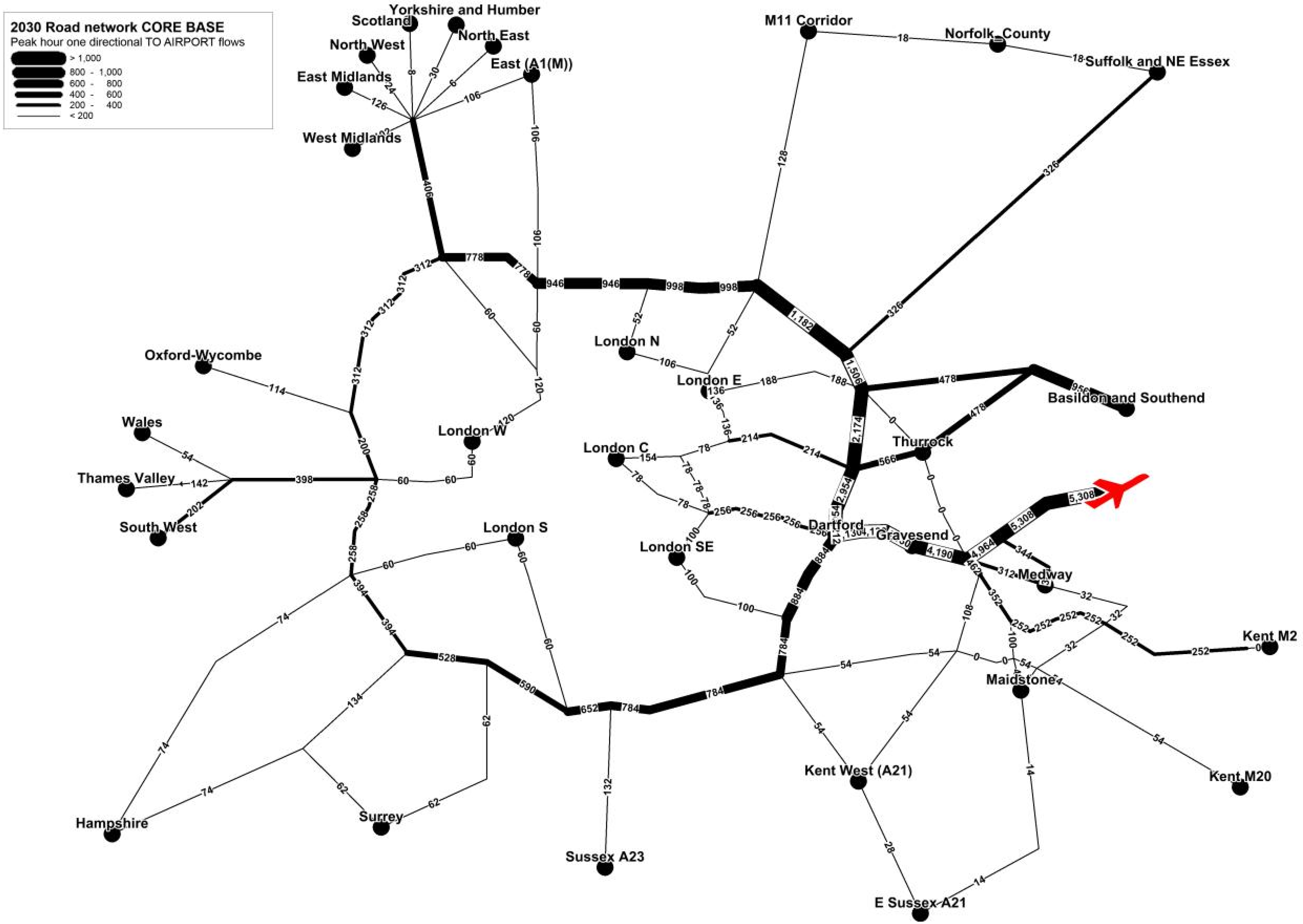
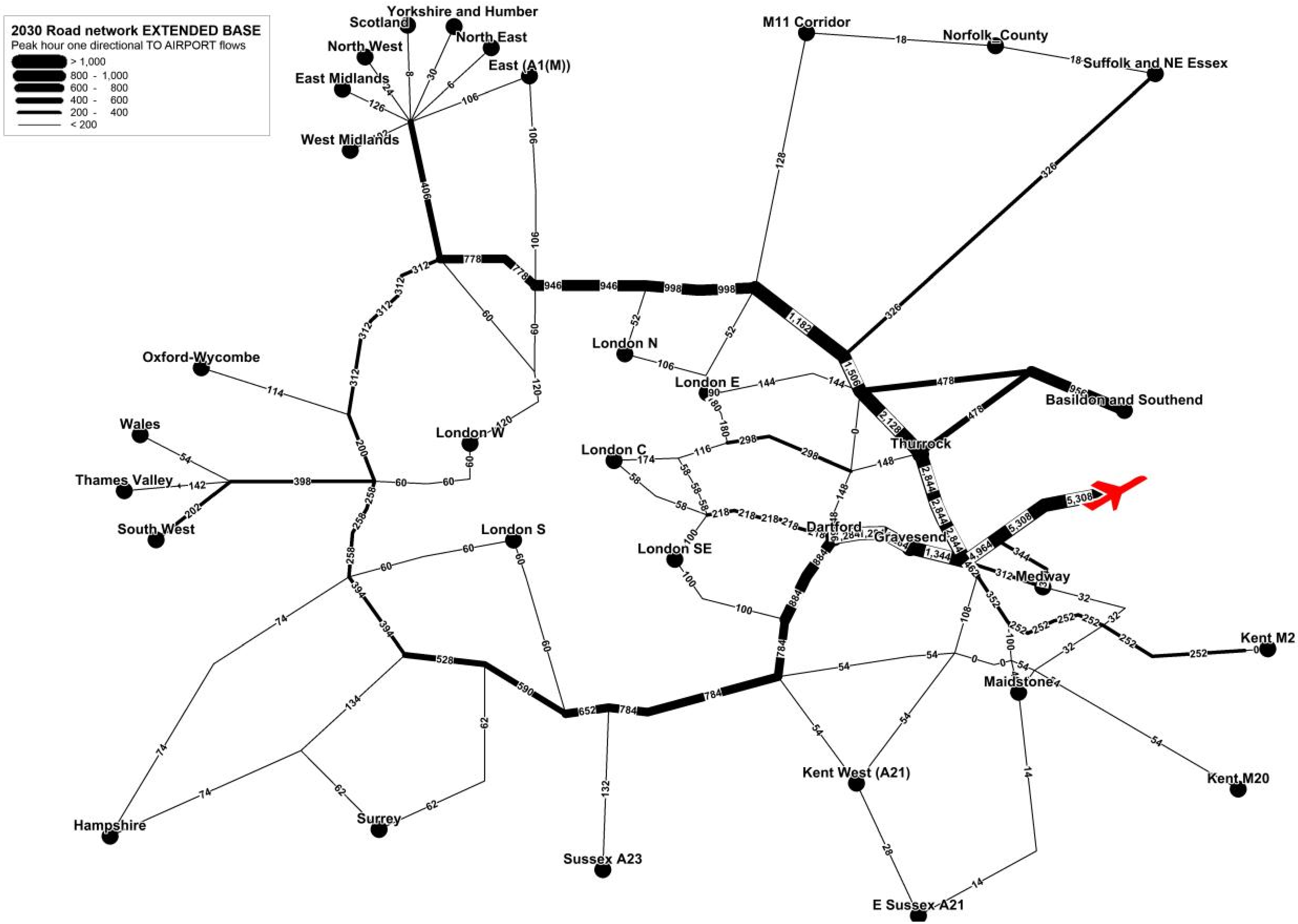


Figure 34: Forecast peak-hour vehicle demand to the ITE Airport in 2030 (extended baseline)



3.6.6 The impact of airport traffic on road capacity was then assessed in a number of steps, as follows:

- Background traffic was estimated for each link using Annual Average Daily Flow (AADF) data for 2010 from the DfT's Traffic Counts website[21] - since links were not coded by direction, the two-way daily flow was assumed to split with 53% in the peak direction based on a tidal peak-hour analysis of flows on the M25 sourced from the TRADS website[22];
- 2010 AADFs were then converted to 2030 and 2050 estimates using factors derived from Regional Traffic Forecasts produced by the DfT's Transport Analyis and Strategic Modelling (TASM) Division using the National Transport Model (NTM);
- Single direction AADF was then converted to a peak-hour using a factor of 6.9%, which was derived from analysis of a sample of daily profile flows on key sections of road sourced from the TRADS website;
- The current average number of lanes in a single direction on each link was then identified using desktop research, notably Google Streetview images;
- The number of lanes per link were then adjusted in the core and extended baseline scenarios to account for the schemes identified by the HA, which are listed in full in Appendix A – in both baselines, aside from the LTC, all the schemes listed were 'smart motorway' initiatives involving the utilisation of the hard shoulder by general traffic during peak periods – the impact of these schemes was replicated in the model by adding a lane to each affected link;
- The links associated with the LTC in the extended baseline were assumed to be dual-four, a similar standard to the sections of the M25 around the Dartford Crossing currently – the dedicated airport link from junction 1 of the A2/M2 was initially assumed to be dual-four, although one of the objectives of the subsequent analysis was to determine the number of lanes required on this new infrastructure to accommodate forecast demand in different scenarios;
- A theoretical link capacity was then calculated based on an assumed upper limit of 2,000 PCUs per lane per hour – therefore, most sections of the M25 with 4 lanes in each direction were assumed to have a capacity of 8,000 PCUs per hour in a single direction;
- Volume/Capacity Ratios (VCRs) were then calculated for each link for forecast background demand in 2030 and 2050 both with and without airport traffic – a key aim of the analysis was to identify the road links that would likely require upgrading in 2030 and 2050 even if the ITE airport was not delivered, as opposed to those where capacity issues would likely be created specifically as a result of airport traffic.

3.6.7 The VCRs for each scenario calculated using the methodology described above are summarised in Chapter 5 of this report. A key point to note is that the identified peak hour for the ITE based on the analysis of airport passenger arrival and departure times is an AM peak hour, and the flow of airport trips during this hour is predominantly towards the airport, mainly because many more staff are expected to arrive for work during this hour than leave work.

3.6.8 This means that for some road links, background demand during the AM peak may be lower than the analysis suggests. For example, background flow on the A2 in the AM peak is likely to be predominantly towards London, with lower flows heading outbound from London in the direction of the airport. This would mean there may be additional road capacity to accommodate airport trips in this direction.

3.6.9 However, a single peak-hour factor was applied to the AADF data during this analysis in order to minimise the risk of over-looking capacity issues that may arise on the road network during other peak periods. Since the analysis does not distinguish traffic flow by direction, the assumption is that any upgrade works identified to increase road capacity would need to be applied in both directions.

[21] http://www.dft.gov.uk/traffic-counts/
[22] https://trads.hatris.co.uk/

3.6.10 It should be stressed that any analysis based on theoretical link capacity is high-level in nature, and more detailed modelling will be required to ascertain the impact of airport traffic on specific junctions if the ITE proposal is added to the AC's short-listed options.

4. Rail access assessment

4.1 Overview

4.1.1 The peak-hour demand forecasts and trip distribution/mode share analysis developed for the ITE Airport in 2030 and 2050, described in the previous chapter, was used to assess the provision of future rail services to the airport site.

4.1.2 A range of rail service options were identified primarily based on a review of the ITE proposals summarised in Chapter 2, and assembled into four packages. Demand on each service in each package was then forecast using the parameters derived from the calibrated base 2012 Heathrow rail mode choice logit model, described in the previous Chapter, based on assumptions regarding the GC of trips to the airport from different districts in the future years.

4.1.3 The logit model results were then collated to identify total airport-related rail passenger demand on key corridors. These numbers were then compared with background passenger demand estimates on these corridors provided by Network Rail and TfL to determine the likely location and scale of rail capacity issues and to draw conclusions regarding the level of service that would be experienced by rail passengers in each of the four options based on forecast crowding on services. In addition, rail journey times were analysed for each option and compared with current journey times to Heathrow to assess the overall change in rail accessibility to the ITE.

4.2 Proposed rail access strategies

4.2.1 The starting point for assembling the rail packages was to identify the core schemes included in multiple ITE proposals received by the AC. These included the following:

- Express service via HS1 from St. Pancras connecting to the airport via a spur in the vicinity of Hoo Junction – included in all submissions with minor variations and assumed to take approximately 26 minutes from St. Pancras to the ITE airport;
- The extension of both branches of Crossrail from Abbey Wood in the south via Dartford, Gravesend and Hoo Junction and from Shenfield in the north via Billericay – the southern branch extension was included in all three submissions, while both MTTRA and Foster + Partners included a northern branch extension – this was assumed to take approximately 51 minutes from Tottenham Court Road to the airport;
- The provision of a semi-fast service from Waterloo to the airport via Bromley South and Swanley – included in the Foster + Partners and MTTRA submissions, and IAAG highlighted the potential for a similar service to Waterloo via Ebbsfleet/Gravesend – this was assumed to take 42 minutes from Waterloo to the airport;
- Regional services linking to North Kent (via the Chatham Main Line at Strood) and South Essex (via a river crossing to the Fenchurch Street line at Grays) – included in the Mayor of London, IAAG and Foster + Partners submissions.

4.2.2 In addition, the proposal for a new express service from Waterloo via London Bridge, Canary Wharf and Barking Riverside was included as it was the centre-piece of the Mayor of London’s rail submission, and it was also considered a good approach to test the impact of an additional express service in the event that the HS1 option proved to be unfeasible in capacity terms. The total AEX journey time was assumed to be 28 minutes from Waterloo to the airport.

4.2.3 A number of schemes included in individual ITE proposals were excluded from testing at this stage for a variety of reasons as follows:

- Proposals incorporating an HS1-HS2 link were excluded following the decision taken earlier this year by the Government to drop a similar proposal as a component of the core HS2 scheme;

- The proposal for a link to Milton Keynes via the North Kent line, HS1, North London line and West Coast Main line was excluded following consultation with NR, who indicated that the following issues would be significant:
  - Line utilisation on the North Kent line between Springhead junction and Strood;
  - Capacity for through trains as a result of the CP4 redevelopment of Gravesend station;
  - Line utilisation on HS1, particularly if an additional express service for the airport was accommodated;
  - Line utilisation on a North Kent line-HS1 link, which was explored during analysis of the proposed HS1-HS2 connection – this analysis suggested little or no spare capacity in light of large and growing passenger and freight markets;
- The proposal for a link to Reading via the Chatham Main line, Herne Hill, the West London line and a new connection to the Great Western Main line at North Pole was also excluded following discussions with NR, who cited the following concerns:
  - The Chatham Main line between Swanley and Factory junctions is currently at capacity;
  - Similarly the West London line is currently at capacity with orbital and regional passenger services as well as high freight utilisation;
  - The Great Western Main line in this area is currently undergoing significant change as part of Crossrail, and it is unlikely that surplus capacity on the route to Reading will be available without major changes to planned services;
- Other proposals for direct rail services to the rest of the UK bypassing London (including an "HS3" service to Eastern England and the Stevenage connection identified by MTTRA) were also excluded on the basis that there was no evidence to suggest that background demand on these services would make such proposals viable;
- Proposals for services to Liverpool Street were excluded following discussions with Network Rail, who indicated that platform capacity would be a severe constraint;
- Proposals for services to other south London termini such as Victoria and London Bridge were excluded on the basis that they would provide a similar type of service as the proposal from Waterloo;
- Proposals for Park & Ride (P&R) services put forward by Foster + Partners were excluded on the basis of an initial assessment that indicated that such measures were unlikely to carry a significant proportion of rail passengers (as headline mode share estimates used in this study assumed that a majority of passengers would travel from London) and uncertainty surrounding the extent of demand management measures that would be in place at the airport (which would have a significant impact on the uptake of P&R) – however, if the Estuary is short-listed for further Phase 2 assessment, it is recommended that the feasibility of P&R is considered in more detail.

4.3 Rail options

4.3.1 The schemes identified in the previous section for testing during this analysis were assembled into the following four packages, as follows:

- Rail Option 1 – minimum requirements – consisting of the HS1 express spur, the Crossrail southern extension, and rail services from South Essex and North Kent;
- Rail Option 2 – enhanced National Rail connections – consisting of Option 1 plus the addition of a direct service to Waterloo calling at Bromley South and Swanley (the 'Waterloo Stopper');
- Rail Option 3 – Crossrail northern extension – consisting of Option 2 plus the extension of the northern branch of Crossrail from Shenfield through Billericay to the airport;
- Rail Option 4 – enhanced express connections – consisting of Option 2 plus the addition of the Mayor of London's express service to Waterloo via Barking Riverside, Canary Wharf, and London Bridge.

4.3.2 The components of each of the four rail options outlined above included a number of assumptions regarding infrastructure requirements based on discussions with NR, TfL and HS1. These assumptions are summarised below and the feasibility of each component is discussed in more detail later in this chapter:

- All rail services to the ITE would stop at the airport at a new subterranean railway station located under the main terminal buildings, providing direct and legible walking connections between platforms and terminal facilities;
- A new four-track alignment would be provided connecting the new airport station to existing rail infrastructure at Hoo Junction, which is situated on the line connecting Gravesend and Higham stations and currently provides access to the Thamesport freight line – this alignment would be used by all the rail schemes identified in the options above and four tracks was considered to be required in all options tested;
- Two of the four new tracks identified above would be extended across Hoo Junction to create a new two-track alignment to the east of Gravesend connecting Hoo Junction with the existing Channel Tunnel Rail Link (CTRL) in the vicinity of the village of Thong – this would provide express services using HS1 from St. Pancras with a direct route to the airport – the rail options tested do not assume that any services would link the airport directly to areas to the south via CTRL and so a single two-track chord for services to and from London was assumed to be required;
- HS1 express services were assumed to operate on existing CTRL track between St. Pancras and the aforementioned new chord/track alignment east of Gravesend, with two dedicated platforms provided for airport services at St. Pancras – one new (provided on a cantilevered extension to the existing station structure) and one converted from current use;
- The Crossrail southern branch extension from Abbey Wood via Dartford and Gravesend was assumed to require the existing corridor to be four-tracked all the way from Abbey Wood to Hoo Junction – the section of this corridor between Abbey Wood and Gravesend has already been safeguarded for a potential south-eastern extension of Crossrail to Gravesend and beyond[23];
- The Crossrail northern branch extension from Shenfield was assumed to run on existing tracks through Billericay to a new two-track spur in the vicinity of Ramsden Bellhouse that would run to the west of Wickford and to the east of Basildon into a new tunnel with a portal to the west of Canvey Island that would run directly into the subterranean airport station – this is in line with the proposal put forward by MTTRA – it was noted that a different alignment was shown for the Crossrail northern branch extension in the Foster + Partners submission, linking Stratford to stations at Barking and Essex Parkway before accessing the airport over a multi-modal bridge along the LTC Option C alignment, but the MTTRA proposal was tested during this study as to the east of Stratford the Foster + Partners proposal appears to involve a re-routing of the current Crossrail alignment being built to Shenfield;
- The Waterloo Stopper service was assumed to run on existing track from Waterloo through Bromley South and Swanley, and then use the existing section of track between the spur to the west of Longfield and the spur to the CTRL south-west of Gravesend – this would allow the service to use the same new chord/track alignment to the east of Gravesend as the HS1 services described above to reach the airport;
- Discussions with Network Rail indicated that a number of local enhancements would be required to the ‘Waterloo Stopper’ corridor in the Greater London area to alleviate line utilisation issues and make such a service feasible, including resolving issues at the Herne Hill rail junction and platform capacity issues at Waterloo;
- Discussions with NR also indicated that providing new services direct to the airport direct from the Chatham Main Line would be problematic due to line utilisation issues and as a result, a dedicated airport shuttle service from Strood was assumed to be provided accessing the airport on the aforementioned new four-track alignment via a new chord at Hoo Junction – if the ITE option is short-listed for Phase 2 assessment, further consideration could be given to the

[23] Source: http://www.crossrail.co.uk/route/safeguarding/abbey-wood-to-hoo-junction

feasibility of using Strood as a termini for the shuttle as opposed to alternatives such as using Rochester station via a new Medway rail crossing – it should be noted that significant modifications would be needed at the existing Strood station to accommodate up to 4 shuttle services per hour;

- If Strood were to be taken forward as the preferred termini for the shuttle from North Kent, some local enhancements may be required in Option 1 (excluding the Waterloo Stopper) to allow a single interchange from the Chatham Main Line serving locations in South East London, notably Bromley South and Swanley – this could include the provision of a new chord to the south of Strood station or walking links from the existing station to new platforms on the Chatham Main Line to the south in the vicinity of the railway bridge, which would allow fast Kent services between Rochester and Swanley to stop at Strood – such interventions would be less important in the other three options as the Waterloo Stopper would provide a direct link from South East London to the airport;
- Similarly, due to line utilisation issues identified by NR on the Fenchurch Street line via Grays, it has been assumed that a shuttle would be provided from Grays station that would use existing track through Tilbury Town before crossing the river via a modified multi-modal bridge on the LTC Option C alignment and connecting to Hoo Junction;
- The AEX included in Option 4 would run underground through new tunnels between Waterloo and a portal to the west of Dagenham Dock (similar to the location of the current CTRL portal) – the service would then run at surface level on two new tracks alongside the existing CTRL between the portal west of Dagenham Dock and a new portal in the vicinity of the northern approach to the Dartford road crossing, which would lead into a new underground section through West Thurrock and Grays before emerging at surface level in the vicinity of the aforementioned LTC Option C alignment proposed for use by the Grays Shuttle – the service would then use the same tracks as the Shuttle to reach the airport via Hoo Junction;
- New subterranean stations are assumed to be provided for the AEX connected to existing facilities at Waterloo, London Bridge and Canary Wharf as well as a new subterranean station at Barking Riverside.

4.3.3 Table 13 includes a summary of the rail proposals included in each of the four options identified above alongside those in the ITE proposals received by the AC for comparative purposes. The four options are illustrated graphically on the plans in Figures 35 to 38. It should be noted that the plans are indicative only and more detailed consideration and planning is required to determine route alignments and service configurations.

Table 13: Summary of rail schemes included in Jacobs options and ITE proposals received by the AC

Scheme	Jacobs options				ITE proposals			
	1	2	3	4	Mayor of London	Foster + Partners	Metrotidal Tunnel and Thames Reach Airport Ltd (MTTRA)	Independent Aviation Advisory Group (IAAG)
HS1 spur	✓	✓	✓	✓	✓	✓	✓	✓
Waterloo semi-fast service		✓	✓	✓		✓	✓	✓
Crossrail southern branch extension	✓	✓	✓	✓	✓	✓	✓	
AEX service from Waterloo, London Bridge, Canary Wharf and Barking Riverside				✓	✓			
National rail connections to Fenchurch Street line	✓	✓	✓	✓	✓	✓		✓
National rail connections to North Kent line	✓	✓	✓	✓	✓	✓		✓
Crossrail northern branch extension			✓			✓	✓	
HS1-HS2 link					✓	✓	✓	
HS3 link to north and Europe							✓	
Reading link via Bromley South						✓		
Milton Keynes link via Watford						✓		
Regional connections to Woking, Brighton, Ipswich, Stansted, Stevenage and Watford							✓	
Semi-fast services to Liverpool Street, Victoria and London Bridge							✓	✓
Connections to Charing Cross and Clapham Junction								✓

Figure 35: ITE Airport rail access – Option 1

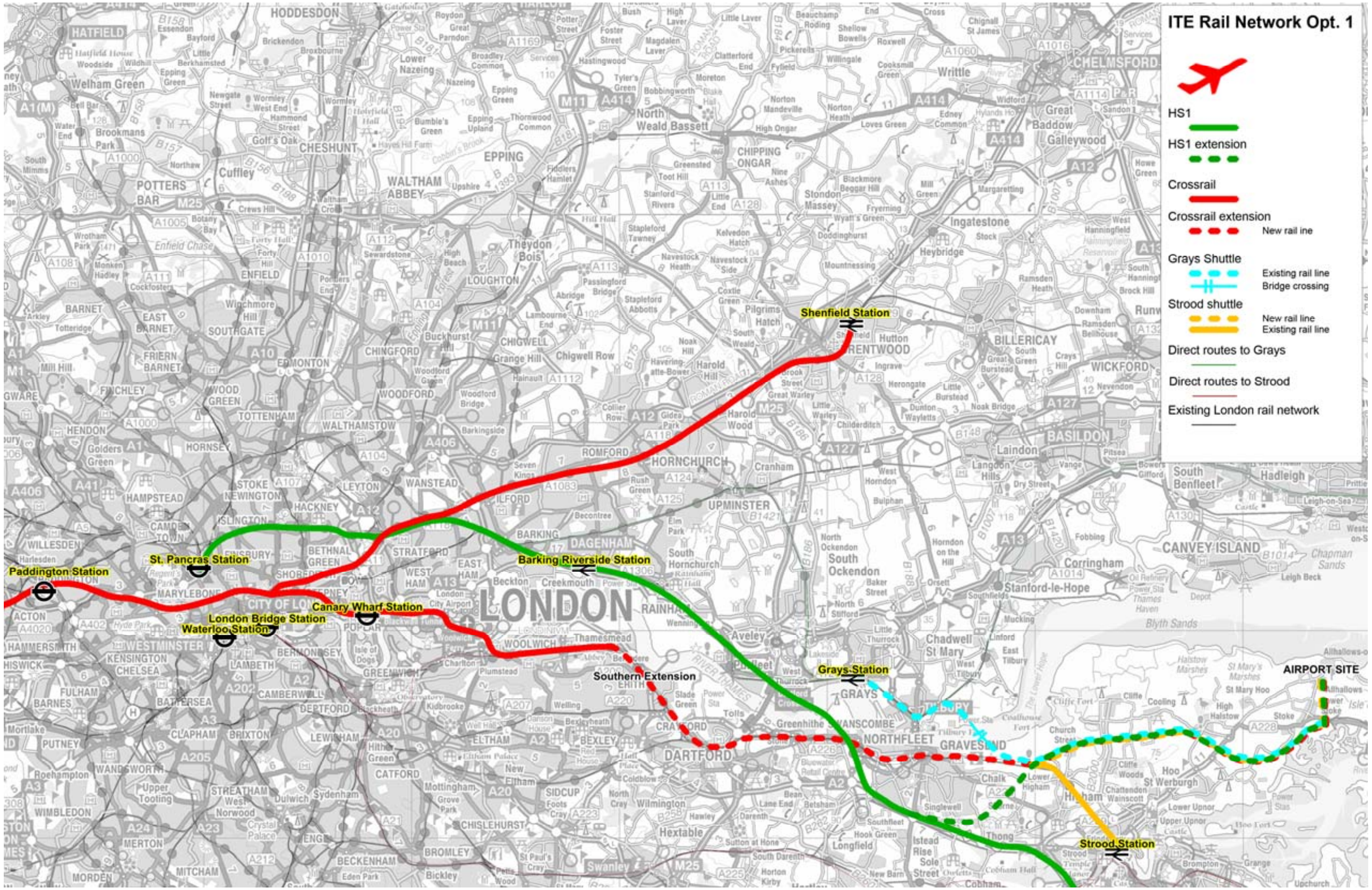


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Figure 36: ITE Airport rail access – Option 2

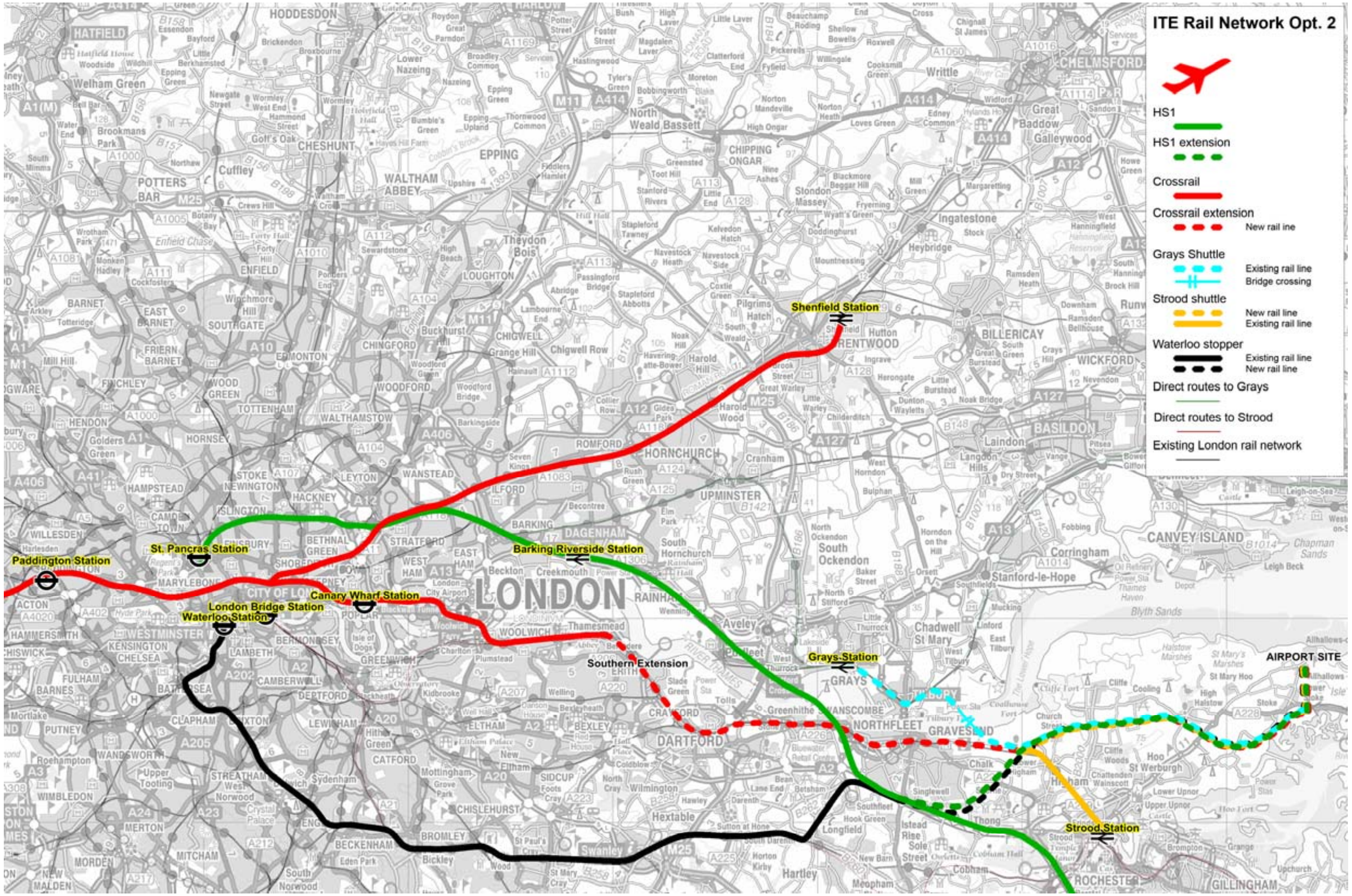

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Figure 37: ITE Airport rail access – Option 3

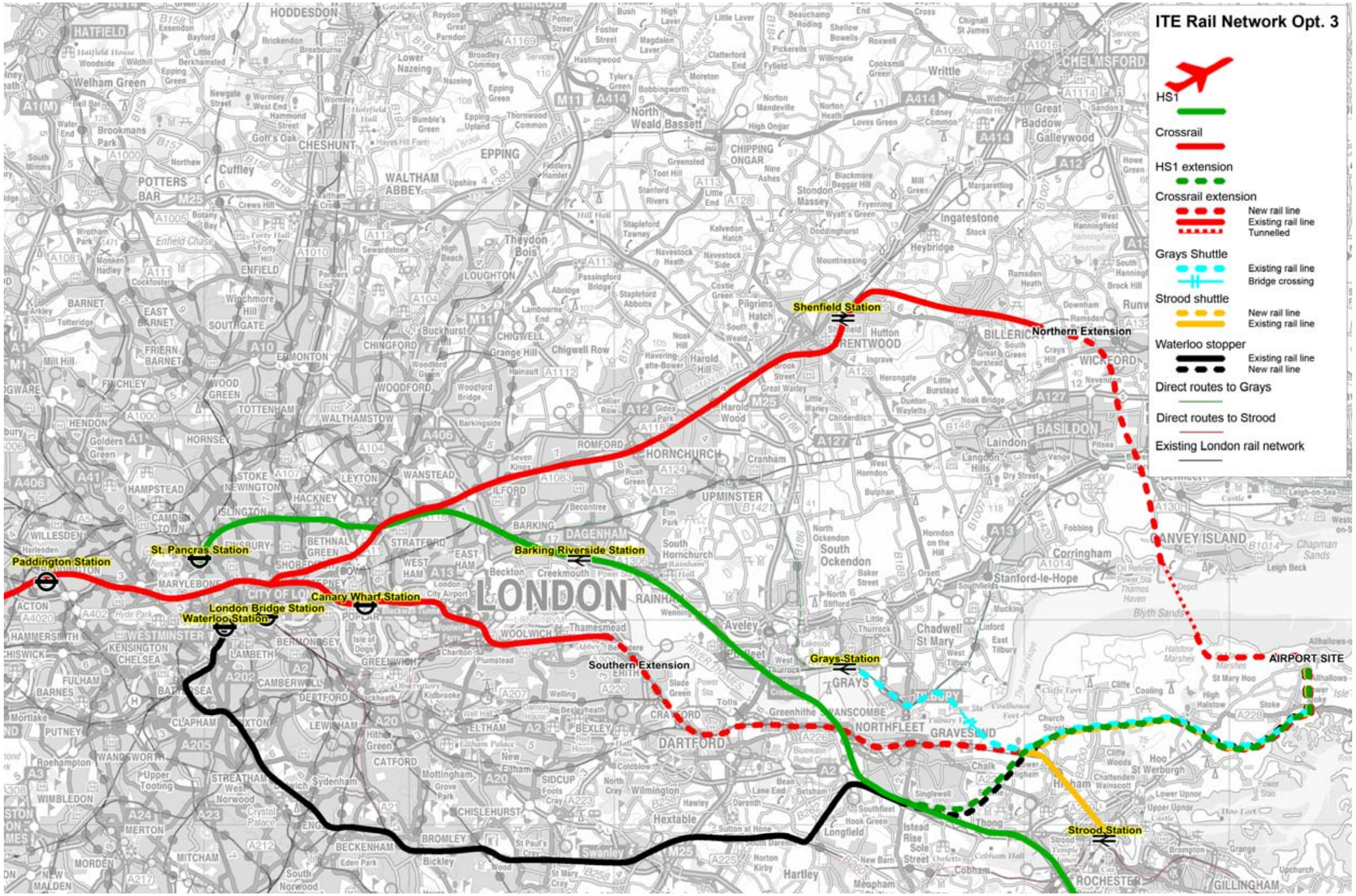

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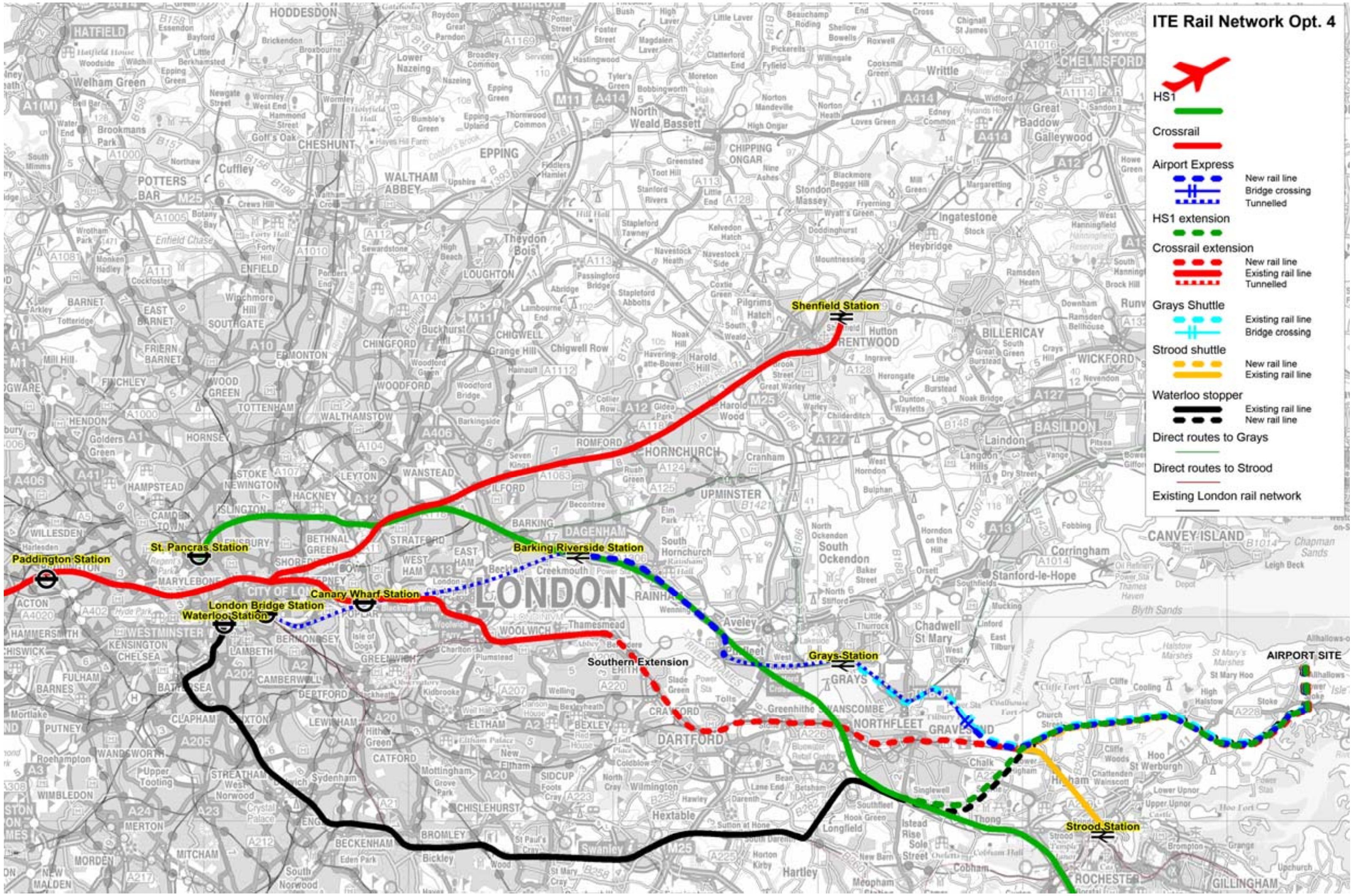
Figure 38: ITE Airport rail access – Option 4



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4.4 Forecasting assumptions

ITE logit model inputs and parameters

4.4.1 GC to the ITE airport was calculated for each rail option described above using the same approach as that applied to Heathrow rail options for the base logit model. Analysis was undertaken at district level in London, Kent and Essex using similar representative stations to those identified for the development of the base model while for other regions in the UK, a representative district and associated station was identified to reduce the number of GC inputs required.

4.4.2 A number of key inputs for the ITE GC calculations should be noted as follows:

- Passengers boarding Crossrail services from central London stations were assumed to wait for a southern branch train due to the shorter in-train time in Options 3 and 4 when compared with the northern branch – 12 trains per hour were assumed on each branch and in-train times were estimated based on information provided on the Crossrail website;
    - it should be noted that for the purposes of this study it was assumed that all 12 trains on the southern branch of Crossrail would serve the airport in Options 1, 2 and 4 while in Option 3 all 12 trains on both branches would do the same – this is higher than the estimated number of Crossrail trains that will serve Heathrow once the line is operational, but was assumed necessary for the ITE since in the rail options tested Crossrail would be the primary 'non-express' rail service to the airport (similar to the Piccadilly Line at Heathrow) – in addition, it was assumed that the airport station would be on the main Crossrail branchline in each option, rather than on a dedicated spur, as will be the case for the Heathrow service;
- 4 trains per hour were assumed on HS1 and AEX services, and journey times were estimated based on discussions with Network Rail – it should be noted that HS1 Ltd have stated that 4tph may not be available for the ITE airport service, based on assumptions of a pratical line capacity of 12-13tph, a current operating pattern of 7tph and assuming that other new serices (both international and domestic) may take up the available train paths – however, we have consulted with contacts in the rail industry who have suggested that that it should be feasible to cater for 4tph for the ITE airport service based on a combination of increasing line capacity to around 16-18tph and making reasonable assumptions that not all the available train paths will be taken up by additional international or domestic services;
- All fares were based on current values and no attempt was made to account for changes in fare up to 2030 or 2050 – it is acknowledged that DfT WebTAG values of time for rail passengers are forecast to increase by just over 40% between 2012 and 2030 and that if this increase was applied in the model in isolation it would lead to increased mode share forecasts for premium services such as HS1 and the AEX – however, if the government's current policy of capping annual rail fare rises at the Retail Price Index (RPI) + 1% is maintained over the same time period, this would lead to a rise of close to 40% in the real value of rail fares based on the DfT's preferred measure of inflation (the ONS GDP deflator, which is typically lower than the RPI) – in the context of the demand model developed for this study, such a rise in real rail fares would cancel out to a significant degree the impact of the increasing values of time and lead to a similar mode share forecast produced using current fares and values of time – it should be noted that if the previous government's policy of capping fares at RPI + 3% was restored and applied in the model, this would transfer demand away from premium services to standard National Rail services and Crossrail;
- The airport was assumed to be located in Zone 9 as this allowed fares for standard rail and tube trips in London to be estimated from existing data – Crossrail passengers were assumed to pay for standard tickets the same as tube passengers;
- Rail fares from Kent and Essex to Strood and Grays were estimated using current fares to those stations, with a Zone 7-9 oyster ticket cost added for use of the shuttle services (a current Oyster peak single costs £1.70);

- HS1 and AEX fares were estimated based on analysis of HEX and GEX costs, accounting for likely cost-per-km savings due to the additional journey distance from central London to the ITE;
- Taxi was only considered as a viable secondary mode for HS1 and AEX services, in the same way that it was only a viable secondary mode for HEX in the base model.

4.4.3 The same parameters calibrated for Heathrow rail mode share in the base model were applied to the inputs described above to calculate GC estimates. This included the in-vehicle comfort factors, wait and interchange time penalties, and Mode Constants – the exception to this was the Heathrow Connect Mode Constant due to the lack of a comparable service to the ITE in any of the options. Crossrail was assumed to have a similar comfort factor as tube services.

Background rail assumptions

4.4.4 GC assumptions for rail trips were also developed with reference to the Core and Extended Baselines provided by the AC, which are detailed in Appendix A. Following a review of the rail schemes included in both baselines, it was decided that only two were likely to have a significant impact on rail mode choice to the ITE airport as secondary connecting rail modes – Crossrail 2 and the Thameslink 2018 programme (Crossrail is listed as a core baseline scheme but was assumed as a primary rail mode in the option packages). As a result, GC estimates accounted for the likely impact of these two schemes on rail frequencies, journey times and the number of interchanges required to use each final rail option identified in each package. These impacts were informed by discussions with Network Rail.

4.4.5 Since Crossrail 2 was included in the AC's extended baseline rather than its core baseline, the central scenario tested for rail as part of this study can therefore be considered to be an extended baseline scenario. A sensitivity test was also run to assess rail mode share to an airport in the ITE without Crossrail 2 in place in 2030, as there is currently some uncertainty that the scheme would be in place by the 2030 airport opening year if it is progressed.

4.4.6 All other baseline schemes affecting the network outside London were judged unlikely to have a significant impact on final rail mode choice to the airport, as they would not generally impact on the passenger arrival terminus in London. These schemes included HS2 following the decision to abandon a proposed HS2-HS1 spur as part of the core HS2 scheme, meaning that passengers from Birmingham and Manchester would still arrive at Euston as they do on current services. If an HS1-HS2 spur had been included in the baseline this conversely would likely impact on mode choice to an airport in the ITE for rail trips arriving from the north.

4.4.7 A number of other major London rail schemes were listed in the extended baseline including the Bakerloo line southern extension, Overground Gospel Oak to Barking Riverside, DLR extensions to Catford and Bromley, and the Northern Line extension to Nine Elms and Battersea. It was assumed that these would only impact on some local mode choices and would not make a significant difference to the overall mode share calculations, and so they were not referenced in GC calculations.

4.5 Forecast rail mode share

4.5.1 The inputs and assumptions described above resulted in the forecast rail mode shares for the four options both to and from the airport in Table 14 and Table 15 – GC inputs and assumptions were fixed for both 2030 and 2050 and the mode shares calculated are the same for both years as a result. The discrepancy in mode share between the tables is due to the higher tidal flow of employees to the airport in the AM peak - employee trip origins are clustered around the airport with high proportions in Kent and Essex, and these trips predominantly use National Rail services, which explains the higher mode share assigned to these services for rail trips to the airport when compared with rail trips from the airport.

Table 14: Overall forecast rail mode share to ITE Airport

Rail mode	Option 1	Option 2	Option 3	Option 4
HS1	31%	26%	25%	19%
AEX	0%	0%	0%	22%
Crossrail	42%	36%	40%	28%
National Rail	27%	39%	35%	31%
- North Kent Lines	*14%*	*12%*	*12%*	*10%*
- South Essex Lines	*13%*	*13%*	*9%*	*10%*
- Waterloo Stopper	*0%*	*14%*	*14%*	*10%*
TOTAL	**100%**	**100%**	**100%**	**100%**

Table 15: Overall forecast rail mode share from ITE Airport

Rail mode	Option 1	Option 2	Option 3	Option 4
HS1	39%	33%	33%	25%
AEX	0%	0%	0%	25%
Crossrail	45%	37%	38%	27%
National Rail	16%	30%	30%	23%
- North Kent Lines	*11%*	*9%*	*9%*	*7%*
- South Essex Lines	*5%*	*5%*	*4%*	*4%*
- Waterloo Stopper	*0%*	*17%*	*17%*	*13%*
TOTAL	**100%**	**100%**	**100%**	**100%**

4.5.2 A key point to note with regard to the mode shares in the tables above is the broad similarity with the HEX mode share to Heathrow recorded during the 2012 CAA survey – this indicated that 32% of all rail passenger trips to the airport were made by HEX. It should also be noted that, as expected, the logit model is very sensitive to the assumed fares charged for express services, and changing the fares has a significant impact on the proportion of rail passengers using these services.

4.5.3 As stated previously, the sub-rail mode shares calculated for each option and summarised above are all based on a headline 40% rail mode share for passengers and 25% for employees. This and the assumptions regarding the level of rail ‘meet and greet’ demand resulted in an overall forecast of 4,382 rail trips to the airport and 3,061 from the airport in the peak hour in 2030, rising to 6,129 trips to and 4,298 trips from in 2050.

4.5.4 This means for example that the forecast number of trips using Crossrail as a mode to and from the airport is highest in Option 1 at over 1,800 trips to the airport and over 1,300 from it in 2030, rising to over 2,600 to and over 1,900 from in 2050. Similarly, forecast demand on HS1 is also highest in Option 1 at over 1,300 to and over 1,200 from in 2030, rising to over 1,800 to and 1,700 from in 2050.

4.5.5 The aforementioned sensitivity test without Crossrail 2 in place changed these mode share estimates very little, as shown in Table 16 and Table 17 below, since it only directly affects rail trips from a relatively small number of districts in south-west and north-east London. The main noticeable change is a very marginal reduction in HS1 mode share in some options due to the improved access to King’s Cross/St. Pancras station provided by Crossrail 2 from certain districts in the main scenarios.

Table 16: Overall forecast rail mode share to ITE Airport (sensitivity test excluding Crossrail 2)

Rail mode	Option 1	Option 2	Option 3	Option 4
HS1	30%	25%	25%	19%
AEX	0%	0%	0%	22%
Crossrail	43%	36%	40%	28%
National Rail	27%	39%	35%	31%
- North Kent Lines	*14%*	*12%*	*12%*	*10%*
- South Essex Lines	*13%*	*13%*	*9%*	*10%*
- Waterloo Stopper	*0%*	*14%*	*14%*	*11%*
TOTAL	**100%**	**100%**	**100%**	**100%**

Table 17: Overall forecast rail mode share to ITE Airport (sensitivity test excluding Crossrail 2)

Rail mode	Option 1	Option 2	Option 3	Option 4
HS1	39%	32%	32%	24%
AEX	0%	0%	0%	25%
Crossrail	45%	37%	37%	27%
National Rail	16%	31%	30%	23%
- North Kent Lines	11%	9%	9%	7%
- South Essex Lines	5%	5%	4%	4%
- Waterloo Stopper	0%	17%	17%	13%
TOTAL	**100%**	**100%**	**100%**	**100%**

4.6 Rail capacity analysis

4.6.1 The rail demand forecasts derived from the mode shares for the extended baseline scenario including Crossrail 2 summarised above were then allocated to rail corridors based on information about the components of the rail journeys used to calculate GC in the model. Airport-related rail demand by corridor was then compared with estimates of rail capacity and background demand in 2030 and 2050 for each option to identify potential issues. Table 18 and Table 19 below summarise the results of this process.

4.6.2 Train paths and capacities were defined following discussions with NR on the feasibility of operating the National Rail elements of each option, while Crossrail frequencies and capacities were sourced from information published on the Crossrail website[24].

4.6.3 In terms of background demand, TfL provided outputs from AM peak hour modelling for Crossrail in 2031 and 2041 – the 2031 data was assumed to be valid for 2030 while 2050 forecasts were derived through extrapolation. Peak line loadings were used for each section along with an assumption that 66% of background demand on the eastbound Core section of the line between Paddington and Liverpool Street would be on southern branch trains due to the impact of Canary Wharf. It should be noted that analysis to determine additional background demand arising from potential new stations in locations such as Dartford, Gravesend and Billericay was beyond the scope of this study and has not been included in the forecasts, although it is likely that this demand would constitute a small proportion of total line loadings.

[24] http://www.crossrail.co.uk/

4.6.4 For background demand on National Rail services, NR provided average peak hour estimates of capacity utilisation for existing proposed services in 2030 and 2050 based on analysis undertaken for the London & South East and Kent Route Utilisation Strategies (RUSs)[25]. In some cases, existing proposed services were used as proxies for new airport services that were not included in the RUS assumptions, notably in the case of the Waterloo semi-fast service via Bromley South and Swanley – in this case, forecast utilisation on fast services from Bromley South to Victoria were assumed to apply.

4.6.5 Background demand on rail services was estimated based on forecasts developed without an airport in place in the ITE and as a result, they do not account for potential extra capacity created as a result of adding airport-related services to existing assumed provision in the two future years. For example, if the Waterloo Stopper via Bromley South was provided on top of current assumed fast Kent services through Bromley South to Victoria this would create more capacity for non-airport passengers and may reduce average service utilisation). The provision of airport services in this way would depend on resolving key line utilisation issues and the associated increase in frequency would also likely induce some additional demand, but it may be reasonable to assume that the background demand estimates provided in the following tables represent conservative estimates as a result.

4.6.6 Conversely, another key point to bear in mind is that the analysis detailed in this report does not account for any additional journeys made on the network as a result of local indirect or induced employment or wider area catalytic growth from an ITE airport. As mentioned earlier in this report, the present level of uncertainty surrounding such forecasts means that they could not be accounted for in the analysis, but they would likely increase background rail demand in London and the South East to an undefined degree.

4.6.7 In general terms, since no modelling was undertaken to assess background demand on airport-related services, the numbers quoted in the tables should be treated as high-level and preliminary pending further analysis if the ITE is short-listed as a fourth potential option by the AC.

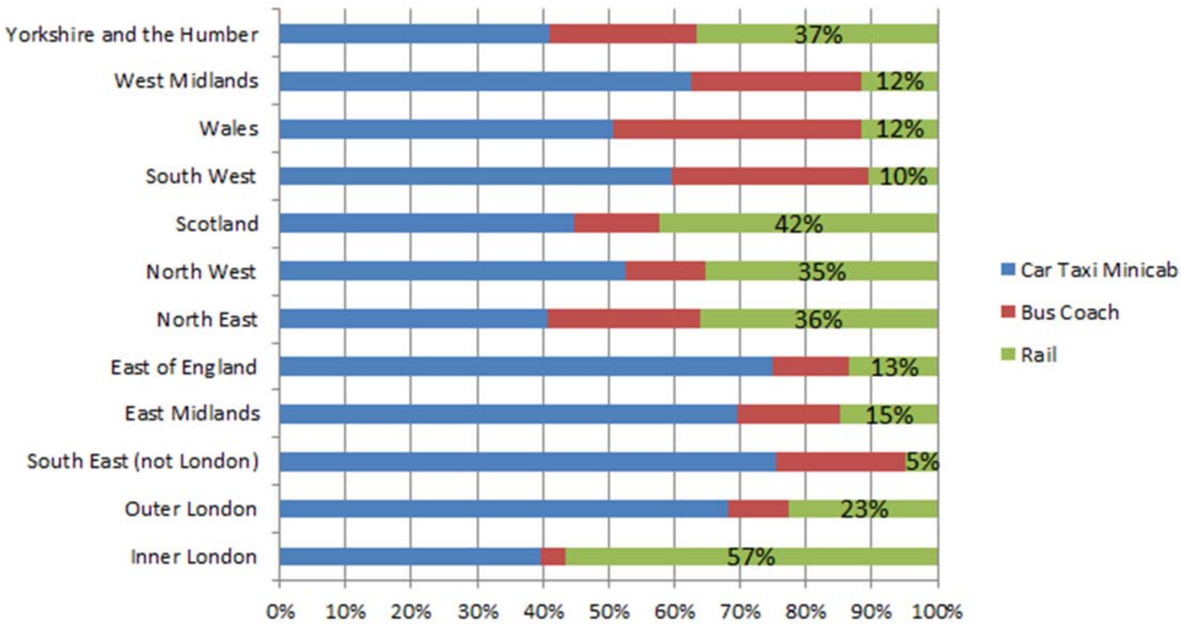
4.6.8 HS1 and AEX services were assumed to be dedicated for airport passengers only and no background demand was assumed to use these services.

4.6.9 A 2030 sensitivity test with a rail headline mode share of 60% has also been included for comparative purposes and is shown in Table 20. This test was developed by amending the observed Heathrow headline mode share by region (summarised in Figure 39) proportionally for the ITE until an overall rail target of 60% was established. The results of this process are illustrated in Figure 40 – a cap of 95% by rail was set for each region to account for the fact that a number of trips are always likely to be made by car.

4.6.10 The conclusion arising from the 60% rail sensitivity test is that achieving such an overall rail mode share with the options tested in this study would be extremely unlikely, since it would require an unrealistic rail mode share from many regions to compensate for high private transport mode share from others, notably South East England. Such a target may be hypothetically possible with the provision of additional direct rail services between the airport and regions outside London as identified in many of the ITE proposals received by the AC in December and May this year. However, as stated previously in this report, it is considered very unlikely that airport demand alone would make such services viable, and no evidence has been presented to suggest that there would be high background demand on these services.

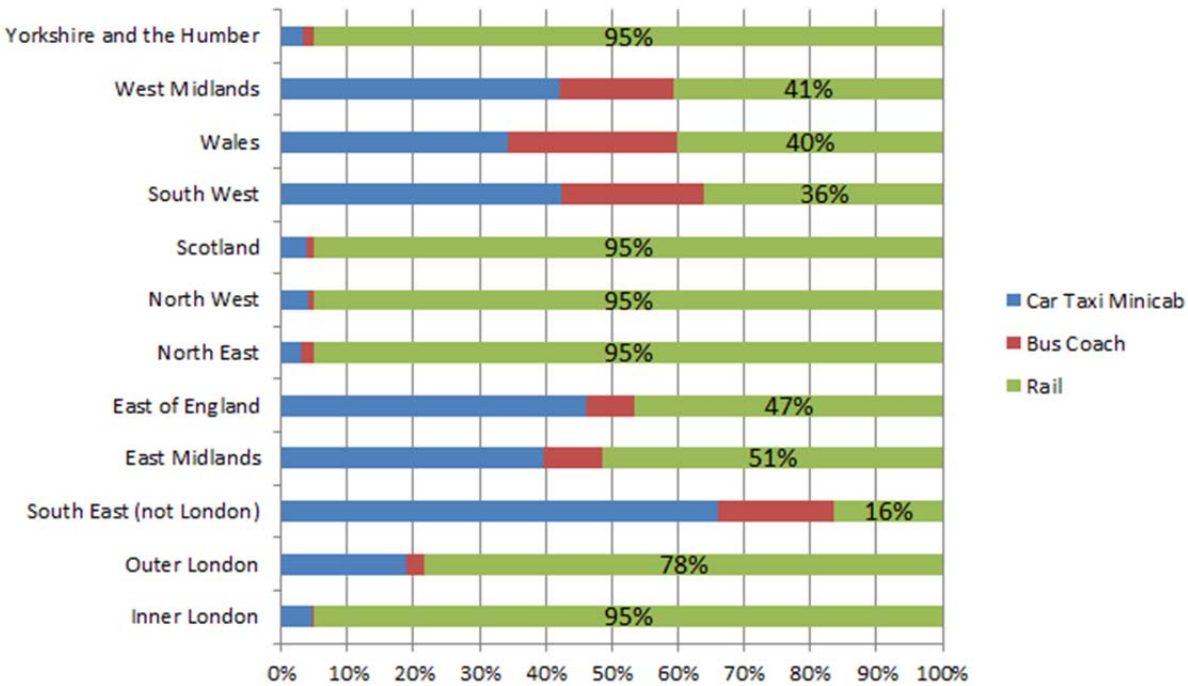
[25] http://www.networkrail.co.uk/aspx/4449.aspx

Figure 39: Observed Heathrow 2012 headline mode share by region



Source: CAA 2012 Heathrow passenger survey data

Figure 40: Assumed ITE 2030 headline mode share by region (60% rail mode share sensitivity test)



4.6.11 A second sensitivity test was also run to forecast the impact of increasing the overall employee numbers at the airport to include local indirect and induced employment as well as local direct on-airport and off-airport employees. The aforementioned 2011 Optimal Economics report indicated an estimate of 29,700 local indirect and induced jobs in 2030. When added to the local direct on- and off-airport job numbers this produced a total of 114,000 jobs. The results of this sensitivity test for rail are shown in Table 21, which indicates that the main impacts are, as you would expect, on standard rail connections via Grays and Strood.

4.6.12 In Option 1, forecast Volume/Capacity ratios (VCRs) for the Grays Shuttle to the airport increase from 52% in the main 2030 forecast to 67% while the Strood Shuttle the increase is from 53% to 62%. These impacts then dissipate across the network on local connections to both Strood and Grays, with the biggest impacts seen on trains from Southend and Rochester. In the case of the latter the higher employee numbers exacerbate the crowding issue identified in the main 2030 scenario with high background demand on trains passing through the Medway towns towards London. The higher employee numbers also add a small amount of additional demand on the already over-crowded Waterloo Stopper in Options 2, 3 and 4.

4.6.13 This sensitivity test clearly indicates that any significant increase in employee numbers at the airport will add to pressure on local rail connections. However, the results should be treated with some caution as the impact of local indirect and induced employment may not manifest itself in terms of an increase in commuting trips to and from the airport site, and may actually result in a bigger increase in local area trips where the airport is neither an origin or a destination. As mentioned previously, such impacts would need to be incorporated in the background passenger demand estimates provided by TfL and NR once development scenarios for the airport have been more clearly established.

Table 18: Summary rail capacity analysis for ITE options (2030)[26]

Line	Section (between)	Direction (related to ITE Airport)	*2030 capacity* Assumed train paths	Assumed number of cars (NR)	Train capacity	Hourly capacity	2030 background passengers	2030 background V/C	Background pax notes	ITE airport rail forecast flows Op 1 (Do Min)	Op 2	Op 3	Op 4	ITE airport + background rail forecast V/C Op 1 (Do Min)	Op 2	Op 3	Op 4
HS1	All	To	4		700	2,800	0	0%		1,341	1,120	1,112	841	48%	40%	40%	30%
HS1	All	From	4		700	2,800	0	0%		1,208	1,009	1,006	751	43%	36%	36%	27%
AEX	All (London Riverside-Airport)	To	4		700	2,800	0	0%					947				34%
AEX	All (London Riverside-Airport)	From	4		700	2,800	0	0%					762				27%
Crossrail South	Core (Paddington-Liverpool Street)	To	12		1,417	17,000	14,750	87%	Peak link Padd-Bond St - assumed 66% on southern trains branch to get to CW (east of Whitechapel split used)	1,116	894	897	702	93%	92%	92%	91%
Crossrail South	Liverpool Street-Canary Wharf	To	12		1,417	17,000	10,000	59%		1,326	1,082	1,030	853	67%	65%	65%	64%
Crossrail South	Canary Wharf-Airport	To	12		1,417	17,000	2,500	15%		1,861	1,571	1,492	1,240	26%	24%	23%	22%
Crossrail South	Core (Paddington-Liverpool Street)	From	12		1,417	17,000				979	789	791	616				
Crossrail South	Liverpool Street-Canary Wharf	From	12		1,417	17,000			No background demand data provided by TfL	1,084	882	868	688				
Crossrail South	Canary Wharf-Airport	From	12		1,417	17,000				1,363	1,122	1,093	842				
Crossrail North	Stratford-Airport	To	12		1,417	17,000	3,000	18%	No figures provided east of Stratford so link to west of Stratford used			249				19%	
Crossrail North	Stratford-Airport	From	12		1,417	17,000			No background demand data provided by TfL			57					
North Kent Line (Strood Shuttle)	All	To	4	4	280	1,120	0	0%		594	518	518	449	53%	46%	46%	40%
North Kent Line (East of ITE)	Rochester-Strood	To	4	12	840	3,360	3,024	90%	Av utilisation of 90% (NR)	214	214	214	210	96%	96%	96%	96%
North Kent Line (West of ITE)	Swanley-Strood	To	4	12	840	3,360	1,764	53%	Assumed 50% of Up direction	209	160	160	127	59%	57%	57%	56%
North Kent Line (South of ITE)	Maidstone-Strood	To	4	6	420	1,680	840	50%	Av utilisation of 50% (NR)	32	32	32	29	52%	52%	52%	52%
North Kent Line (NW of ITE)	Dartford-Strood	To	4	12	840	3,360	1,260	38%	*Assumed 50% of Up direction*	140	112	112	83	42%	41%	41%	40%
North Kent Line (Strood Shuttle)	All	From	4	4	280	1,120	0	0%		332	270	270	212	30%	24%	24%	19%
North Kent Line (East of ITE)	Rochester-Strood	From	4	12	840	3,360	1,512	45%	*Assumed 50% of Up direction*	28	28	28	28	46%	46%	46%	46%
North Kent Line (West of ITE)	Swanley-Strood	From	4	12	840	3,360	3,528	105%	Av utilisation of 105% (NR)	182	143	143	112	110%	109%	109%	108%
North Kent Line (South of ITE)	Maidstone-Strood	From	4	6	420	1,680	420	25%	*Assumed 50% of Up direction*	6	6	6	6	25%	25%	25%	25%
North Kent Line (NW of ITE)	Dartford-Strood	From	4	12	840	3,360	2,520	75%	Av utilisation of 75% (NR)	115	92	92	67	78%	78%	78%	77%
South Essex Line (Grays Shuttle)	All	To	4	4	280	1,120	0	0%		586	568	408	445	52%	51%	36%	40%
South Essex Line (East of Grays)	Southend-Grays	To	4	12	840	3,360	1,512	45%	Av utilisation of 45% (NR)	393	393	243	311	57%	57%	52%	54%
South Essex Line (West of Grays)	Fenchurch St-Grays	To	4	12	840	3,360	1,512	45%	*Assumed 50% of Up direction*	152	134	127	97	50%	49%	49%	48%
South Essex Line (Grays Shuttle)	All	From	4	4	280	1,120	0	0%		158	146	122	107	14%	13%	11%	10%
South Essex Line (East of Grays)	Southend-Grays	From	4	12	840	3,360	756	23%	*Assumed 50% of Up direction*	54	54	33	42	24%	24%	23%	24%
South Essex Line (West of Grays)	Fenchurch St-Grays	From	4	12	840	3,360	3,024	90%	Av utilisation of 90% (NR)	98	86	83	60	93%	93%	92%	92%
Waterloo stopper	Waterloo-Bromley South	To	2	12	840	1,680	966	58%	*Assumed 50% of Up direction*		563	560	425		91%	91%	83%
Waterloo stopper	Bromley South-Swanley	To	2	12	840	1,680	882	53%	*Assumed 50% of Up direction*		605	602	460		89%	88%	80%
Waterloo stopper	Swanley-Airport	To	2	12	840	1,680	756	45%	*Assumed 50% of Up direction*		605	602	460		81%	81%	72%
Waterloo stopper	Waterloo-Bromley South	From	2	12	840	1,680	1,932	115%	Av utilisation of 115% (NR)		482	481	361		144%	144%	136%
Waterloo stopper	Bromley South-Swanley	From	2	12	840	1,680	1,764	105%	Av utilisation of 105% (NR)		514	513	387		136%	136%	128%
Waterloo stopper	Swanley-Airport	From	2	12	840	1,680	1,512	90%	Av utilisation of 90% (NR)		514	513	387		121%	121%	113%

Sources: Background demand, train capacities and service frequency for Crossrail provided by TfL; background demand estimates (average capacity utilisation per train service in the AM peak hour) for National Rail services provided by Network Rail

[26] Background demand for Crossrail the subject of on-going discussions with TfL

Table 19: Summary rail capacity analysis for ITE options (2050)[27]

Line	Section (between)	Direction (related to ITE Airport)	2050 capacity: Assumed train paths	2050 capacity: Assumed number of cars (NR)	2050 capacity: Train capacity	2050 capacity: Hourly capacity	2050 background passengers	2050 background V/C	Background pax notes	ITE airport rail forecast flows: Op 1 (Do Min)	ITE airport rail forecast flows: Op 2	ITE airport rail forecast flows: Op 3	ITE airport rail forecast flows: Op 4	ITE airport + background rail forecast V/C: Op 1 (Do Min)	ITE airport + background rail forecast V/C: Op 2	ITE airport + background rail forecast V/C: Op 3	ITE airport + background rail forecast V/C: Op 4
HS1	All	To	4		700	2,800	0	0%		1,884	1,575	1,564	1,182	67%	56%	56%	42%
HS1	All	From	4		700	2,800	0	0%		1,700	1,420	1,416	1,057	61%	51%	51%	38%
AEX	All (London Riverside-Airport)	To	4		700	2,800	0	0%					1,331				48%
AEX	All (London Riverside-Airport)	From	4		700	2,800	0	0%					1,074				38%
Crossrail South	Core (Paddington-Liverpool Street)	To	12		1,417	17,000	17,967	106%	Peak link Padd-Bond St - assumed 66% on southern trains branch to get to CW (east of Whitechapel split used)	1,557	1,248	1,251	979	115%	113%	113%	111%
Crossrail South	Liverpool Street-Canary Wharf	To	12		1,417	17,000	13,067	77%		1,851	1,512	1,439	1,191	88%	86%	85%	84%
Crossrail South	Canary Wharf-Airport	To	12		1,417	17,000	2,722	16%		2,604	2,198	2,087	1,731	31%	29%	28%	26%
Crossrail South	Core (Paddington-Liverpool Street)	From	12		1,417	17,000			No background demand data provided by TfL	1,368	1,103	1,106	861				
Crossrail South	Liverpool Street-Canary Wharf	From	12		1,417	17,000				1,516	1,234	1,214	962				
Crossrail South	Canary Wharf-Airport	From	12		1,417	17,000				1,913	1,576	1,535	1,180				
Crossrail North	Stratford-Airport	To	12		1,417	17,000	3,811	22%	No figures provided east of Stratford so link to west of Stratford used			316				24%	
Crossrail North	Stratford-Airport	From	12		1,417	17,000			No background demand data provided by TfL			76					
North Kent Line (Strood Shuttle)	All	To	4	4	280	1,120	0	0%		823	717	717	621	73%	64%	64%	55%
North Kent Line (East of ITE)	Rochester-Strood	To	4	12	840	3,360	3,696	110%	Av utilisation of 110% (NR)	293	293	293	288	119%	119%	119%	119%
North Kent Line (West of ITE)	Swanley-Strood	To	4	12	840	3,360	2,100	63%	*Assumed 50% of Up demand*	289	223	223	176	71%	69%	69%	68%
North Kent Line (South of ITE)	Maidstone-Strood	To	4	6	420	1,680	1,176	70%	Av utilisation of 70% (NR)	44	44	44	40	73%	73%	73%	72%
North Kent Line (NW of ITE)	Dartford-Strood	To	4	12	840	3,360	1,596	48%	*Assumed 50% of Up demand*	196	157	157	117	53%	52%	52%	51%
North Kent Line (Strood Shuttle)	All	From	4	4	280	1,120	0	0%		463	375	375	295	41%	34%	34%	26%
North Kent Line (East of ITE)	Rochester-Strood	From	4	12	840	3,360	1,848	55%	*Assumed 50% of Up demand*	38	38	38	37	56%	56%	56%	56%
North Kent Line (West of ITE)	Swanley-Strood	From	4	12	840	3,360	4,200	125%	Av utilisation of 125% (NR)	254	199	199	156	133%	131%	131%	130%
North Kent Line (South of ITE)	Maidstone-Strood	From	4	6	420	1,680	588	35%	*Assumed 50% of Up demand*	8	8	8	7	36%	36%	36%	35%
North Kent Line (NW of ITE)	Dartford-Strood	From	4	12	840	3,360	3,192	95%	Av utilisation of 95% (NR)	162	129	129	94	100%	99%	99%	98%
South Essex Line (Grays Shuttle)	All	To	4	4	280	1,120	0	0%		819	793	602	622	73%	71%	54%	56%
South Essex Line (East of Grays)	Southend-Grays	To	4	12	840	3,360	2,184	65%	Av utilisation of 65% (NR)	541	541	362	428	81%	81%	76%	78%
South Essex Line (West of Grays)	Fenchurch St-Grays	To	4	12	840	3,360	1,848	55%	*Assumed 50% of Up demand*	216	190	181	137	61%	61%	60%	59%
South Essex Line (Grays Shuttle)	All	From	4	4	280	1,120	0	0%		222	205	176	151	20%	18%	16%	13%
South Essex Line (East of Grays)	Southend-Grays	From	4	12	840	3,360	1,092	33%	*Assumed 50% of Up demand*	74	74	49	58	35%	35%	34%	34%
South Essex Line (West of Grays)	Fenchurch St-Grays	From	4	12	840	3,360	3,696	110%	Av utilisation of 110% (NR)	139	122	118	84	114%	114%	114%	113%
Waterloo stopper	Waterloo-Bromley South	To	2	12	840	1,680	1,176	70%	*Assumed 50% of Up demand*		787	784	594		117%	117%	105%
Waterloo stopper	Bromley South-Swanley	To	2	12	840	1,680	1,050	63%	*Assumed 50% of Up demand*		847	843	643		113%	113%	101%
Waterloo stopper	Swanley-Airport	To	2	12	840	1,680	924	55%	*Assumed 50% of Up demand*		847	843	643		105%	105%	93%
Waterloo stopper	Waterloo-Bromley South	From	2	12	840	1,680	2,352	140%	Av utilisation of 140% (NR)		676	674	505		180%	180%	170%
Waterloo stopper	Bromley South-Swanley	From	2	12	840	1,680	2,100	125%	Av utilisation of 125% (NR)		722	719	542		168%	168%	157%
Waterloo stopper	Swanley-Airport	From	2	12	840	1,680	1,848	110%	Av utilisation of 110% (NR)		722	719	542		153%	153%	142%

[27] Background demand for Crossrail the subject of on-going discussions with TfL

Table 20: Sensitivity test - summary rail capacity analysis for ITE options (60% headline rail mode share scenario - 2030)[28]

Line	Section (between)	Direction (related to ITE Airport)	2030 capacity: Assumed train paths	Assumed number of cars (NR)	Train capacity	Hourly capacity	2030 background passengers	2030 background V/C	Background pax notes	ITE airport rail forecast flows: Op 1 (Do Min)	Op 2	Op 3	Op 4	ITE airport + background rail forecast V/C: Op 1 (Do Min)	Op 2	Op 3	Op 4
HS1	All	To	4		700	2,800	0	0%		1,823	1,519	1,508	1,153	65%	54%	54%	41%
HS1	All	From	4		700	2,800	0	0%		1,690	1,407	1,402	1,063	60%	50%	50%	38%
AEX	All (London Riverside-Airport)	To	4		700	2,800	0	0%					1,247				45%
AEX	All (London Riverside-Airport)	From	4		700	2,800	0	0%					1,062				38%
Crossrail South	Core (Paddington-Liverpool Street)	To	12		1,417	17,000	14,750	87%	Peak link Padd-Bond St - assumed 66% on southern trains branch to get to CW (east of Whitechapel split used)	1,688	1,348	1,351	1,069	97%	95%	95%	93%
Crossrail South	Liverpool Street-Canary Wharf	To	12		1,417	17,000	10,000	59%		1,979	1,607	1,538	1,277	70%	68%	68%	66%
Crossrail South	Canary Wharf-Airport	To	12		1,417	17,000	2,500	15%		2,588	2,161	2,048	1,712	30%	27%	27%	25%
Crossrail South	Core (Paddington-Liverpool Street)	From	12		1,417	17,000			No background demand data provided by TfL	1,551	1,243	1,245	983				
Crossrail South	Liverpool Street-Canary Wharf	From	12		1,417	17,000				1,738	1,407	1,376	1,112				
Crossrail South	Canary Wharf-Airport	From	12		1,417	17,000				2,089	1,712	1,649	1,314				
Crossrail North	Stratford-Airport	To	12		1,417	17,000	3,000	18%	No figures provided east of Stratford so link to west of Stratford used			302				19%	
Crossrail North	Stratford-Airport	From	12		1,417	17,000			No background demand data provided by TfL			110					
North Kent Line (Strood Shuttle)	All	To	4	4	280	1,120	0	0%		762	649	649	557	68%	58%	58%	50%
North Kent Line (East of IoG)	Rochester-Strood	To	4	12	840	3,360	3,024	90%	Av utilisation of 90% (NR)	229	229	229	224	97%	97%	97%	97%
North Kent Line (West of IoG)	Swanley-Strood	To	4	12	840	3,360	1,764	53%	Assumed 50% of Up direction	296	224	224	180	61%	59%	59%	58%
North Kent Line (South of IoG)	Maidstone-Strood	To	4	6	420	1,680	840	50%	Av utilisation of 50% (NR)	38	38	38	33	52%	52%	52%	52%
North Kent Line (NW of IoG)	Dartford-Strood	To	4	12	840	3,360	1,260	38%	*Assumed 50% of Up direction*	199	159	159	120	43%	42%	42%	41%
North Kent Line (Strood Shuttle)	All	From	4	4	280	1,120	0	0%		500	401	401	320	45%	36%	36%	29%
North Kent Line (East of IoG)	Rochester-Strood	From	4	12	840	3,360	1,512	45%	*Assumed 50% of Up direction*	44	44	44	42	46%	46%	46%	46%
North Kent Line (West of IoG)	Swanley-Strood	From	4	12	840	3,360	3,528	105%	Av utilisation of 105% (NR)	270	207	207	165	113%	111%	111%	110%
North Kent Line (South of IoG)	Maidstone-Strood	From	4	6	420	1,680	420	25%	*Assumed 50% of Up direction*	12	12	12	10	26%	26%	26%	26%
North Kent Line (NW of IoG)	Dartford-Strood	From	4	12	840	3,360	2,520	75%	Av utilisation of 75% (NR)	175	139	139	103	80%	79%	79%	78%
South Essex Line (Grays Shuttle)	All	To	4	4	280	1,120	0	0%		678	653	479	510	61%	58%	43%	46%
South Essex Line (East of Grays)	Southend-Grays	To	4	12	840	3,360	1,512	45%	Av utilisation of 45% (NR)	423	423	261	335	58%	58%	53%	55%
South Essex Line (West of Grays)	Fenchurch St-Grays	To	4	12	840	3,360	1,512	45%	*Assumed 50% of Up direction*	211	185	175	135	51%	51%	50%	49%
South Essex Line (Grays Shuttle)	All	From	4	4	280	1,120	0	0%		251	231	192	172	22%	21%	17%	15%
South Essex Line (East of Grays)	Southend-Grays	From	4	12	840	3,360	756	23%	*Assumed 50% of Up direction*	84	84	52	65	25%	25%	24%	24%
South Essex Line (West of Grays)	Fenchurch St-Grays	From	4	12	840	3,360	3,024	90%	Av utilisation of 90% (NR)	157	137	131	97	95%	94%	94%	93%
Waterloo stopper	Waterloo-Bromley South	To	2	12	840	1,680	966	58%	*Assumed 50% of Up direction*		808	804	618		106%	105%	94%
Waterloo stopper	Bromley South-Swanley	To	2	12	840	1,680	882	53%	*Assumed 50% of Up direction*		869	865	671		104%	104%	92%
Waterloo stopper	Swanley-Airport	To	2	12	840	1,680	756	45%	*Assumed 50% of Up direction*		869	865	671		97%	96%	85%
Waterloo stopper	Waterloo-Bromley South	From	2	12	840	1,680	1,932	115%	Av utilisation of 115% (NR)		727	724	554		158%	158%	148%
Waterloo stopper	Bromley South-Swanley	From	2	12	840	1,680	1,764	105%	Av utilisation of 105% (NR)		778	775	598		151%	151%	141%
Waterloo stopper	Swanley-Airport	From	2	12	840	1,680	1,512	90%	Av utilisation of 90% (NR)		778	775	598		136%	136%	126%

[28] Background demand for Crossrail the subject of on-going discussions with TfL

Table 21: Sensitivity test - summary rail capacity analysis for ITE options (including local indirect and induced employment - 2030)

Line	Section (between)	Direction (related to ITE Airport)	2030 capacity: Assumed train paths	Assumed number of cars (NR)	Train capacity	Hourly capacity	2030 background passengers	2030 background V/C	Background pax notes	ITE airport rail forecast flows: Op 1 (Do Min)	Op 2	Op 3	Op 4	ITE airport + background rail forecast V/C: Op 1 (Do Min)	Op 2	Op 3	Op 4
HS1	All	To	4		700	2,800	0	0%		1,392	1,163	1,152	876	50%	42%	41%	31%
HS1	All	From	4		700	2,800	0	0%		1,212	1,012	1,009	754	43%	36%	36%	27%
AEX	All (London Riverside-Airport)	To	4		700	2,800	0	0%					1,018				36%
AEX	All (London Riverside-Airport)	From	4		700	2,800	0	0%					768				27%
Crossrail South	Core (Paddington-Liverpool Street)	To	12		1,417	17,000	14,750	87%	Peak link Padd-Bond St - assumed 66% on southern trains branch to get to CW (east of Whitechapel split used)	1,169	935	937	735	94%	92%	92%	91%
Crossrail South	Liverpool Street-Canary Wharf	To	12		1,417	17,000	10,000	59%		1,419	1,159	1,092	917	67%	66%	65%	64%
Crossrail South	Canary Wharf-Airport	To	12		1,417	17,000	2,500	15%		2,053	1,744	1,645	1,393	27%	25%	24%	23%
Crossrail South	Core (Paddington-Liverpool Street)	From	12		1,417	17,000			No background demand data provided by TfL	983	792	794	619				
Crossrail South	Liverpool Street-Canary Wharf	From	12		1,417	17,000				1,092	889	873	693				
Crossrail South	Canary Wharf-Airport	From	12		1,417	17,000				1,379	1,136	1,106	854				
Crossrail North	Stratford-Airport	To	12		1,417	17,000	3,000	18%	No figures provided east of Stratford so link to west of Stratford used			323				20%	
Crossrail North	Stratford-Airport	From	12		1,417	17,000			No background demand data provided by TfL			63					
North Kent Line (Strood Shuttle)	All	To	4	4	280	1,120	0	0%		695	614	614	540	62%	55%	55%	48%
North Kent Line (East of ITE)	Rochester-Strood	To	4	12	840	3,360	3,024	90%	Av utilisation of 90% (NR)	285	285	285	280	98%	98%	98%	98%
North Kent Line (West of ITE)	Swanley-Strood	To	4	12	840	3,360	1,764	53%	Assumed 50% of Up direction	219	167	167	133	59%	57%	57%	56%
North Kent Line (South of ITE)	Maidstone-Strood	To	4	6	420	1,680	840	50%	Av utilisation of 50% (NR)	42	42	42	38	53%	53%	53%	52%
North Kent Line (NW of ITE)	Dartford-Strood	To	4	12	840	3,360	1,260	38%	*Assumed 50% of Up direction*	149	119	119	90	42%	41%	41%	40%
North Kent Line (Strood Shuttle)	All	From	4	4	280	1,120	0	0%		341	278	278	220	30%	25%	25%	20%
North Kent Line (East of ITE)	Rochester-Strood	From	4	12	840	3,360	1,512	45%	*Assumed 50% of Up direction*	34	34	34	33	46%	46%	46%	46%
North Kent Line (West of ITE)	Swanley-Strood	From	4	12	840	3,360	3,528	105%	Av utilisation of 105% (NR)	183	144	144	113	110%	109%	109%	108%
North Kent Line (South of ITE)	Maidstone-Strood	From	4	6	420	1,680	420	25%	*Assumed 50% of Up direction*	7	7	7	6	25%	25%	25%	25%
North Kent Line (NW of ITE)	Dartford-Strood	From	4	12	840	3,360	2,520	75%	Av utilisation of 75% (NR)	116	92	92	67	78%	78%	78%	77%
South Essex Line (Grays Shuttle)	All	To	4	4	280	1,120	0	0%		751	730	518	575	67%	65%	46%	51%
South Essex Line (East of Grays)	Southend-Grays	To	4	12	840	3,360	1,512	45%	Av utilisation of 45% (NR)	524	524	323	415	61%	61%	55%	57%
South Essex Line (West of Grays)	Fenchurch St-Grays	To	4	12	840	3,360	1,512	45%	*Assumed 50% of Up direction*	173	152	144	111	50%	50%	49%	48%
South Essex Line (Grays Shuttle)	All	From	4	4	280	1,120	0	0%		172	160	131	118	15%	14%	12%	11%
South Essex Line (East of Grays)	Southend-Grays	From	4	12	840	3,360	756	23%	*Assumed 50% of Up direction*	65	65	40	51	24%	24%	24%	24%
South Essex Line (West of Grays)	Fenchurch St-Grays	From	4	12	840	3,360	3,024	90%	Av utilisation of 90% (NR)	100	88	85	61	93%	93%	93%	92%
Waterloo stopper	Waterloo-Bromley South	To	2	12	840	1,680	966	58%	*Assumed 50% of Up direction*		594	591	449		93%	93%	84%
Waterloo stopper	Bromley South-Swanley	To	2	12	840	1,680	882	53%	*Assumed 50% of Up direction*		640	637	488		91%	90%	82%
Waterloo stopper	Swanley-Airport	To	2	12	840	1,680	756	45%	*Assumed 50% of Up direction*		640	637	488		83%	83%	74%
Waterloo stopper	Waterloo-Bromley South	From	2	12	840	1,680	1,932	115%	Av utilisation of 115% (NR)		485	483	363		144%	144%	137%
Waterloo stopper	Bromley South-Swanley	From	2	12	840	1,680	1,764	105%	Av utilisation of 105% (NR)		517	516	389		136%	136%	128%
Waterloo stopper	Swanley-Airport	From	2	12	840	1,680	1,512	90%	Av utilisation of 90% (NR)		517	516	389		121%	121%	113%

4.6.14 The initial conclusions derived from the rail capacity analysis in the previous section can be summarised as follows:

- An HS1 express service from St. Pancras would have sufficient capacity to accommodate forecast demand in both 2030 and 2050 in each option tested, based on the following assumptions:
  - An assumed service pattern of 4 trains per hour (tph) – HS1 Ltd have stated that these paths may not be available, based on assuming a pratical capacity of 12-13tph,a current operating pattern of 7tph, and assuming that other new serices (both international and domestic) may take up the available train paths – however, consultations with the rail industry suggested that it should be feasible to cater for 4tph for the ITE airport service through a combination of increasing the line capacity to 16-18tph and making the reasonable assumption that not all the available train paths will be taken up by additional international or domestic services – there remains however a risk associated with the assumption that 4tph on HS1 can be delivered;
  - An effective operating capacity of 700 passengers per train (similar to the current capacity per service on the Heathrow Express, based on discussions with NR);
  - A one-way average current fare equivalent of £17.25 (based on current 2012 values and prices – this is similar to the current cost per minute of a Gatwick Express ticket);
- There is sufficient capacity eastbound on Crossrail during the AM peak hour to accommodate forecast demand in 2030 in each option tested, although airport passengers boarding the service in central London are very likely to have to stand for the part of their journey through the core section;
- Capacity issues occur in the eastbound direction in the AM peak hour on the core section of Crossrail in 2050 based on the current assumed level of service, although this is primarily due to background demand generating a utilisation close to capacity, with forecast airport demand increasing utilisation above this threshold;
- The Airport Express service proposed by the Mayor of London (with stops at Barking Riverside, Canary Wharf, London Bridge and Waterloo) is not likely to be required in terms of capacity, certainly in 2030, but would provide a much improved level of service for airport passengers, and could (depending on the fare charged) relieve to a small extent the aforementioned capacity issues emerging on Crossrail in the 2050 AM peak hour;
- Some airport-related National Rail services would likely be over capacity as a result of background demand during the AM peak hour in both 2030 and 2050, based on forecasts for current proposed services provided by NR – airport-related trips would exacerbate these capacity issues and significant capacity enhancements would be required on a number of routes such as through the Medway Towns in the Up direction (towards London) and on the approach to Waterloo via Bromley South and Swanley – further discussions are currently underway with Network Rail regarding the possible opening of the "Bromley North Branch Line" from Bromley to London Bridge, which would take much of the local Bromley demand, and leave much more capacity for the ITE airport demand.

4.6.15 A key point to note is that all of the conclusions derived above are based on central assumptions of 40% rail mode share for passengers and 25% for employees. The packages representing a higher level of rail intervention, particularly Option 4 involving an additional express service from south London termini and Canary Wharf, would likely increase the headline rail mode share above these central assumptions, particularly for passengers. Employees are forecast to cluster in districts in Kent and Essex that would not benefit from an additional express service from London, and those living within the catchment would be unlikely to pay a premium fare for such a service due to a low value of time.

4.7 Deliverability issues

4.7.1 The key issues in terms of the deliverability of the components of the rail options described above have been identified as follows:

- Providing four new train paths on the existing CTRL between St. Pancras and a new spur to the south of Gravesend has been identified as a key risk by HS1 Ltd, who have indicated that accounting for future growth in domestic and European services, there may be no spare line utilisation capacity or platform capacity at St. Pancras to accommodate airport services – in the event that train paths could not be accommodated, the provision of an alternative express service such as TfL's AEX proposal would become necessary in capacity terms to deliver an airport in the ITE in 2030;
- The provision of a two-track spur from Hoo Junction to the CTRL would involve land acquisition for its entire length that may involve some residential properties in the village of Thong and woodland areas in the vicinity of the village;
- Four-tracking the Abbey Wood to Hoo Junction corridor to accommodate a Crossrail southern branch extension to the airport would likely involve extensive land acquisition plus the reconfiguration of stations along the route, particularly the sections passing through South-East London (around Belvedere and Erith) and the urban areas of Dartford and Gravesend;
- Platform capacity at Waterloo is a significant risk affecting delivery of the Waterloo Stopper, as is platform capacity at other London termini if the Bromley North connection is considered necessary and is feasible as a means of alleviating background demand on fast Kent services;
- Line utilisation on the Chatham Main Line is a significant risk, with costs/land acquisition issues associated with providing additional track capacity;
- The reconfiguration of Strood station to accommodate a shuttle service is a significant risk, and options to provide a direct connection to the Chatham Main Line to the south-west would present significant challenges if Strood was selected as the preferred termini for a shuttle service from North Kent;
- Line utilisation for the Grays Shuttle is a risk, particularly in light of an increasing number of train paths allocated to freight associated with the London Gateway port – if four-tracking is considered a requirement then land acquisition to widen the rail corridor east of Grays would be a risk, as would the reconfiguration of Grays station;
- The alignment of rail junctions between LTC Option C and existing tracks on both sides of the river would present significant challenges if the current proposal for a bridge was adapted for multi-modal operation;
- Issues associated with the delivery of the AEX would present significant challenges, including the feasibility of subterranean stations and tunnels at Waterloo/London Bridge/Canary Wharf/Barking Riverside, the tunnel through Grays, land acquisition associated with surface sections between Dagenham and Dartford Crossing, and alignment issues with the tunnel portal east of Grays and the multi-modal rail bridge on LTC Option C alignment;

4.8 Rail journey times

4.8.1 The information used to calculate GC for each of the four rail options was also used to establish a real clock time estimate for rail trips to an airport in the ITE from each district. This real clock-time consisted of total in-vehicle time (including connecting taxi trip time where this was a secondary mode for premium express services), wait time (based on service frequency), and interchange time, without the application of any of the penalties/factors or consideration of fare associated with calculating GC. It should be noted that the clock times reported in this section do not include first and last leg walk times for any journey.

4.8.2 The district level clock time estimates could then be weighted by forecast demand based on the mode shares described earlier to calculate an overall average rail clock time to reach an airport in the ITE in each of the four options. These weighted average clock times are shown in Table 22, both to and from the airport – the times shown to the airport are shorter than those from the airport as a result of employees, who account for a higher proportion of total demand to the airport in the modelled AM peak hour. The assumption that employee home locations are clustered in districts local to the airport means that on average they make shorter rail trips than passengers.

Table 22: Average rail clock time (in minutes) weighted by forecast demand for ITE rail options

Average journey time	Option 1 (Do Min)	Option 2	Option 3	Option 4
To airport	80.8	82.7	82.4	80.5
From airport	85.7	88.1	88.0	85.0

4.8.3 The table indicates clearly that Options 4 and 1 provide the shortest overall rail journey times to the airport, primarily because in those options a higher proportion of total rail trips are made by express services. In Option 4 this is because of the provision of two express routes via St. Pancras (HS1) and Waterloo/London Bridge/Canary Wharf/Barking Riverside (AEX), while in Option 1 the relative lack of standard rail alternatives such as the Waterloo Stopper service means that more passengers use the sole express route from St. Pancras via HS1.

4.8.4 If passengers are considered separately from employees, the weighted average journey times increase slightly when compared to the 'from airport' times indicated above but are the same in both directions, since for the purposes of this study passengers were assumed to make similar journeys both to and from the airport.

4.8.5 The graphs in Figure 41 and Figure 42 illustrate the distribution of rail clock times to the ITE by passenger demand for Option 1 and Option 4. Journey times are shown in 5-minute increments with the upper limit indicated – the graph for Option 1 therefore indicates that approximately 28% of passengers would take between 55 and 60 minutes to travel to the airport by rail. Although 55-60 minutes is the most common rail travel time in both Options 1 and 4, the skewed distributions (which include a low but reasonably significant number of longer journeys) mean that the mean average time is **86.3** minutes in Option 1 and **85.6** minutes in Option 4 – this is slightly longer than the total averages calculated from the airport and described above due to the removal of shorter employee trips from the analysis.

Figure 41: ITE Rail Option 1 clock times by passenger demand

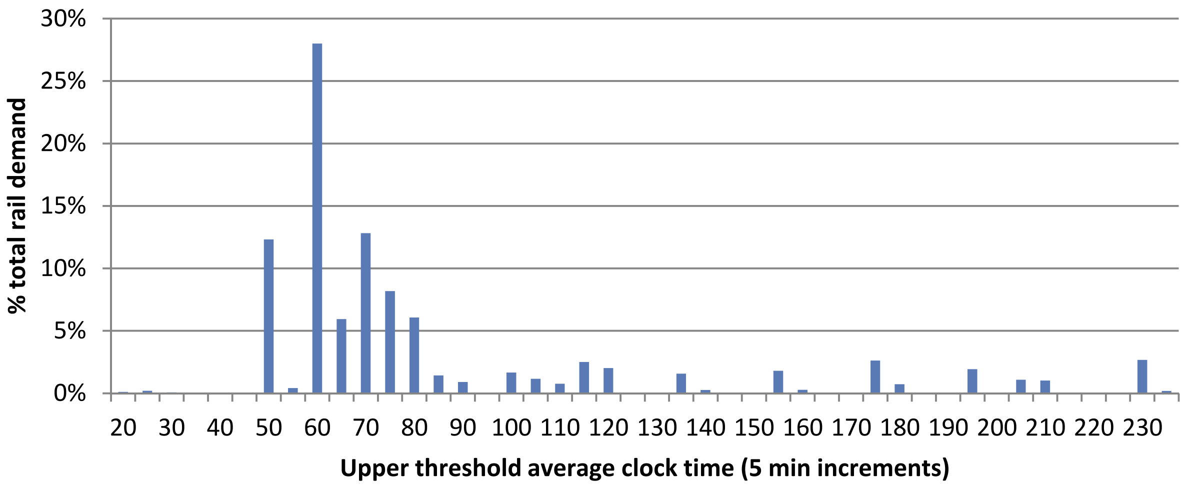
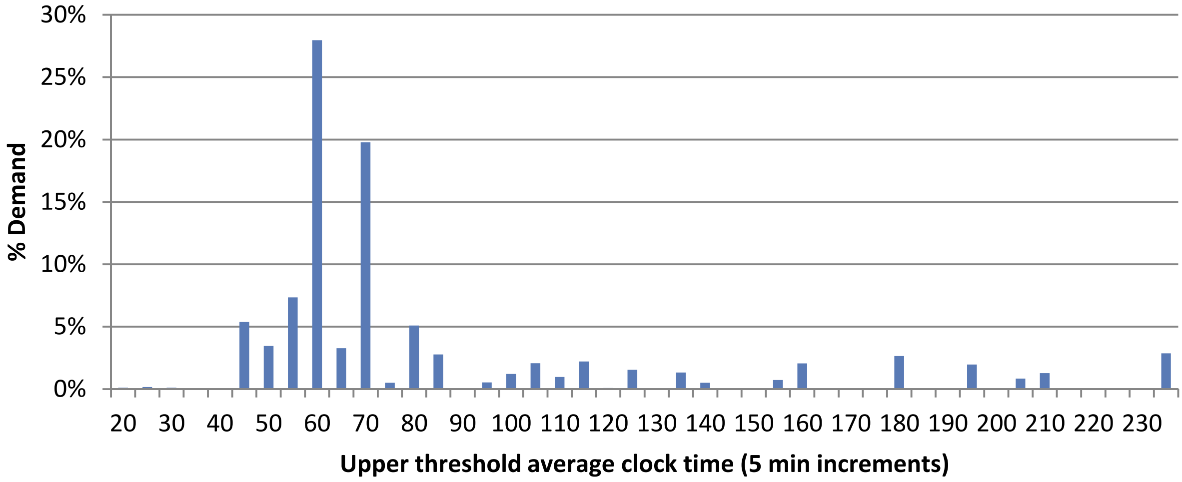


Figure 42: ITE Rail Option 4 clock times by passenger demand



4.8.6 These forecast average journey times compare unfavourably with preliminary analysis drawn from the Phase 2 Heathrow modelling, which is being undertaken to assess the feasibility of surface access to the airport if a third runway is delivered. Analysis of the 2030 base-line for Heathrow (which does not include schemes dependent on the third runway) indicates that the mean average demand-weighted rail clock time is **73.4** minutes, This means that accounting for the forecast change in distribution of trips to the ITE, rail passengers would still likely spend an additional 12 to 15 minutes or so travelling depending on the rail option selected.

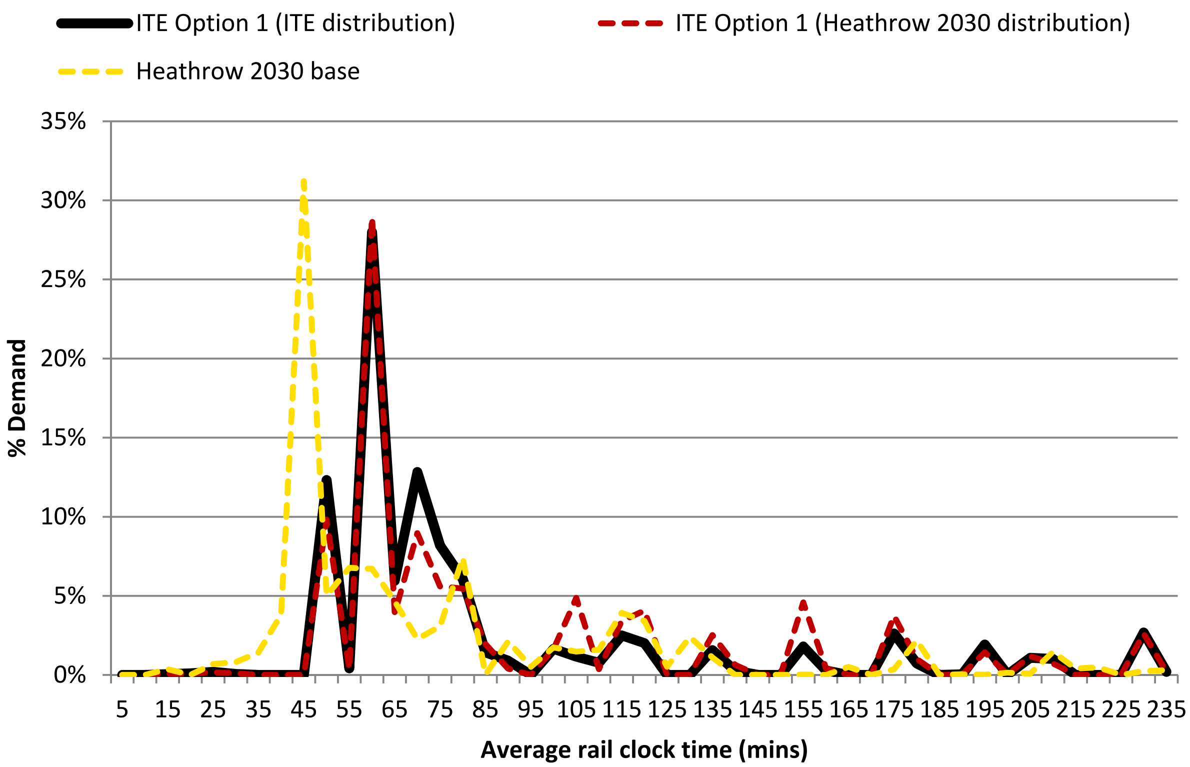
4.8.7 As mentioned in Chapter 1 of this report, the main analysis undertaken as part of this study has not considered the quantitative impact of any transition from Heathrow to the ITE – the trip distributions used in the main forecasts reflect an 'end-state' scenario assuming that a shift in passenger and employee trip origins and destinations based on the new location of the airport would have already taken place. In reality it is likely that, particularly in the opening year, many UK residents and businesses that regularly use Heathrow would not have relocated to areas closer to the ITE, leading to a more pronounced increase in travel times.

4.8.8 The potential impact of this transition on rail journey times is shown in Figure 43, which compares the distribution of rail journey times to Heathrow in the 2030 base-line with ITE Option 1 assuming both the forecast distribution used in this study and the Heathrow 2030 rail distribution. As well as highlighting the shorter average rail journey time to Heathrow described above, the graph also indicates that if the Heathrow 2030 distribution is applied to ITE Option 1, a higher volume of longer rail journeys would occur when compared with the same option using the forecast ITE distribution. The weighted mean average rail journey time to the ITE in Option 1 increases to **91.7** minutes in this scenario, as passengers travelling from areas close to Heathrow have to make the journey across London to reach the ITE.

4.8.9 The analysis described above demonstrates that in the years following the opening of the ITE airport, the rail journey time impacts associated with effectively replacing Heathrow with an airport in a more remote location may be more pronounced than expected. Over time, a transition of activity is likely to occur as residents and businesses that use the airport regularly gradually relocate to more convenient areas. However, even once this transition has occurred, it is likely that passengers will on average spend longer travelling to the airport by rail than they would to Heathrow.

4.8.10 In addition, while the analysis undertaken has focussed on rail clock times, the use of Generalised Cost figures would highlight that there is also likely to be an impact in terms of increased rail fares incurred by passengers travelling to the ITE. This analysis has not been included in the report due to the current uncertainty about the fares that would be applied to ITE express services, which are not directly comparable with HEX in terms of distance from the airport. However, it is likely that any analysis of Generalised Cost comparing with the Heathrow 2030 baseline would highlight negative impacts for the ITE.

Figure 43: Rail clock time analysis – ITE Option 1 v Heathrow 2030 base



4.8.11 At a district level, Table 23 indicates the shortest possible rail clock times to the ITE in Options 1 and 4 by standard rail (including Crossrail, the Waterloo Stopper and the Grays and Strood shuttles) and express rail (including HS1 and, in Option 4, AEX) from districts that currently produce a high proportion of rail demand at Heathrow – the table indicates the 33 London boroughs and the top 10 districts outside London ranked according to the number of annual rail trips generated to Heathrow according to the CAA data. The ITE clock times are illustrated alongside equivalent times for rail access to Heathrow in the 2030 base line described above for both express services (HEX) and standard rail (all other options including Crossrail and the Piccadilly Line). In terms of the ITE, there is generally little difference across the options in terms of the shortest possible clock time from most districts although the benefits of AEX in Option 4 are evident for trips from Southwark (via London Bridge) and Tower Hamlets (via Canary Wharf).

4.8.12 The table illustrates that from boroughs in the east of London, the ITE rail options do provide for shorter standard rail journey times than in the Heathrow 2030 base-line – the key location in this respect is Tower Hamlets. However, from many of the districts identified, rail journey times to Heathrow in 2030 will be shorter than they would be to the ITE – this includes the two districts that between them generate approximately a third of all rail trips to Heathrow at present, Westminster and Kensington & Chelsea.

4.8.13 The table also highlights the benefits that would be generated by the ITE Option 4 in terms of express journey times, as the AEX provides for additional stations at Waterloo, London Bridge, Canary Wharf and Barking Riverside. Without the AEX in Option 1, express journey times from London boroughs are only faster to the ITE where the representative station has a direct connection to King's Cross (examples include Enfield and Haringey).

4.8.14 This analysis suggests then that if the ITE is compared with Heathrow on a level playing field in 2030, accounting for the impact of schemes in the AC's core and extended baselines that will be delivered regardless of whether a third runway is delivered at Heathrow, the average rail passenger would have a shorter journey to Heathrow than they would to the ITE (accounting for the trip distribution/mode share assumptions and rail options tested for the ITE as part of this study). This simply reflects the fact that in general terms, Heathrow is likely to be located closer to key population and employment centres across the UK in 2030 and 2050 than the ITE.

Table 23: Comparison of rail clock times from key stations to Heathrow (2030 base-line) and ITE rail options

District	Representative station	ITE OPTION 1		ITE OPTION 4		Heathrow (2030)		Difference (ITE Option 1 v Heathrow)		Difference (ITE Option 4 v Heathrow)	
		Shortest standard rail clock time	Shortest Express clock time	Shortest standard rail clock time	Shortest Express clock time	Shortest standard rail clock time	Shortest Express clock time	Standard rail	Express rail	Standard rail	Express rail
All 33 London boroughs (ranked by total rail passenger trips to Heathrow in 2012)											
Westminster	Oxford Circus	65	46	65	46	41	37	25	9	25	9
Kensington and Chelsea	South Kensington	78	57	78	57	44	40	34	17	34	17
Camden	Kings Cross St. Pancras Underground	62	34	62	34	49	43	14	-10	14	-10
Tower Hamlets	Canary Wharf	42	66	42	28	49	47	-8	19	-8	-20
City of London	Moorgate	56	47	56	46	40	47	16	0	16	-1
Hammersmith and Fulham	Hammersmith	78	65	78	65	35	42	44	23	44	23
Islington	Highbury & Islington	72	44	72	44	65	50	7	-6	7	-6
Lambeth	Brixton	80	57	80	52	57	51	23	6	23	1
Ealing	Acton Town	80	72	80	72	27	57	54	16	54	16
Southwark	London Bridge	56	51	56	32	56	48	0	3	0	-17
Wandsworth	Clapham Junction	76	58	76	54	56	52	20	6	20	2
Hackney	Hackney Central	74	52	74	52	76	59	-2	-7	-2	-7
Haringey	Wood Green	84	56	84	56	72	64	12	-8	12	-8
Hounslow	Hounslow Central	102	89	102	89	14	67	88	22	88	22
Brent	Wembley Park	82	61	82	61	60	54	22	8	22	8
Barnet	Finchley Central	86	62	86	62	67	61	20	1	20	1
Newham	Stratford	57	67	57	43	64	67	-7	0	-7	-24
Greenwich	Greenwich	54	78	54	45	69	66	-16	12	-16	-21
Lewisham	New Cross	66	67	66	52	65	68	1	-1	1	-16
Richmond upon Thames	Twickenham	101	83	101	83	48	52	53	31	53	31
Merton	Wimbledon	80	63	80	63	64	60	16	3	16	3
Waltham Forest	Walthamstow Central	75	58	75	52	70	67	5	-9	5	-14
Enfield	Cockfosters	98	70	98	70	87	85	11	-15	11	-15

District	Representative station	ITE OPTION 1		ITE OPTION 4		Heathrow (2030)		Difference (ITE Option 1 v Heathrow)		Difference (ITE Option 4 v Heathrow)	
		Shortest standard rail clock time	Shortest Express clock time	Shortest standard rail clock time	Shortest Express clock time	Shortest standard rail clock time	Shortest Express clock time	Standard rail	Express rail	Standard rail	Express rail
Redbridge	Redbridge	75	77	75	42	71	76	5	1	5	-34
Hillingdon	Hatton Cross	108	94	108	94	7	74	101	20	101	20
Bromley	Bromley South BR	55	90	47	77	82	78	-28	12	-35	-1
Croydon	East Croydon	85	71	85	61	84	80	1	-10	1	-20
Barking and Dagenham	Barking	45	76	45	23	71	75	-26	1	-26	-53
Bexley	Bexley BR	39	88	39	72	92	90	-54	-2	-54	-18
Havering	Upminster	38	86	38	55	91	88	-54	-2	-54	-33
Harrow	South Harrow	100	82	100	82	50	85	50	-4	50	-4
Sutton	Sutton Common	115	90	108	85	98	82	17	8	10	3
Kingston upon Thames	Surbiton	92	75	90	65	82	73	10	2	8	-9
Top 10 districts outside London (ranked by total rail passenger trips to Heathrow in 2012)											
Cambridge	Cambridge	140	120	140	120	127	129	13	-9	13	-9
Leeds	Leeds	203	175	203	175	188.5	184	15	-9	15	-9
Bristol, City of	Bristol Temple Meads	228	223	228	223	119.5	142.5	109	81	109	81
Oxford	Oxford	149	145	149	145	65	113	84	32	84	32
Peterborough	Peterborough	118	101	118	101	122	119	-4	-18	-4	-18
Birmingham	Birmingham New Street	160	137	160	137	80	75.5	80	62	80	62
Manchester	Manchester Piccadilly	208	185	208	185	131	126.5	77	59	77	59
Canterbury	Canterbury West	96	103	96	103	119	138.5	-23	-36	-23	-36
York	York	203	175	203	175	187.5	183	16	-8	16	-8
Nottingham	Nottingham	187	159	187	159	170.5	168	17	-9	17	-9

4.8.15 Table 24 indicates the impact of the ITE rail options tested on the number of rail interchanges that would need to be made by passengers travelling to and from the same key Heathrow rail trip generators described above.

4.8.16 The table clearly indicates the benefits of AEX in Option 4 in terms of reducing the number of interchanges required for express passengers from key locations, as it would provide direct express connections to the ITE from St. Pancras, Barking Riverside, London Bridge and Waterloo. However, when the number of interchanges required on standard rail are compared with the equivalent figure for Heathrow, the situation is worse for a lot of trips – this includes those where a direct standard rail trip can be made to Heathrow on the Piccadilly Line (for example, from Kensington & Chelsea, where the representative station is South Kensington, a direct trip can be made to Heathrow on the Piccadilly Line involving no interchanges while the identified representative trip via standard rail to the ITE would involve making two interchanges).

4.8.17 The analysis described above on both rail clock times and interchanges should be treated as indicative only and some caution should be exercised when interpreting the results for a number of reasons as follows:

- Journey times and interchanges identified for each borough are related to a representative station within that borough that was identified qualitatively for modelling purposes – journeys from other other stations within each borough may obviously have different journey characteristics;
- The trips via different rail options identified for each representative station were selected based on the shortest possible generalised cost to the airport from that station – in some cases, this may involve making more interchanges than the absolute minimum possible via another route in order to use services that have a higher frequency or a shorter journey time;
- The Heathrow 2030 baseline travel times and interchange information are being developed as part of the AC's Phase 2 assessment of the three short-listed options as mentioned earlier, but have been used in this study to compare Heathrow and the ITE on a like for like basis in 2030 – however, this means that they are preliminary outputs and are subject to change.

Table 24: Comparison of minimum number of interchanges required from key stations to Heathrow (2030 base-line) and ITE rail options

District	Representative station	ITE OPTION 1		ITE OPTION 4		Heathrow (2030)		Difference (Option 1 vs Heathrow 2030)		Difference (Option 4 vs Heathrow 2030)	
		Least interchanges Standard Rail	Least Interchanges Express	Least interchanges Standard Rail	Least Interchanges Express	Least interchanges Standard Rail	Least Interchanges Express	Standard rail	Express rail	Standard rail	Express rail
All 33 London boroughs (ranked by total rail passenger trips to Heathrow in 2012)											
Westminster	Oxford Circus	1	1	1	1	1	1	0	0	0	0
Kensington and Chelsea	South Kensington	2	1	2	1	0	1	2	0	2	0
Camden	Kings Cross St. Pancras Underground	1	0	1	0	0	1	1	-1	1	-1
Tower Hamlets	Canary Wharf	0	1	0	0	0	1	0	0	0	-1
City of London	Moorgate	1	1	1	1	0	1	1	0	1	0
Hammersmith and Fulham	Hammersmith	1	1	1	1	0	1	1	0	1	0
Islington	Highbury & Islington	2	1	2	1	1	1	1	0	1	0
Lambeth	Brixton	2	1	1	1	1	1	1	0	0	0
Ealing	Acton Town	1	1	1	1	0	2	1	-1	1	-1
Southwark	London Bridge	1	1	1	0	1	1	0	0	0	-1
Wandsworth	Clapham Junction	1	1	1	1	1	1	0	0	0	0
Hackney	Hackney Central	1	1	1	1	1	1	0	0	0	0
Haringey	Wood Green	2	1	2	1	0	1	2	0	2	0
Hounslow	Hounslow Central	2	1	2	1	0	1	2	0	2	0
Brent	Wembley Park	1	1	1	1	1	1	0	0	0	0
Barnet	Finchley Central	1	1	1	1	1	1	0	0	0	0
Newham	Stratford	1	1	1	1	1	1	0	0	0	0
Greenwich	Greenwich	1	2	1	1	1	1	0	1	0	0
Lewisham	New Cross	2	1	2	1	1	1	1	0	1	0
Richmond upon Thames	Twickenham	1	1	1	1	1	1	0	0	0	0
Merton	Wimbledon	1	1	1	1	1	1	0	0	0	0
Waltham Forest	Walthamstow Central	1	1	1	1	1	1	0	0	0	0
Enfield	Cockfosters	2	1	2	1	0	3	2	-2	2	-2
Redbridge	Redbridge	1	2	1	1	1	2	0	0	0	-1
Hillingdon	Hatton Cross	2	1	2	1	0	1	2	0	2	0

District	Representative station	ITE OPTION 1		ITE OPTION 4		Heathrow (2030)		Difference (Option 1 vs Heathrow 2030)		Difference (Option 4 vs Heathrow 2030)	
		Least interchanges Standard Rail	Least Interchanges Express	Least interchanges Standard Rail	Least Interchanges Express	Least interchanges Standard Rail	Least Interchanges Express	Standard rail	Express rail	Standard rail	Express rail
Bromley	Bromley South BR	1	1	0	1	1	3	0	-2	-1	-2
Croydon	East Croydon	1	1	1	1	1	2	0	-1	0	-1
Barking and Dagenham	Barking	1	1	1	0	1	1	0	0	0	-1
Bexley	Bexley BR	1	2	1	1	2	2	-1	0	-1	-1
Havering	Upminster	1	2	1	2	1	1	0	1	0	1
Harrow	South Harrow	2	2	2	2	1	3	1	-1	1	-1
Sutton	Sutton Common	1	2	1	2	1	2	0	0	0	0
Kingston upon Thames	Surbiton	1	1	1	1	2	2	-1	-1	-1	-1
Top 10 districts outside London (ranked by total rail passenger trips to Heathrow in 2012)											
Cambridge	Cambridge	1	1	1	1	1	2	0	-1	0	-1
Leeds	Leeds	2	1	2	1	1	2	1	-1	1	-1
Bristol, City of	Bristol Temple Meads	1	2	1	2	1	1	0	1	0	1
Oxford	Oxford	1	2	1	2	0	1	1	1	1	1
Peterborough	Peterborough	1	1	1	1	1	2	0	-1	0	-1
Birmingham	Birmingham New Street	2	2	2	2	1	1	1	1	1	1
Manchester	Manchester Piccadilly	2	2	2	2	1	1	1	1	1	1
Canterbury	Canterbury West	1	1	1	1	1	2	0	-1	0	-1
York	York	2	1	2	1	1	2	1	-1	1	-1
Nottingham	Nottingham	2	1	2	1	1	2	1	-1	1	-1

4.9 Rail level of service

4.9.1 The forecast Volume/Capacity Ratios (VCRs) on key sections of the rail network with background plus airport demand, which were calculated and described earlier for each of the rail options tested, were used to estimate the average level of crowding experienced by rail passengers travelling ***to*** the airport in 2030 and 2050. At the time of reporting, TfL had not provided the AC with background forecast demand for westbound Crossrail services, and since this service was forecast to be used by a large proportion of rail passengers travelling ***from*** the airport in future years, average crowding could not be assessed for trips in this direction.

4.9.2 For the purposes of this analysis, the overall level of crowding experienced by passengers in each of the four options was assumed to equate to the worst level of crowding they experienced on the last leg of their rail journey to the airport, excluding any crowding issues on connecting modes (analysis of which was not within the scope of this study).

4.9.3 In the case of Crossrail and the Waterloo Stopper, the worst level of crowding experienced was related to where they board the service, with for example those trips using the Core section between Paddington and Liverpool Street experiencing worse levels of crowding on Crossrail than those boarding at Stratford or Canary Wharf. In the case of the regional rail options, the crowding level assigned to each trip was dictated by the direction from which they approached the airport.

4.9.4 Summary crowding levels are shown for each option in 2030 and 2050 in Table 25 and Table 26 below. It should be noted that the passenger numbers quoted are sourced from the rail capacity tables provided above but represent non-cumulative totals on each section of line – in effect, those passengers that start their journey on that particular section.

4.9.5 Table 25 therefore indicates that in 2030 in Option 1, of the total of 1,861 passengers travelling to the airport on the Crossrail southern branch, 1,116 travelled from the Core section, with additional passengers boarding at Liverpool Street and Canary Wharf. In terms of the regional rail options, the 0 figures for the Strood Shuttle indicate that in the model, no trips that were assigned to the shuttle began their journey at Strood, since the station was not selected as representative of a district – all passengers on the shuttle were therefore assumed to have made connections from other rail services approaching Strood and so for the purposes of this analysis, the crowding level assigned to those trips was that calculated for the approaching service. In contrast in Option 1 in 2030, 41 passengers from Thurrock were forecast to travel to the airport and were assumed to begin their journey on the Grays Shuttle – the remainder of trips on the Grays Shuttle connected from other services approaching from Fenchurch Street or Southend and as with the Strood shuttle, the crowding level assigned to those trips is assumed to equate to the level forecast on the approaching service.

4.9.6 The tables indicate that overall, rail passengers to the airport experience the lowest overall levels of crowding in Option 4. This is to be expected since a higher proportion of rail passengers in that option is forecast to use express services (HS1 and AEX), which have more spare capacity. The other three options are very similar, with Option 3 exhibiting a slight reduction in crowding levels due to a very small number of passengers travelling on the Crossrail northern branch extension from Stratford, which has very low forecast background levels of demand.

4.9.7 The overall conclusions on the effectiveness of each option to meet demand levels predicted and deliver satisfactory rail journey times and levels of service are summarised in Chapter 8.

Table 25: Average crowding weighted by demand on ITE rail services (2030)

Line	Section (between)	VCR (background + airport)				Passenger forecast (non-cumulative)			
		Op 1	**Op 2**	**Op 3**	**Op 4**	**Op 1**	**Op 2**	**Op 3**	**Op 4**
HS1	All	48%	40%	40%	30%	1,341	1,120	1,111	841
AEX	All				34%				947
Crossrail South	Core (Paddington-Liverpool Street)	93%	92%	92%	91%	1,116	894	897	702
Crossrail South	Liverpool Street-Canary Wharf	67%	65%	65%	64%	210	188	133	151
Crossrail South	Canary Wharf-Airport	26%	24%	24%	22%	535	489	493	387
Crossrail North	Stratford-Airport			19%				249	
North Kent Line (Strood Shuttle)	All	53%	46%	44%	40%	0	0	0	0
North Kent Line (East of ITE)	Rochester-Strood	96%	96%	95%	96%	214	214	184	210
North Kent Line (West of ITE)	Swanley-Strood	59%	57%	57%	56%	209	160	160	127
North Kent Line (South of ITE)	Maidstone-Strood	52%	52%	52%	52%	32	32	32	29
North Kent Line (NW of ITE)	Dartford-Strood	42%	41%	41%	40%	140	112	112	83
South Essex Line (Grays Shuttle)	All	52%	51%	36%	40%	41	41	38	37
South Essex Line (East of Grays)	Southend-Grays	57%	57%	52%	54%	393	393	243	311
South Essex Line (West of Grays)	Fenchurch St-Grays	50%	49%	49%	48%	152	134	127	97
Waterloo stopper	Waterloo-Bromley South		91%	91%	83%		563	560	425
Waterloo stopper	Bromley South-Swanley		89%	88%	80%		42	42	35
Waterloo stopper	Swanley-Airport		81%	81%	72%		0	0	0
Total AM peak hour rail passengers:						**4,382**	**4,382**	**4,382**	**4,382**
Average VCR (weighted by forecast demand):						**61.3%**	**62.3%**	**59.3%**	**53.1%**

Table 26: Average crowding weighted by demand on ITE rail services (2050)

Line	Section (between)	VCR (background + airport)				Passenger forecast (non-cumulative)			
		Op 1	Op 2	Op 3	Op 4	Op 1	Op 2	Op 3	Op 4
HS1	All	67%	56%	56%	42%	1,884	1,575	1,564	1,182
AEX	All				48%				1,331
Crossrail South	Core (Paddington-Liverpool Street)	115%	113%	113%	111%	1,557	1,248	1,251	979
Crossrail South	Liverpool Street-Canary Wharf	88%	86%	85%	84%	294	264	188	212
Crossrail South	Canary Wharf-Airport	31%	29%	28%	26%	753	686	648	540
Crossrail North	Stratford-Airport			24%				316	
North Kent Line (Strood Shuttle)	All	73%	64%	64%	55%	0	0	0	0
North Kent Line (East of ITE)	Rochester-Strood	119%	119%	119%	119%	293	293	293	288
North Kent Line (West of ITE)	Swanley-Strood	71%	69%	69%	68%	289	223	223	176
North Kent Line (South of ITE)	Maidstone-Strood	73%	73%	73%	72%	44	44	44	40
North Kent Line (NW of ITE)	Dartford-Strood	53%	52%	52%	51%	196	157	157	117
South Essex Line (Grays Shuttle)	All	73%	71%	54%	56%	62	62	59	57
South Essex Line (East of Grays)	Southend-Grays	81%	81%	76%	78%	541	541	362	428
South Essex Line (West of Grays)	Fenchurch St-Grays	61%	61%	60%	59%	216	190	181	137
Waterloo stopper	Waterloo-Bromley South		117%	117%	105%		787	784	594
Waterloo stopper	Bromley South-Swanley		113%	113%	101%		60	59	49
Waterloo stopper	Swanley-Airport		105%	105%	93%		0	0	0
Total AM peak hour rail passengers:						**6,129**	**6,129**	**6,129**	**6,129**
Average VCR (weighted by forecast demand):						**79.1%**	**80.3%**	**77.0%**	**68.7%**

5. Road access assessment

5.1 Overview

5.1.1 The methodology for assessing the impact of the ITE airport on road capacity is described earlier in this report. As indicated, a key aim was to establish the capacity enhancements that would likely be required in 2030 and 2050 as a result of DfT forecast increases in background traffic volumes, as distinct from the enhancements that would be required specifically as a result of airport-related traffic.

5.1.2 The analysis of airport-related traffic assumed a headline mode share for private vehicles of 48% for passengers and 65% for employees, with the passenger mode share varying by region of origin/destination based on analysis of the Heathrow 2012 CAA survey data. For the purposes of this analysis, all private vehicles were assumed to be cars with an average vehicle occupancy of 1.6 for passengers and 1.2 for employees.

5.1.3 A number of scenarios were tested to draw conclusions with regard to the impact of airport-related traffic on road capacity, as follows:

- 2030 background traffic (core baseline enhancements);
- 2030 background traffic (extended baseline);
- 2050 background traffic (core baseline enhancements);
- 2050 background traffic (extended baseline);
- 2030 background + airport traffic (core baseline);
- 2030 background + airport traffic (extended baseline);
- 2050 background + airport traffic (core baseline);
- 2050 background + airport traffic (extended baseline).

5.2 Results and conclusions

Background traffic

5.2.1 The plans in Figure 44 and Figure 45 indicate the impact of forecast background traffic on the road network in 2030 and 2050.

5.2.2 In 2030, sections of the M25 to the west of London are forecast to have a Volume/Capacity Ratio (VCR) of over 100% along with the Dartford Crossing and the section to the west of the junction with the A23. Small sections of the M2 and M20 are also forecast to be over capacity, and the two plans illustrate the impact of schemes in the extended baseline (notably the smart motorway scheme on the M4) in reducing VCRs on some sections of road.

5.2.3 In 2050, the plans illustrate that large sections of the road network are forecast to be over capacity as a result of background traffic, including the southern and western sections of the M25 from its junction with the M40 all the way round to Dartford, and the M1, M11, M4 and M40 approaches to the M25. In addition, the A2 west of Gravesend is also expected to be over capacity as a result of background traffic in 2050.

5.2.4 It should be noted that the background traffic forecasts assume unconstrained (TEMPRO) growth and take no impact of potential measures to dampen down the demand for the strategic motorways (eg congestion charging, the construction of parallel local distributors and changing working patterns with more home working). Furthermore, they do not at present include any estimate of traffic redistribution as a result of the Lower Thames Crossing Option C alignment.

Figure 44: 2030 Background VCR

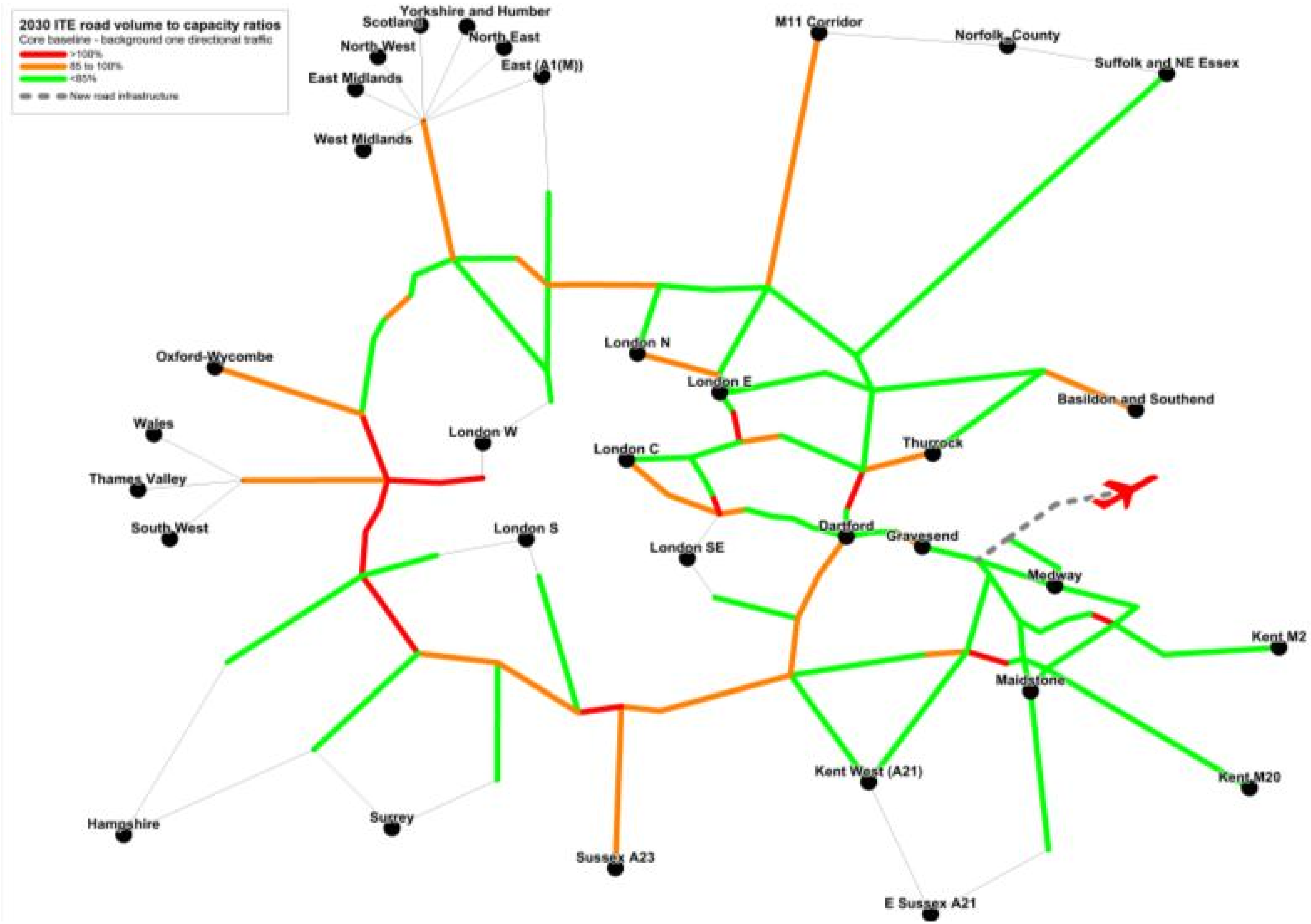
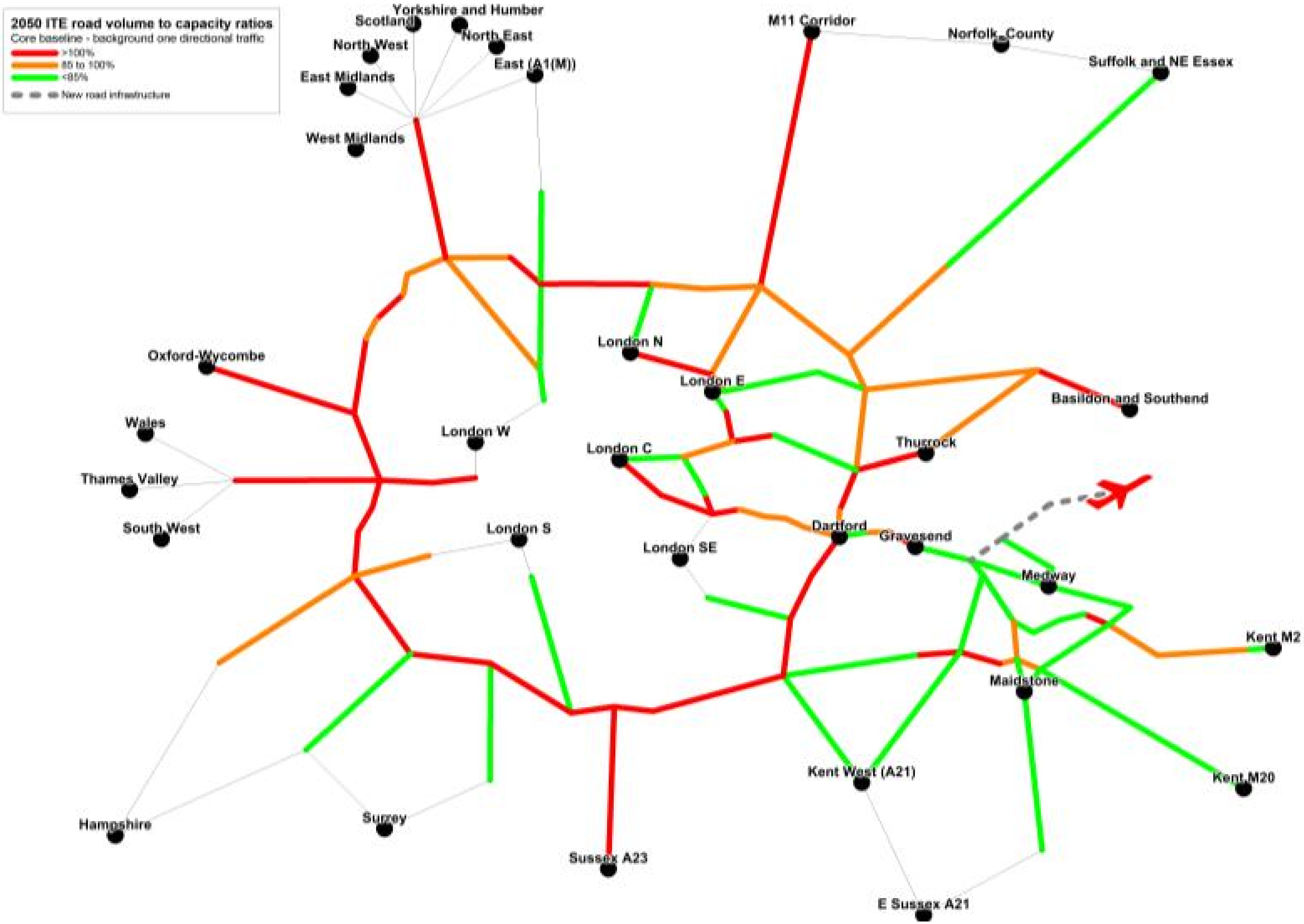


Figure 45: 2050 background VCR



Airport impacts

5.2.5 The road impacts specifically related to the airport were assessed taking into account the capacity issues created by background traffic described above. Airport-related car trips calculated and summarised in Chapter 3 were added to background traffic and new VCRs were calculated for both the core and extended baselines. These 'background + airport' VCRs were then compared with the 'background only' VCRs to identify the links where capacity issues could be attributed specifically to airport-related traffic.

5.2.6 VCR thresholds of 85% and 100% were used to distinguish between those links where airport-related traffic pushed the link in question close to saturation point (i.e. where capacity enhancements may be needed to improved network performance), as opposed to those where the saturation point was exceeded (where enhancements would definitely be needed based on the analysis undertaken).

5.2.7 The plans in Figure 46 to Figure 49 illustrate the results of this analysis, categorising links as follows:

- Links with no capacity issues arising from airport-related traffic, coloured in green – this included those links where the VCR was already over 100% as a result of background traffic, such as the Dartford Crossing in both the 2030 and 2050 core baselines;
- Links where airport-related traffic increased forecast VCR from under 85% to over 85%, coloured in yellow – these are links where capacity enhancements may be necessary as a result of airport-related traffic;
- Links where airport-related traffic increased forecast VCR to over 100% and the absolute number of airport vehicles forecast on the link was less than 2,000 (suggesting that a capacity increase of 1 additional lane in either direction would be sufficient to meet demand), coloured in orange; and finally
- Links where airport-related traffic increased forecast VCR to over 100% and the absolute number of airport vehicles forecast on the link was more than 2,000 (suggesting that a capacity increase of 2 additional lanes in either direction would be required to meet demand), coloured in red – the latter two categories signified those links where capacity enhancements would definitely be required as a result of airport-related traffic based on the analysis undertaken.

5.2.8 The core baseline plan for 2030 indicates that the following road links would need capacity enhancements as a result of airport-related traffic:

- The A2 between the M25 and its junction with the M2 (junction 1);
- The M25 between junctions 3 and 4, 6 and 7, 8 and 10, 23 and 25, and 29 and 30;
- The A282 south of the Dartford Crossing (M25 between junctions 1A and 1B).

5.2.9 In addition, works may be required in 2030 on the following links as airport traffic increases the VCR above 85%:

- The M25 between junctions 2 and 3, 4 and 5, 16 and 17, 21A and 22, 25 and 26, and 27 and 29;
- The A12 on its approach to the M25 from the east;
- The A127 on its approach to the M25 from the east;
- Small sections of the A2 to the west of the M25;
- Small sections of the A13 south-west of Basildon.

Figure 46: 2030 airport impact – core baseline

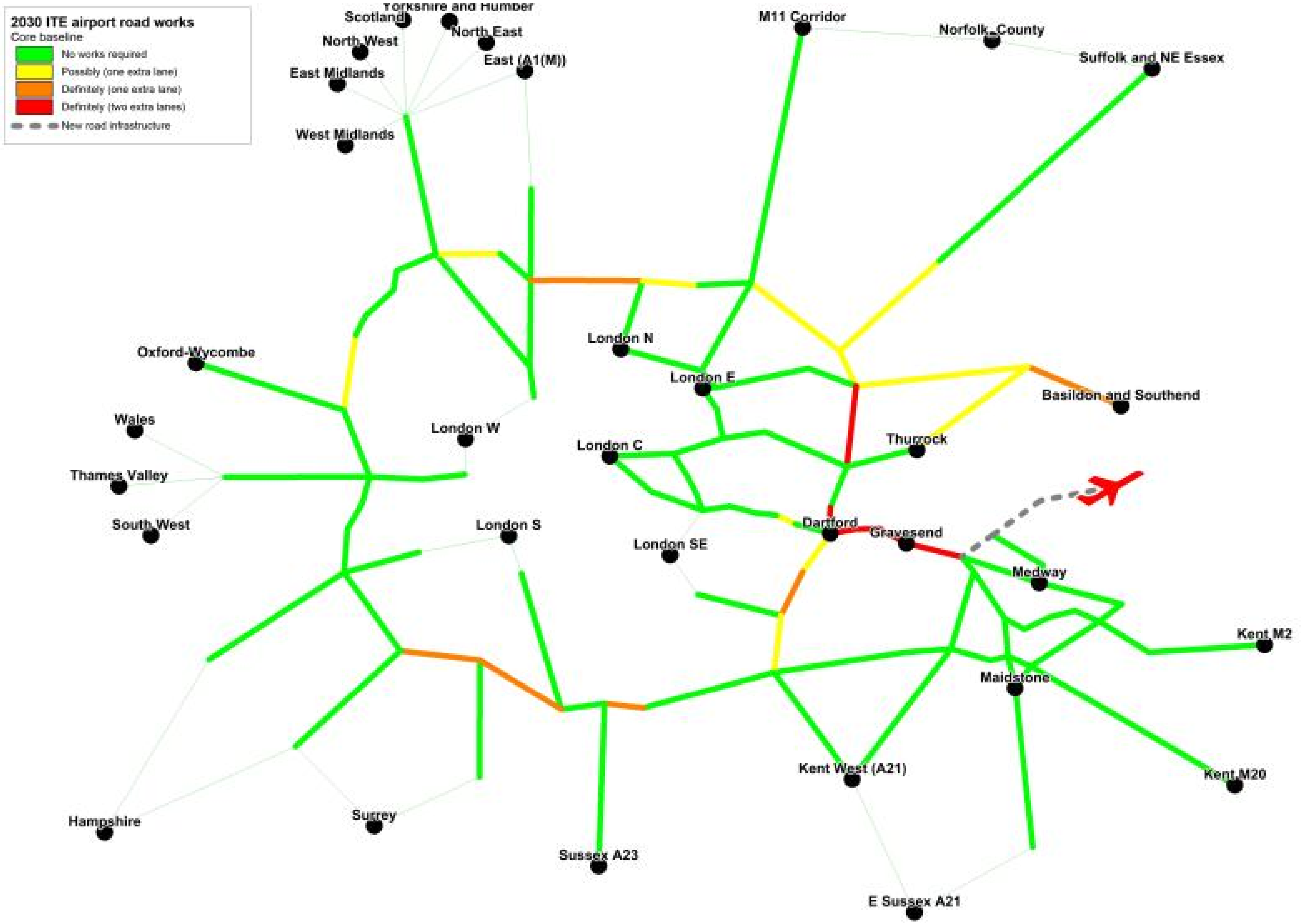


Figure 47: 2030 airport impact – extended baseline

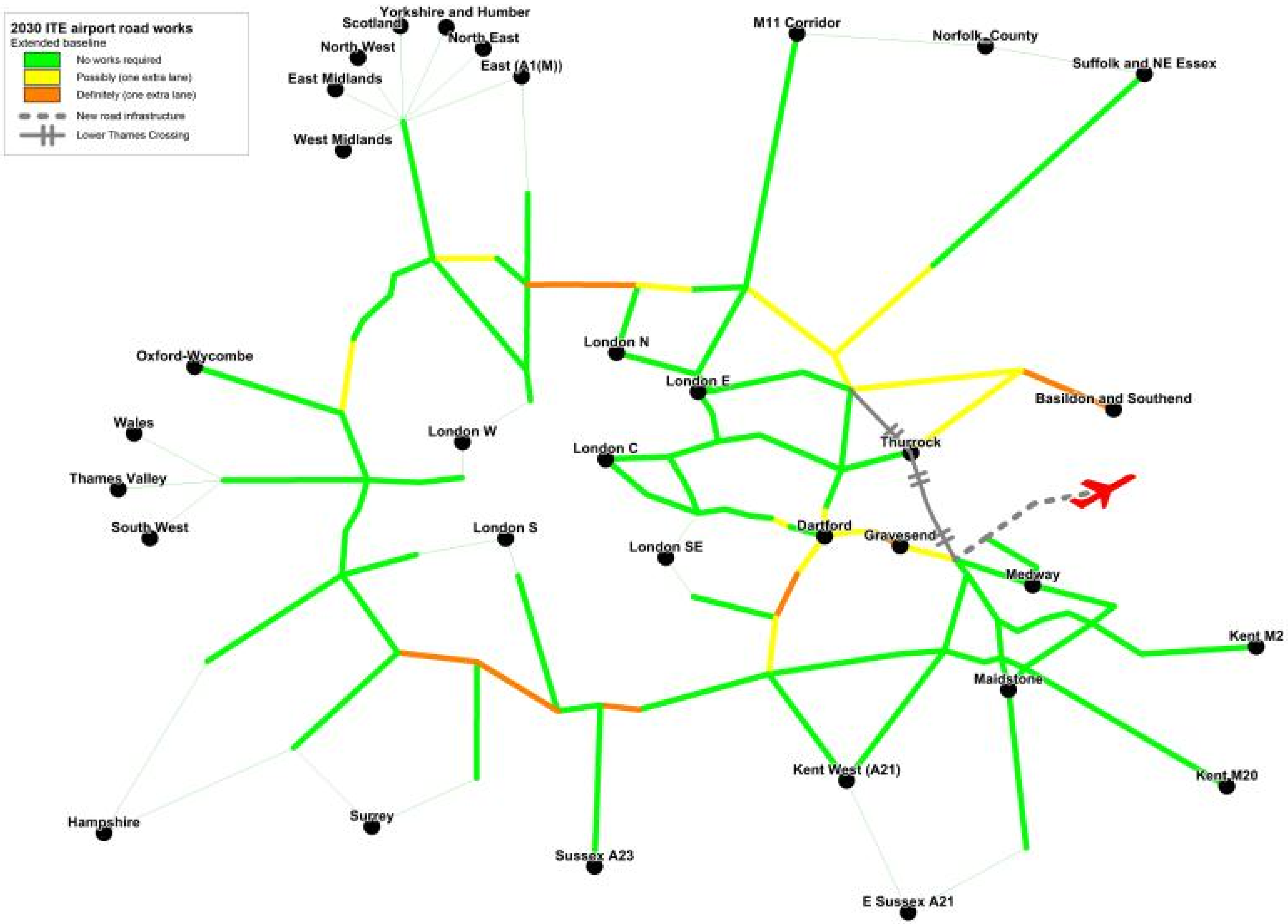


Figure 48: 2050 airport impact – core baseline

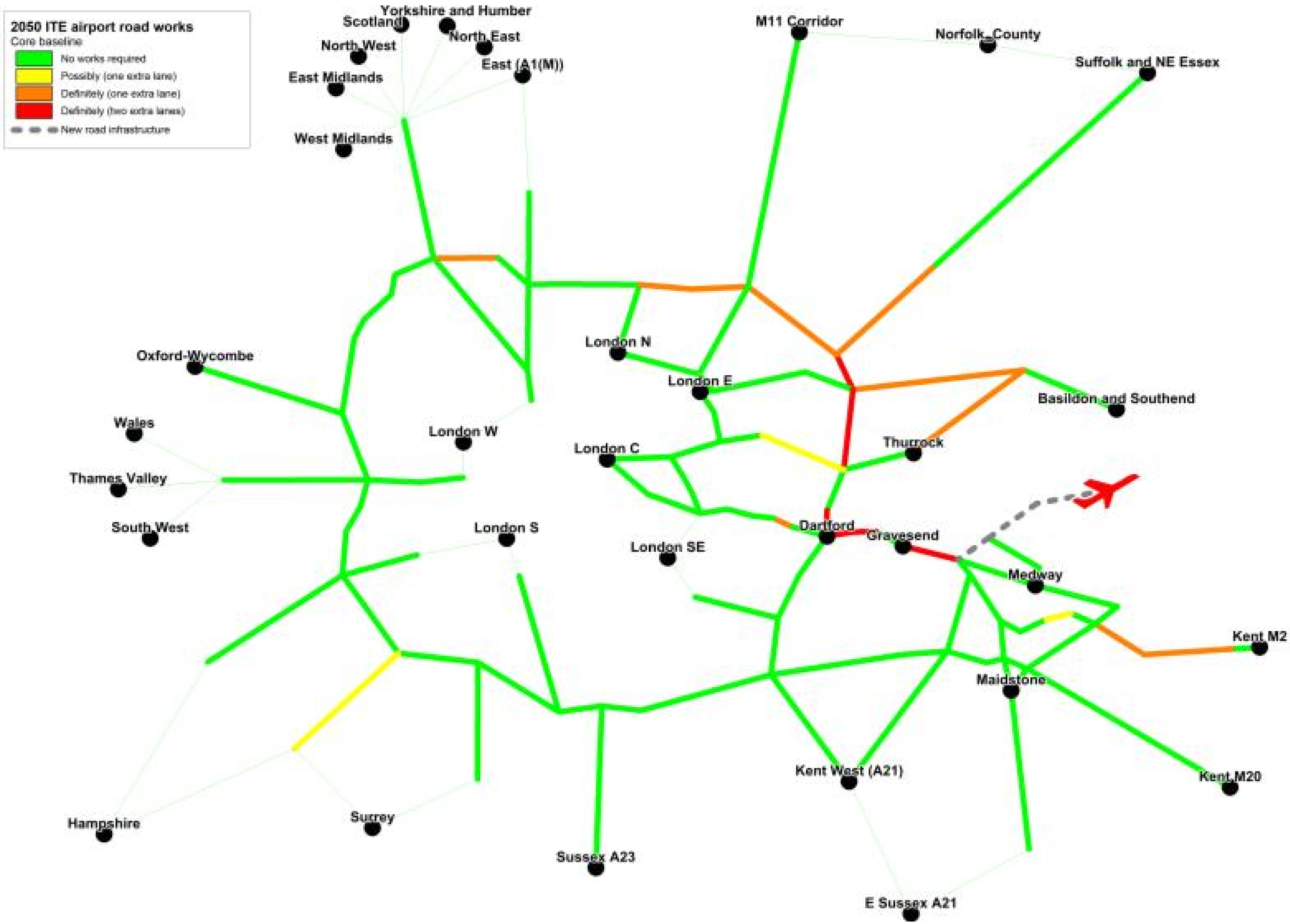
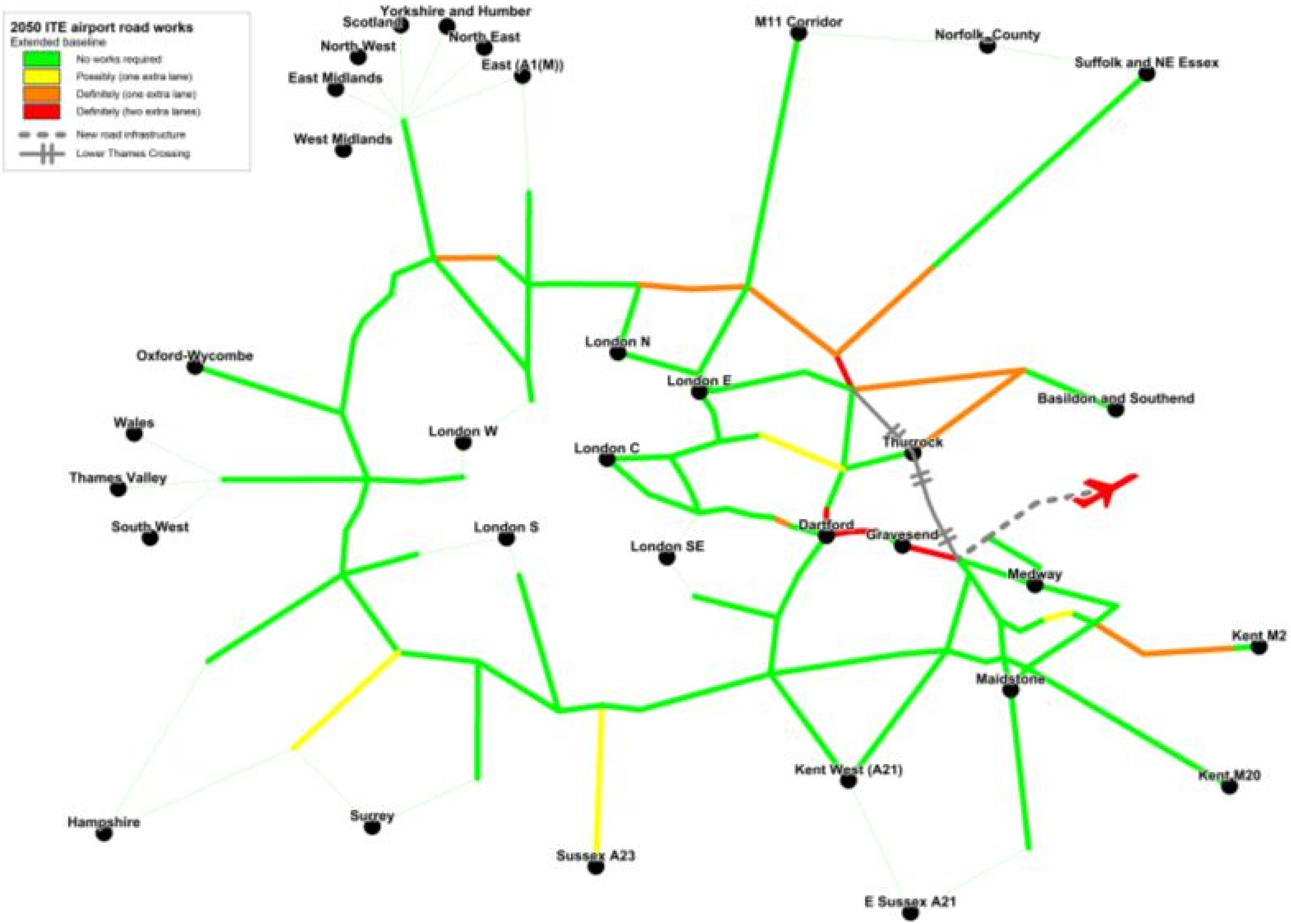


Figure 49: 2050 airport impact – extended baseline



5.2.10 By 2050, additional enhancements would definitely be needed on some of the links identified above in the core baseline, including:

- The M25 between junctions 21A and 22, 25 and 26, and 27 and 29;
- The A2 west of the M25; the A13 south-west of Basildon; the A127 on its approach to the M25; and the A12 on its approach to the M25 from the east.

5.2.11 In addition to those links, the analysis suggest that works would also definitely be required on the M25 between junctions 26 and 27 and also on sections of the M2 in Kent to the east of the airport.

5.2.12 The capacity issues highlighted for the A2 west of the M25, the A13, the A127 and the A12 should be treated with caution due to the coarseness of the network in these locations.

5.2.13 In the extended baseline in 2030, the impact of the LTC in diverting airport-related traffic away from the M25 in the vicinity of the Dartford Crossing means that the list of links that would definitely need enhancing as a result of airport traffic is shorter than in the core baseline, and includes:

- The M25 between junctions 3 and 4, 6 and 7, 8 and 10, 23 and 24, and 25 and 26;
- A small section of the A2 west of Gravesend, between its junctions with the A2260 and the A227.

5.2.14 Additional enhancements may also be required on the following links in 2030 in the extended baseline as VCRs exceed 85% as a result of airport-related traffic:

- The remaining length of the A2 between the M25 and its junction with the M2;
- The M25 between junctions 2 and 3, 4 and 5, 16 and 17, 21A and 22, 25 and 26, and 27 and 29;
- The A282 south of the Dartford Crossing (M25 between junctions 1A and 1B);
- The A12 on its approach to the M25 from the east;
- The A127 on its approach to the M25 from the east;
- Small sections of the A2 to the west of the M25;
- Small sections of the A13 south-west of Basildon.

5.2.15 As in the core baseline, many of the links identified as possible enhancements as a result of airport-related traffic in 2030 would definitely need enhancements in the 2050 extended baseline, including most of the A2 between the M25 and its junction with the M2.

5.2.16 As with the core baseline analysis, the capacity issues highlighted for the A2 west of the M25, the A13, the A127 and the A12 should be treated with caution as the network in these locations is not defined in detail. In addition, the identification of works on the A2 between the M25 and the M2, and the M25 in vicinity of the Dartford Crossing in the extended baseline should be treated with some caution as the analysis has not accounted for the impact of the LTC on background demand on these sections of the road network. Since the LTC is likely to significantly reduce background traffic in these areas, it is less likely that road widening works would be required as a result of airport-related traffic in the identified areas if the LTC is delivered. This is particularly the case since the analysis has indicated that all airport-related traffic approaching on the M25 from the north would use the new LTC, leaving the A2 between the M25 and M2 as a route used exclusively by airport-related traffic approaching on the M25 from the south.

6. Engineering costs

6.1 Rail cost methodology

6.1.1 Of the four rail options assessed as described earlier in this report, options 3 and 4 were selected by the AC for more detailed assessment of costs and environmental impact. as these options between them included all the individual schemes that were incorporated in the rail assessment.

6.1.2 The rates and prices utilised within the Thames Estuary Airport for Rail connections from Airport to London and its local and dedicated lines have been built up from previous estimates which utilised Crossrail and other rail projects previously undertaken by Jacobs for Network Rail as a base for the proposed works and adjusted for time and location factors. In addition we have developed all-in rates from Network Rail Candy data base of rates adjusted for escalation costs up to current prices.

6.1.3 For signalling this has been measured as SEU Units and a standard all- in rate applied. The rate was determined by reference previous discussions with Network Rail on item coverage for signalling and an agreed build-up of costs.

6.1.4 A standard all-in rate for Electrification and Power, Permanent Way and telecommunication has been previously agreed with Network Rail on other pre-feasibility projects.

6.1.5 In operational property the main items anticipated have been identified an appropriate cost per square metre has been utilised. These items include main platform areas; fit out to new or existing stations, walkways and access to and from the stations to other facilities and any station buildings. These rates have been developed from previous studies and have been benchmarked against pricing books.

6.1.6 Potential Structures have been identified and a standard cost developed on the basis that for each structure the area will be 15m x 24m or 360m^2. This gives a cost per metre square of approximately £8,333/m^2. The range of costs normally expected is £4,500 to £6,000 /m2. The cost thus utilised will cover more than adequately any structure that exceeds this standard and will allow for any other works associated with the structure such as road re-alignments and/or improvements.

6.1.7 General Civil works associated with the rail works will include earthworks embankments or cuts; screen planting and fencing boundary and noise, environmental mitigation works; capping layers and drainage blankets; site clearance and demolition works.

- Rates and prices for cut/ fill have been utilised from road and rail projects previously used on basis of m3 cost (imported fill and compaction and excavation and disposal);
- Screen planting based on a linear metre of route as a reasonable allowance;
- Boundary and noise fencing from road and rail projects- assumes 2.5m high at £280/m high and boundary fences at £30/m - mesh fencing 2.5m high with animal proof netting buried 300mm into ground;
- Environmental mitigation measures and alternative land purchase obtained from our Dawlish study where the cost was provided from another similar study/ project at £53,000/ hectare;
- Capping and drainage blanket materials assumes 6F1 or 6F2 and similar type materials- rates obtained from road projects and priced at £60.00/m3 to cover excavation and their disposal cost preparation of ground and the supply, laying and compaction of imported materials;
- Site clearance- a general rate to cover pasture and wooded areas has been utilised amounting to £10,000/ hectare. Rates for general site clearance normally are set at £2,000/hectare but the rate has been enhance to cover small building not as yet fully identified;
- Demolition of major buildings has been covered by a general allowance for each of the options.

6.1.8 In the limited time available it has not been possible to identify Utilities that will need to be diverted or protected. On an option by option basis a Provisional allowance has been included within the option costs.

6.1.9 Indirect costs such as Preliminaries and Design, Testing and Commissioning, Project Management and Sponsor costs have been set at industry standards for a scheme at Pre-feasibility stage.

6.1.10 To be consistent with the analysis we conducted during the Phase 1 analysis, risk cost has been assumed to be 40%, and an optimism bias of 50% has also been applied. These should cover design risk, engineering risks and scope creep, unknown costs or costs not yet developed sufficiently from current information availability, possession regimes and possible escalation costs.

6.1.11 For the Airport Express additional rates were developed for Tunnel Works within the London area and boxes at 4 major stations (Waterloo; London Bridge, Canary Wharf and Barking Riverside. Crossrail costs were analysed for tunnel costs and a rate per metre developed. A rate per box has been developed to cover a length of 280m x 20m width and 8m height. This covers the excavation and disposal of materials, concrete, formwork and reinforcement, shafts to over ground exits, walkways /pedestrian walkways to other areas connections, full interchanges with other rail and underground lines, fit out of box including architectural finishes, Mechanical and electrical installations, messes and offices for train staff; gates; new service connections and utility diversions, new station exit and ticket hall and 20% addition for unmeasured items. We have estimated the costs for the Waterloo, London Bridge and Canary Wharf Stations as £600M each and that of Barking Riverside Station as £300M.

6.1.12 An additional allowance has been included to cover minor upgrades of existing station facilities on basis of a cost/m2 to cover all of the central London Stations on the AEX Route.

6.1.13 An all-in rate of £35,000/m for 12m diameter tunnels has been calculated with additional costs for ventilation shafts at varying depths with control buildings for ventilation and means of escape. Depths of shafts are not yet known as so a spread of depths was utilised to give a reasonable allowance for these works.

6.1.14 A significant cost will be incurred for a River Crossing of the AEX and an extra over cost for building adjacent or above a road crossing has been included. A rate approximately 2.5 times the structures rate has been utilised as the structure is likely to be a multi span structure with significant headroom requirements and is assumed likely to require significant piled foundations and protection to intermediate supports against river erosion.

6.1.15 It should be noted that rail land costs are excluded.

6.2 Rail scheme cost estimates

6.2.1 A summary of the rail and road costs associated with the ITE Airport scheme are shown in Table 27.

Table 27: Summary scheme costs for road and rail packages (£)

Scheme	Option 1 Do minimum	Option 2 Waterloo Stopper	Option 3 Crossrail Northern extension but not AEX	Option 4 AEX but no Crossrail Northern extension
Rail Options				
Common Tracks into Airport	920,000,000	920,000,000	920,000,000	920,000,000
Shuttle to Strood	100,000,000	100,000,000	100,000,000	100,000,000
Shuttle to Grays Station	1,600,000,000	1,600,000,000	1,600,000,000	1,600,000,000
Waterloo Stopper		510,000,000	510,000,000	510,000,000
Southern Crossrail Extension	1,710,000,000	1,710,000,000	1,710,000,000	1,710,000,000
Northern Crossrail Extension			1,030,000,000	
HS1 Extension	235,000,000	235,000,000	235,000,000	235,000,000
Additional HS1 platform at St Pancras	110,000,000	110,000,000	110,000,000	110,000,000
Airport Express				7,660,000,000
Rail costs total	**4,675,000,000**	**5,185,000,000**	**6,215,000,000**	**12,845,000,000**
Risk and optimism bias	5,140,000,000	5,700,000,000	6,840,000,000	14,130,000,000
RAIL TOTAL (inc. risk and optimism bias)	**9,820,000,000**	**10,890,000,000**	**13,050,000,000**	**26,970,000,000**

Note: excludes land costs

6.2.2 The costs summarised above are based on an assessment of an ITE airport located in the Isle of Grain at the eastern end of the Hoo Peninsula. It should be noted that locating the airport at Cliffe, which is at the western end, would reduce the 'common tracks to airport' costs by around £300m due to the shorter distance from Hoo Junction.

6.3 Highways methodology

6.3.1 From the analysis summarised in Chapter 5 above, the additional road widening required due to the ITE airport can be summarised as follows:

- 88km widening of the M25 (73km single lane widening and 15 km double lane widening)
- 17km single lane widening of the M2
- 17km widening of the A2 (2km single lane widening and 15km double lane widening)
- Around 30km single lane widening of the A12/A127/A13/A3 roads on their approach to the M25 from outside London.

6.3.2 Additionally, the construction of the ITE airport brings the predicted v/c ratios above the critical 85% on the following links, and additional road widening may be required as follows:

- 20km single lane widening of the M25
- 3km single lane widening of the M2
- Around 55km single lane widening of the A12/A127/A13/A3 roads

6.3.3 The pure engineering costs of the widening were estimated by categorising each widening section by various type (eg cuttings, embankments, elevated sections and by urban/rural area) and by using Jacobs's databank of highway construction costs, to determine the engineering costs of construction.

6.3.4 These pure engineering costs excluded such important factors as: land costs; environmental mitigation costs and the consequential costs of the scheme itself. To obtain an estimate of these costs we used out-turn costs of recent road widening schemes on the M25.

6.3.5 It has been reported that the recently constructed M25 J16-J23 (M40-A1(M)) widening programme cost £3.4bn for the 35 km stretch. However the Government's Public Accounts Committee have been critical of the out-turn costs and have suggested that these could have been managed better to achieve an out-turn of £2.4bn. Furthermore, these costs include the construction costs and 30 years maintenance costs. Assuming that the maintenance costs account for 20% of the total costs, a new build costs of £1.92bn can be estimated, equivalent to £55m per kilometre.

6.3.6 It has also been reported that the recently constructed M25 J27-J30 (M11-A13) widening programme for the section of the M25 through rural Essex cost £360m for the 27km stretch. This equates to £13m per kilometre.

6.3.7 Taking a weighted average of these (most of the M25 widening due to the ITE airport will be more similar to the J16-J23 section than the J27-J30 section), we have assumed that the road widening costs will vary between £35m-£50m per kilometre. A similar approach and a value of £50m per km was adopted during the Phase 1 analysis.

6.4 Highway costs

6.4.1 Taking the unit road widening costs described in section 6.3 above, we estimate that the highway cost of the ITE will vary between £4.8bn and £8.2bn. This variation is due to two reasons: the variation of the length of road to be widened depending on whether the criteria to widen is 100% capacity or 85% capacity and the variation in unit widening costs.

6.4.2 These costs exclude risk and optimism bias. If these costs are included, they rise to between £10.1bn and £17.2bn.

6.4.3 In addition, it the DfT takes the decision to adopt Lower Thames Crossing Option A, and subsequently the ITE airport is approved, the location of the LTC would be sub-optimal. Under this scenario, the case might be made for the ITE airport to include the incremental cost of LTC Option C over Option A. These incremental costs are estimated to be £2bn.

7. Environmental impacts

7.1 Scope of Assessment

7.1.1 Of the four rail options assessed as described earlier in this report, options 3 and 4 were selected by the AC for more detailed assessment of costs and environmental impact as these options between them included all the individual schemes that were incorporated in the rail assessment.

7.1.2 The objective of this assessment is to identify key potential environmental impacts or constraints arising from new surface transport links to an inner Thames Estuary airport including:

- likely impacts on protected sites, habitats and landscape and the implications in terms of meeting regulatory and planning requirements; and
- any significant local environmental issues (such as air quality, carbon, noise) and potential for mitigation.

7.1.3 The surface access infrastructure requirements involve:

- New rail infrastructure following existing or new rail corridors;
- New road infrastructure; and
- Widening or other improvements on existing highway infrastructure routes.

7.1.4 The assessment is based on preliminary indicative routings. The alignments would need to be developed with more detailed environmental studies and the potential to reduce impacts considered. Therefore, at this strategic level, the focus is on designated sites and other sensitive receptors that might be in close proximity or directly affected by the surface transport improvements within potential transport corridors.

7.1.5 The designated sites considered are limited to sites of international and national importance. These include:

- Ecology: Special Protection Areas (SPAs); Special Areas of Conservation (SACs); Ramsar Sites; Sites of Special Scientific Interest (SSSIs), Ancient Woodlands and National Nature Reserves (NNRs);
- Landscape: Areas of Outstanding Natural Beauty (AONB); and
- Cultural Heritage: Listed Buildings, Registered Parks and Gardens (RPGs) and Scheduled Monuments (SMs).

7.1.6 In addition to designations, the assessment has also considered impacts on:

- Flood Risk: Flood Zone 2[29] and 3[30];
- Agricultural land quality: Grades 1 and 2;
- Noise: Residential properties;
- Carbon: Embedded carbon; and
- Air: Air Quality Management Areas (AQMAs)
- Communities: property impacts.

7.1.7 A summary of the designated features for each route is provided in Appendix B.

[29] This is land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.

[30] This is land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

7.2 Limitations and assumptions

7.2.1 All tunnelled sections have been excluded from the assessment. Impacts from above ground works for tunnels such as vent shafts would need to be considered in later assessment stages if an Estuary airport option was taken forward.

7.2.2 No assessment of noise and air quality impacts arising from the modelled traffic flows has been undertaken. This would not be appropriate for this level of study although would be part of future assessment phases if the Thames Estuary option was taken forward. Therefore, the air quality assessment is limited to the identification of Air Quality Management Areas intersected by the road transport routes and the noise assessment is limited to the identification of potential numbers of receptors in close proximity to the surface access routes.

7.2.3 The identification of noise receptors for the highways improvements has been limited to the new road between the indicative airport location and the A2. Properties adjacent to existing roads are likely to experience existing road noise and a more detailed assessment would be needed to evaluate noise impacts arising from improvements to existing highways as a result of the Thames Estuary airport proposals.

7.2.4 The assessment of embedded carbon considers the length of the surface transport routes and likely lengths of rail track and new highway. At this stage carbon associated with construction activites and specific design requirements such as tunnelling have not been included.

7.2.5 The potential loss or disturbance to designations and other sensitive receptors is based on likely construction footprint rather than permanent footprint of the rail / road corridor. An indicative construction footprint of 100m either side of each route alignment is considered, along with 500m corridor indicative of potential disturbance and a1km corridor to identify potential receptors affected to take account of the potential uncertainty of the route alignments.

7.2.6 The proposed rail routes for the Waterloo Stopper, Strood Shuttle, HS1 Extension, the Crossrail Southern Extension, the Shuttle Service from Grays and the Airport Express all follow the same alignment from Lower Higham to the Hoo Peninsula and in the current analysis they largely affect the same sites. There is higher likelihood of direct loss and disturbance impacts to designated and sensitive sites within the combined 1km corridors. Differences between the potential impacts from these routes which all follow the same broad corridor are due to difference in the exact alignment used within the GIS analysis.

7.2.7 The rail alignment from Lower Higham to the indicative airport site is consistent for a number of the proposed rail links and follows the existing freight rail line, although new tracks would need to be built to accommodate the new services. As noted by Foster +Partners following this corridor and using the same tracks for a number of the services would reduce the potential environmental impacts. Similarly MTTRA have identified the Canvey Hoo tunnel as the best environmental case because it avoids the impacts on Northward Hill nature reserve.

7.2.8 For the assessment of potential environmental risks and constraints related to highways improvements, no distinction has been made between where single lane improvement would be needed compared with where two new carriages are expected. There will be greater impacts associated with two carriage ways compared with one but at this stage of assessment the potential impacts are only being identified at a very high level. In addition no distinction has been made over whether works are required in 2050 or 2030. For this high level review the potential environmental impacts and risks considered are similar whether the works are needed in 2030 or 2050.

7.2.9 One example airport has been selected as the transport destination, this is the Isle of Grain option. This is the basis for determining potential additional impacts over and above the footprint of the airport itself. This will vary for the different airport proposals, for example, TFL has a large footprint and some direct losses to designations from surface access routes will occur within that footprint and therefore, will have been already been considered.

7.3 Assessment for Rail Option 3(a) - excluding Crossrail Northern Extension and Airport Express

7.3.1 Figure 50 and Figure 51 show the proposed routes for options 3(a), 3(b) and 4 with details of the designated sites for nature conservation and cultural heritage interest. Figure 52 shows details of properties close to the routes within options 3(a), 3(b) and 4. Table 28 provides a summary of the environmental constraints for option 3(a).

7.3.2 The three options have a number of routes in common with the Crossrail Southern Extension, HS1 Extension, Strood Stopper, Gray's Shuttle and Waterloo Stopper proposed in all three options. Consequently there is a level of similarity in the potential environment issues for all three options.

Community and Noise

7.3.3 There are a total of 28,497 different residential properties within 500m of all the rail routes within option 3(a) and these could be potential noise receptors for the new railways. Of all the routes within option 3(a), the Crossrail Southern Extension has the highest number of properties within 500m with almost 20,000 residential properties within this distance. This reflects the fact that this alignment passes through urbanised areas.

7.3.4 There are 5500 properties within 100m of the proposed routes in option 3(a). These include 3948 within 100m of the Crossrail Southern Extension. These properties are likely to be directly affected by construction and operation and there would be a risk of loss of some of these properties.

7.3.5 The potential noise receptors are clustered around certain locations for each of the routes as shown on Figure 52. Between the Hoo Peninsula and Lower Higham there are relatively few properties close to the route and those that there are dispersed along the length of the route. However, for the remainder of the routes within option 3(a) there are areas of greater density of properties at Singlewell (Waterloo Stopper and HS1 link), Gravesend, Northfleet, Greenhithe, Dartford, and Thamesmead (Crossrail Southern Extension) and Grays and Tilbury (Grays Shuttle).

Ecology

7.3.6 All the rail routes out to the Hoo Peninsula could directly affect nationally and internationally designated ecological sites, in particular the Medway Estuary and Marshes SPA and Ramsar site and the Thames Estuary and Marshes SPA and Ramsar site, see Figure 55. The longest lengths of route passing through designated sites include:-

- approximately 1.2km of the Crossrail Southern Extension would pass through the Medway Estuary and Marshes (SPA/Ramsar site) designated area; and
- up to 3.7km of the Grays shuttle route would be within the Thames Estuary Ramsar site boundary and 1.7km also lies within the SPA boundary.

7.3.7 For the Isle of Grain option the impacts from the rail routes would be additional to the impacts from the direct land take for the airport footprint. Assuming an approximate construction width of 200m, for one route, this would amount to a loss of an area of around 74 hectares within the Thames Estuary and Marshes Ramsar site and 24 hectares within the Medway Estuary and Marshes, see Figure 53.[31] The area of loss could increase as five railway routes are proposed through this area as part of Option 3(a) but could be reduced through changing the alignment. For TFL, the Medway Estuary SPA and Ramsar site loss is within the footprint of the airport scheme.

[31] This is based on an assumption that 100m either side of the 3.7km line would be affected by construction..

7.3.8 Longer lengths of the rail routes would pass within 100m of both the Thames Estuary and Marshes SPA and Ramsar site and the Medway Estuary and Marshes SPA and Ramsar site and would be likely to have direct effects.

7.3.9 The overall effect on the designated sites is likely to be greater than the area of direct loss with impacts from habitat severance and fragmentation and disturbance which could affect the function of the habitat to support the qualifying species. These effects will need to be taken into account in the assessment of compensation habitat required. The losses would need to be looked at alongside the wider effects of the airport such as disturbance from the airport operations and birdstrike management

7.3.10 This analysis of the internationally designated sites is broadly consistent with the general environmental constraints and risks identified in the response to the Call for Evidence from Foster + Partners. They identified that their proposed railway route would cross a short section of the Thames Estuary and Marshes SPA to the east of Gravesend and that this land-take would have to be compensated for through the provision of replacement habitat. The Transport for London response to the Call for Evidence identified a larger number of internationally designated sites as they used a much wider study area of 10km.

7.3.11 In terms of nationally designated sites, there are also 10 SSSIs within 1km of the routes proposed within Option 3(a). These are: Medway Estuary & Marshes, South Thames Estuary & Marshes, Northward Hill, Swanscombe Skull Site, Bakers Hole, Dalham Farm, Shorne and Ashenbank Woods; Chattenden Woods and Lodge Hill, Globe Pit; Gray's Chalk Pit. The Gray's Shuttle and Crossrail Southern Extension would cross part of the South Thames Estuary and Marshes SSSI for approximately 3.9km with smaller lengths of the HS1 Extension, Strood Shuttle and Waterloo Stopper also passing through this site. The Waterloo Stopper also passes through Shorne and Ashenbank Woods SSSI for approximately 1.4km. Dalham Farm SSSI is very close to the proposed route of all the railway routes out to the Peninsula and is likely to be directly affected.

7.3.12 Foster + Partners noted that their proposal to provide further railway capacity sought to reduce additional impacts on the environment by following an existing transport corridor. They noted that the western end would run through the South Thames Estuary and Marshes SSSI before reaching Gravesend resulting in land-take, loss of habitat and fauna, and increased severance of the SSSI lying to the south of the railway line from the rest of the site. Differences in the exact alignment mean that for example, Foster + Partners have identified Great Crabbes Wood as an additional SSSI which could be impacted.

7.3.13 There are a number of ancient woodlands close to the proposed rail route with 14 areas of ancient woodland within 1km of the proposed routes. This includes four areas of ancient woodland within 100m of the routes and likely to be directly affected by construction through direct habitat loss, severance and fragmentation.

Landscape

7.3.14 The Kent Downs AONB is to the south of the Hoo Peninsula and close to the routes which link to the Peninsula from the south west including the Waterloo Stopper service and the HS1 Extension. Around 1km of the route of the new Waterloo Stopper line would pass directly through the edge of the Kent Downs AONB area.

7.3.15 This Waterloo Stopper route passing through AONB could have a significant impact on the designation. However, it is possible that this alignment could be altered to avoid or minimise this impact.

7.3.16 All of the new rail routes could potentially affect the views across the peninsula from the Kent Downs AONB.

Cultural Heritage

7.3.17 There are a large number of cultural heritage assets on the Hoo Pensilua including a total of 318 listed buildings within 1km of the routes within option 3(a) and 14 Scheduled Monuments within the same rea. This includes for example, 266 listed buildings, including 8 grade I listed buildings within 1km of the Crossrail Southern Extension. These include listed buildings at Church Street and Buckland Farm which are very close to the proposed new railway lines out to the Hoo Peninsula and so could be directly affected. The Scheduled Monument at St Mary's Priory is also within 100m of the new routes.

7.3.18 There are two Registered Parks and Gardens within 1km of the routes contained within option 3(a). These are the Grade II* Gravesend Cemetery on Crossrail Southern Extension and Cobham Hall also Grade II* but directly impacted by the route of the Waterloo Stopper

7.3.19 There would be potential to minimise direct loss of these cultural heritage assets with detailed routing however, it is likely that some assets would be directly affected and the setting for remaining features close to new routes would also be affected.

7.3.20 Foster + Partners noted that the existing railway on the Hoo Peninsula passes close to a number of listed buildings. They report that during project development consideration would be given to assessing vibration impacts and developing measures to mitigate the impact of the additional railway on the setting of heritage features, for example by landscaping. In addition, their response states that the need to demolish a listed building would be avoided as far as possible.

Air

7.3.21 New electric rail routes are unlikely to affect air quality except potentially during construction. It would be expected that good construction management practices would avoid any significant effects.

Carbon

7.3.22 An assessment has been made of the likely embedded carbon associated with rail option 3(a). This is 138920 tCO2e for rail option 3(a).

Figure 50: Ecological and Landscape Designations: Option 3(a) and 3(b): including Crossrail Northern Extension

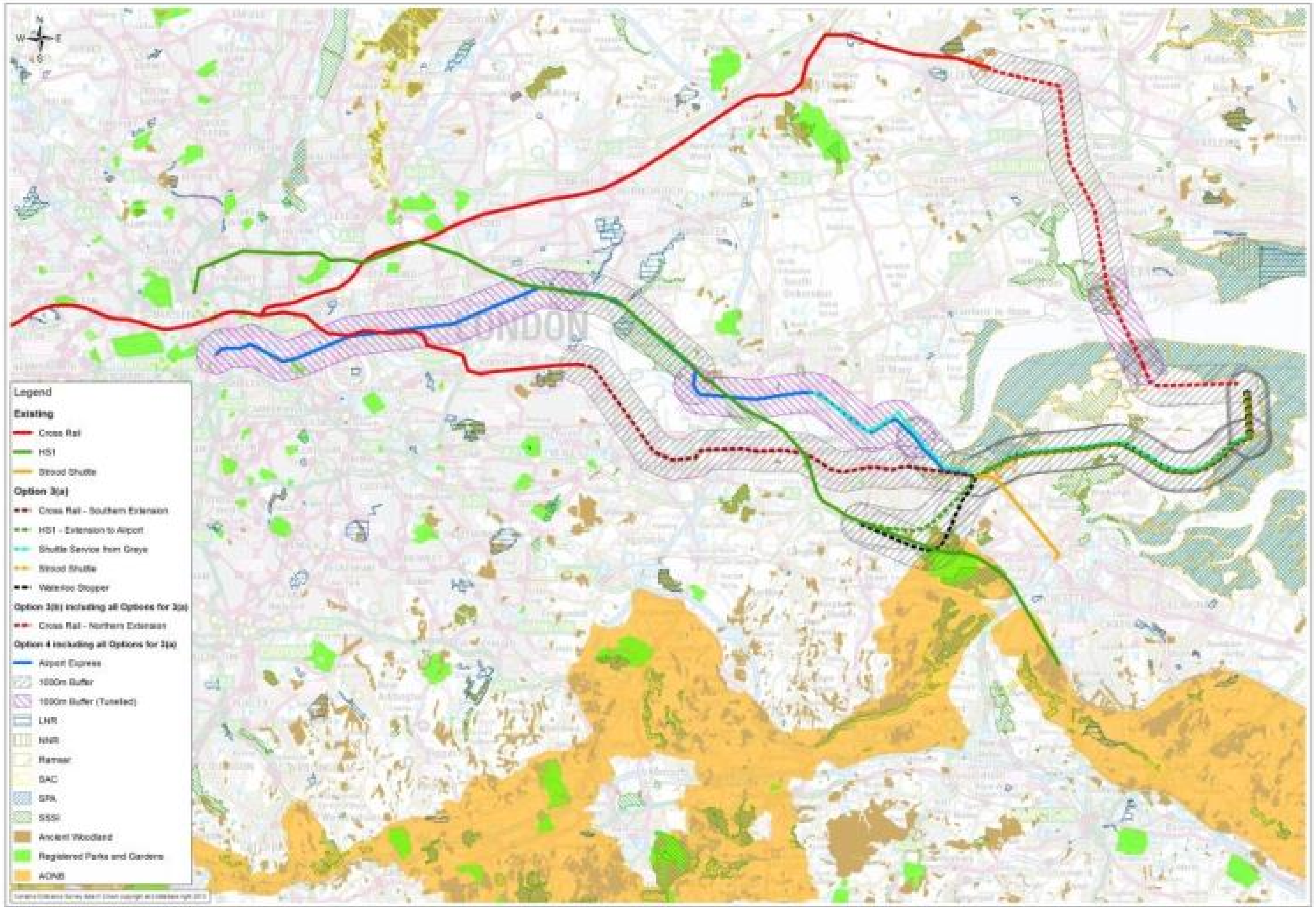


Figure 51: Cultural Heritage Designations: Option 3(a) and 3(b): including Crossrail Northern Extension

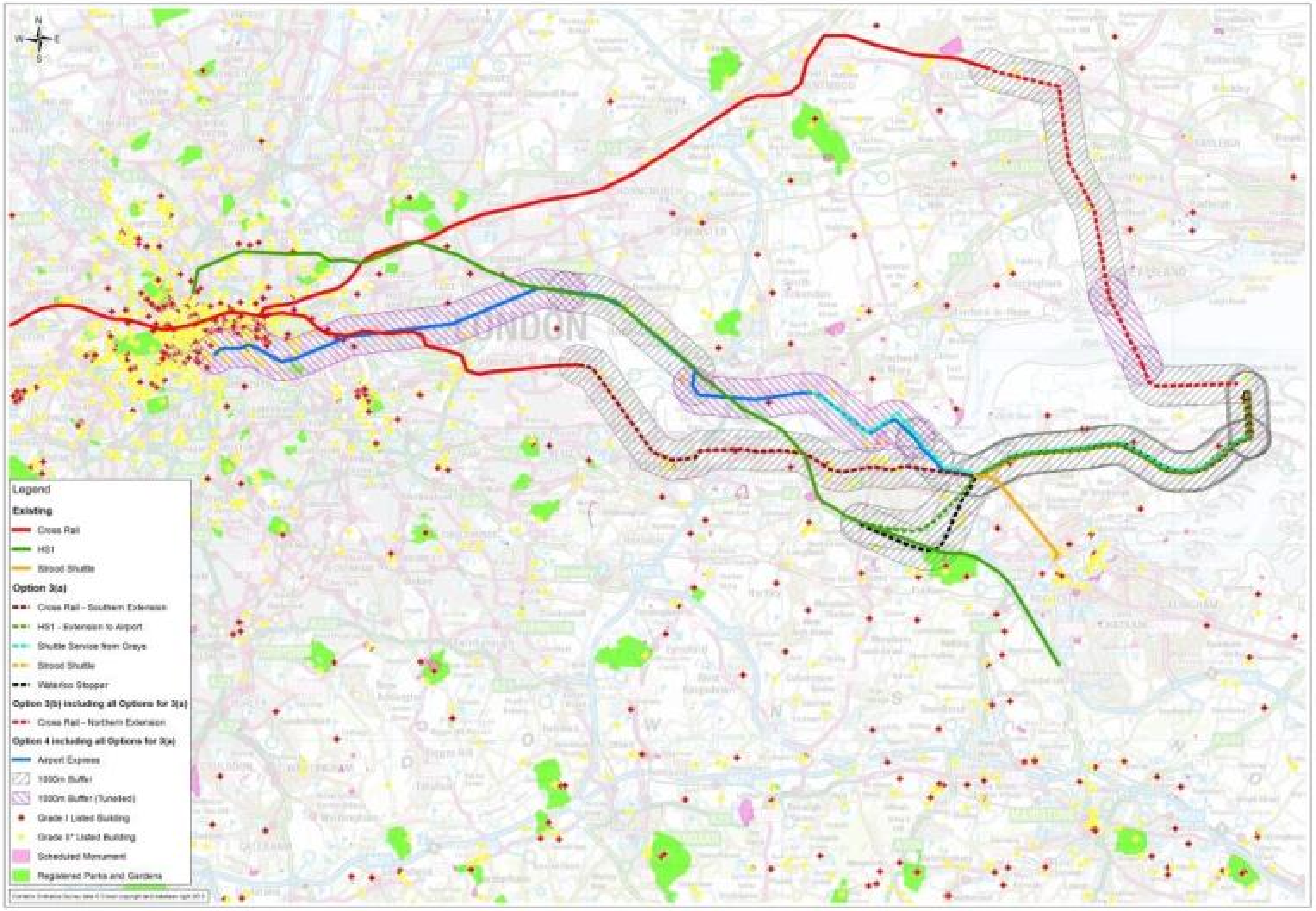


Figure 52: Potential Noise receptors: Option 3(a), 3(b) and 4

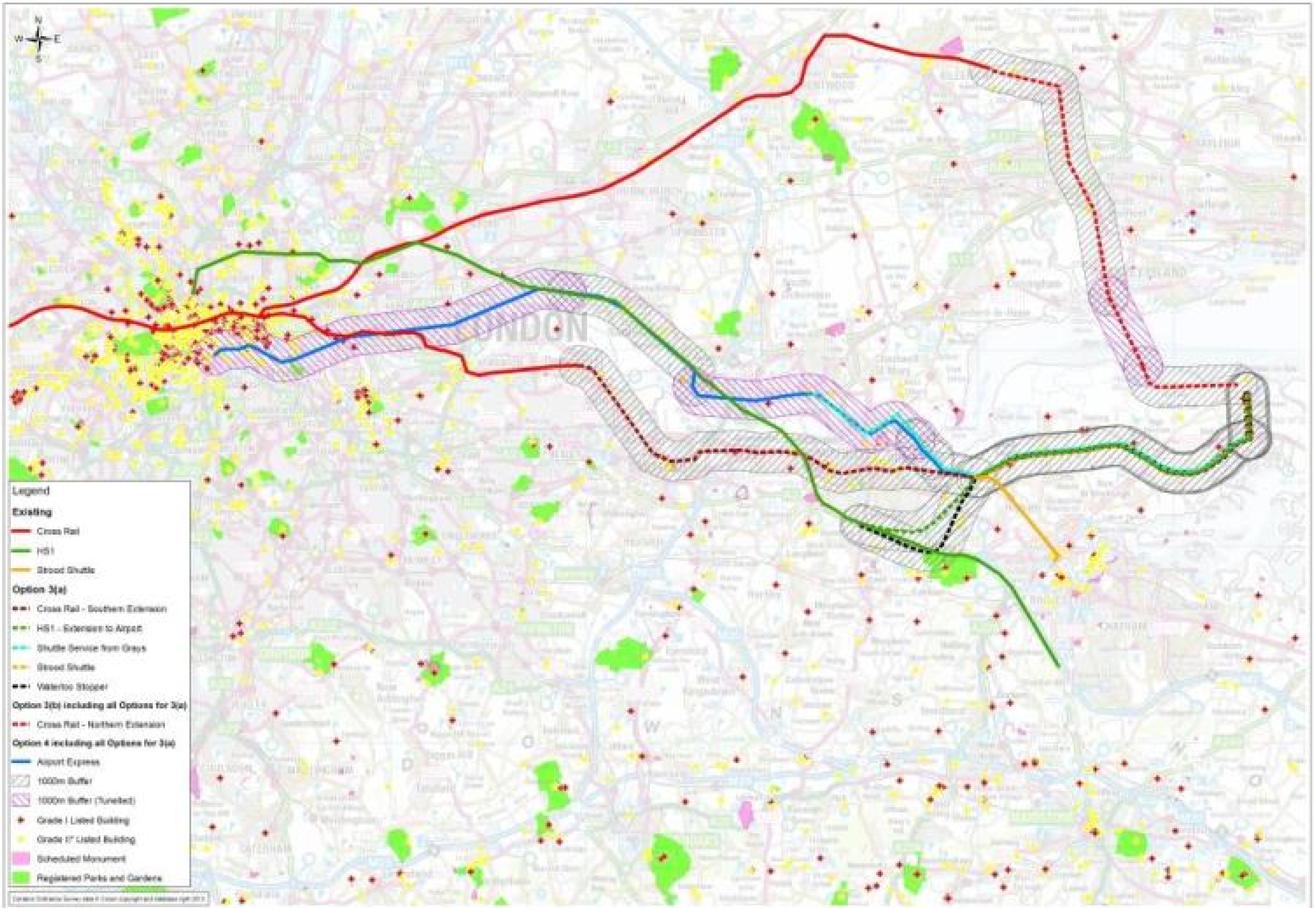


Table 28: Transport options and environmental constraints

Option	SPA*	Ramsar site*	Number of new routes within 100m of SPAs / Ramsar on Hoo Peninsula	SSSI*	Ancient Woodland	NNR*	AONB**	Listed Buildings (1km)	Scheduled Monuments (1km)	RPG (1km)	Residential Properties (500m)	Residential Properties (100m)	SAC	AQMA
Rail 3(a)	2 (2)	2 (2)	5	10 (4)	14 (4)	2 (0)	1 (1)	318	14	2	28497	5500	-	NA
Rail 3(b)	2 (2)	2 (2)	6	12 (6)	17 (5)	2 (0)	1 (1)	337	15	2	32230	6120	-	NA-
Rail 4	2 (2)	2 (2)	6	14 (5)	15 (4)	2 (0)	1 (1)	341	15	2	30499	5712	-	NA-
Road – Extended Base Case	3 (2)	2 (1)	0**	29 (+6 maybe)	314 (+ 213 maybe)	2 (0)	3 (+1 maybe)	1072 (+286 maybe)	45 (+4 maybe)	17	424	72	2	28 (+5 maybe)
Road – Core Base Case	3 (2)	2 (1)	0**	29 (+6 maybe)	321 (+133 maybe)	2 (0)	2 (+1 maybe)	1091 (+210 maybe)	46 (+0 maybe)	17	424	72	2	29 (+4 maybe)

** For the rail options the first number is the number of sites within 1km of proposed route, the number in brackets is the sites within 100m of route. For the road options the first number is the number of sites within 1km of road improvements that will definitely be required and the second number is the number of sites within 1km of roads that 'maybe' required to be improved for that option.*
*** The new road to the airport would pass through an SPA / Ramsar site but within the proposed airport footprint.*

7.4 Assessment for Rail Option 3(b) (including Crossrail Northern Extension)

7.4.1 All of the potential impacts from option 3(a) would also be relevant to option 3(b) as all of the proposed routes within option 3(a) are also part of option 3(b). The addition of the Crossrail Northern Extension would create additional environmental impacts and risks. Table 28 provides a summary of the environmental constraints for option 3(b).

7.4.2 The Crossrail Northern Extension generally affects few designated sites. However, it affects different areas from the other routes within options 3 and 4 and so has the potential to add to the total number of designated sites affected. Therefore, for the overall package of measures within option 3(b) the combined number of environmental constraints and potential impacts are greater than option 3(a) which does not include the Crossrail Northern Extension.

Community and Noise

7.4.3 There are a total of 32,230 different residential properties within 500m of all the rail routes within option 3(b) which could be potential noise receptors. The difference compared with option 3(a) is that around 3700 residential properties lie within 500m of the Crossrail Northern Extension creating additional potential noise receptors. There are 6120 properties within 100m of the proposed routes in option 3(b). This is around 600 properties more than option 3(a) and includes 657 properties within 100m of the Crossrail Northern extension. These properties would be likely to be directly impacted by construction and operation disturbance and there could be a risk of loss of some of these properties.

7.4.4 The Crossrail Northern Extension introduces two additional areas with clusters of properties in close proximity to the route. These are firstly, between Basildon and North Benfleet and secondly, at Wickford. This is shown on Figure 52.

Ecology

7.4.5 The Crossrail Northern Extension would require a northern crossing of the Thames Estuary. This would be achieved using a tunnel (approximately 1.3km in length). As long as the tunnel portals were moved out of the Thames Estuary and Marshes SPA and Ramsar site designated areas additional direct habitat loss could be reduced with only around 100m being identified within the designated area beyond the length of the tunnel. Around 600m of the Crossrail Northern Extension route would be within 100m of the designated sites and so could potentially directly affect it by construction, see Figure 55. In addition, construction of the tunnel portal would be within or very close to the boundaries of the designated sites. This option could have additional impacts on the Thames Estuary and Marshes SPA and Ramsar site compared with option 3(a).

7.4.6 The northern route of the additional crossrail link would also directly impact two additional SSSI, Canvey Wick and Holehaven Creek. Approximately 400m of the route would be within Canvey Wick SSSI and 200m in Holehaven Creek. It would also be within 1km of three additional areas of ancient woodland one of which, Devil's / Crays Woods would be within 100m of the proposed route. Therefore, these sites would be affected through direct habitat loss, severance and fragmentation.

Landscape

7.4.7 There are no additional AONB within 1km of the Crossrail Northern Extension and so the potential impacts on designated landscape is the same for option 3(b) as for option 3(a).

Cultural Heritage

7.4.8 There are a large number of cultural heritage assets on the Hoo Pensilua including a total of 337 listed buildings within 1km of the routes within option 3(b) and 15 Scheduled Monuments within the same distance. This is slightly more than the number of cultural heritage assets within the same distance of the routes within option 3(a) and this is the result of the Crossrail Northern Extension.

7.4.9 There are no additional RPG within 1km of the Crossrail Northern Extension and so the number of RPG potentially affected is the same for option 3(b) as for option 3(a).

Air

7.4.10 New electric rail routes are unlikely to affect air quality except potentially during construction. It would be expected that good construction management practices would avoid any significant effects.

Carbon

7.4.11 An assessment has been made of the likely embedded carbon associated with rail option 3(a). This is 188552 tCO2e for rail option 3(b). This is higher than option 3(a) because of the additional length of track for the Crossrail Northern Extension.

7.5 Assessment of Rail Option 4 (including the Airport Express)

7.5.1 All of the potential impacts from option 3(a) would also be relevant to option 4 as all of the proposed routes within option 3(a) are also part of Option 4. The inclusion of the Airport Express would create additional environmental impacts and risks however, as it part of the route lies along the same corridor as some of the other 3(a) proposed routes, many of the impacts in terms numbers of designations affected, will be similar to those for 3(a). The main additional impacts are outlined below.

7.5.2 Figure 50 and Figure 51 show the proposed routes for option 4 with details of the ecological designated sites and cultural heritage sites. Table 28 provides a summary of the environmental constraints for option 4.

Community and Noise

7.5.3 A total of 30,499 residential properties are within 500m of the routes within option 4. These are potential noise receptors for the new railway routes. The difference in the total number of properties within 500m compared with option 3(a) reflects the fact that there would be around 2000 residential properties within 500m of the Airport Express. There are 5712 properties within 100m of the proposed routes in option 4. This is around 200 properties more than option 3(a) and just under 400 less than option 3(b). These include 231 properties within 100m of the Airport Express. These properties would be likely to be directly impacted by construction and operation disturbance and there could be a risk of loss of some of these properties.

7.5.4 The Airport Express follows a similar route to Gray's shuttle and so would affect similar areas at Grays and Tilbury. It could also affect properties to the south of Dagenham and at Rainham which are within 500m of the route. This is shown on Figure 52.

Ecology

7.5.5 The Airport Express does not additionally affect any internationally designated sites above those potentially affected by the other routes in common with option 3(a). This is because it would follow a similar route to the other rail lines across the Hoo Peninsula. Therefore, direct impacts from habitat loss, severance and fragmentation would be the same as those detailed for option 3(a), as detailed earlier.

7.5.6 However, the Airport Express would be within 1km of four additional SSSIs including Purfleet Chalk Pits and Purfleet Road SSSI and depending on the detailed alignment there is potential for impacts on these sites. Around 2.7km of the route runs through the Inner Thames Marshes SSSI and so there would be direct impacts through habitat loss, severance and fragmentation for this site.

7.5.7 In comparison with the routes in option 3(a) the Airport Express would be within 1km of one additional ancient woodland, Watts Wood and so have the potential for additional impacts.

Landscape

7.5.8 There are no additional AONB within 1km of the Airport Express and so the potential impacts on designated landscape is the same for option 4 as for options 3(a) and 3(b).

Cultural Heritage

7.5.9 There are a large number of cultural heritage assets on the Hoo Peninsula including a total of 341 listed buildings within 1km of the routes within option 4 and 15 Scheduled Monuments within the same distance. This is slightly more than the number of cultural heritage assets within the same distance of the routes within option 3(a) as a result of the Airport Express and broadly consistent with option 3(b).

7.5.10 There are no additional RPG within 1km of the Airport Express and so the number of RPG potentially affected is the same for option 4 as for options 3(a) and 3(b).

Air

7.5.11 New electric rail routes are unlikely to affect air quality except potentially during construction. It would be expected that good construction management practices would avoid any significant effects. Therefore, any potential impact on AQMA is likely to be limited to new station locations.

Carbon

7.5.12 An assessment has been made of the likely embedded carbon associated with rail option 4. This is 223793 tCO2e. This is higher than the other rail options because of the additional length of track for the Airport Express.

7.6 Assessment of road improvements

7.6.1 This assessment considers the new roads proposed to link the indicative airport location on the Hoo Peninsula with the A2. It also considers the capacity improvements (new lanes) required on certain sections of road in order to deal with the additional roads using the network to get to the airport. This includes a core base case and an extended base case. The main difference between these is that in the extended base case a lower Thames crossing is assumed to have been built. The core base case does not allow for this and consequently a larger number of road capacity improvements may be needed on the existing road network in the core base case. Both the core and the base case allow for a new link road between the airport location and the A2.

7.6.2 Due to uncertainty in the future traffic predictions at this stage, some improvements would definitely be required and some others may possibly be required. Where relevant to likely environmental risks or constraints these are highlighted separately below.

7.6.3 Figure 53 to Figure 57 show the designated sites and environmental constraints identified in relation to the proposed road improvements.

7.6.4 A summary of the designated features for relevant to the road improvements is provided in Appendix B.

Extended Base Case - Air

7.6.5 The new road link required from the indicative airport location to the A2 would generally be away from the AQMAs with the exception of where the road joins the A2.

7.6.6 For the capacity improvements required for the extended base case there are 33 AQMAs within close proximity to the road improvements. In particular, the road improvements needed on the M25 to the north and north east pass through existing AQMAs as shown in Figure 53 below.

7.6.7 Of these 33 AQMAs, five are adjacent to a road which are identified as 'maybe' requiring capacity improvement under the extended base case. These are AQMA No.3 (M26), AQMA No.6 (M25-PM10),South Bucks AQMA, Barking and Dagenham and Thurrock AQMA.

Extended Base Case - Landscape

7.6.8 The Chilterns AONB, High Weald AONB, Kent Downs AONB and Surrey Hills AONB are all located in close proximity to roads identified for capacity improvements.

7.6.9 The Surrey Hills and Kent Downs AONB both have sections of road that require capacity improvement. For the Kent Downs AONB this would include part of the new link road to the airport and its junction with the A2. Figure 5 below shows the location of the AONBs. A new link road through the AONB is likely to involve a significant impact on the designated landscape.

7.6.10 The Chilterns AONB is within 1km of improvement work identified as only 'maybe' being required for the extended base case for 2030, (junction 16 and 17 on the M25).

7.6.11 High Weald AONB is within 1km of the improvements that would be needed between junction 8 and 9 on the M23. This improvement is only needed in the extended base case.

Extended Base Case - Ecology

7.6.12 Three SPAs and two Ramsar sites have been identified close to the road improvements. The new link road to the airport site would pass through the Thames Estuary and Marshes SPA and Ramsar site on its route to the airport site for 2.5 – 3km (2.5km for the SPA and 3km for the Ramsar site) however this is likely to have already been affected by the footprint of the airport scheme and so will have already been considered as part of the impacts from the airport, see Figure 58. The improvements to A127 approaching Southend on Sea would be within 1km of Benfleet and Southend Marshes SPA and Ramsar site at its very southern most end. Works between junction 9 and 10 on the M25 and on the A3 up to the M25 would include sections of road within the boundary of the Thames Basin Heaths SPA designation.

7.6.13 The consideration of the wider road network improvements required and designated sites within these areas is the reason why additional sites have been identified, compared with for example Foster + Partners' response to the Call for Evidence. This noted that their proposed new highway link skirts the Medway Estuary and Marshes SPA and Ramsar sites and that this would be mitigated by modifying the alignment to lie outside the designated site.

7.6.14 Three SACs have been identified as close to the proposed capacity improvements. Epping Forest adjacent to improvements between Junction 25 and 26 on the M25 and Mole Gap to Reigate Escarpment adjacent to improvements between Junction 8 and 9 on the M25. There could be disturbance impacts during construction and indirect effects such as air deposition. Queendown Warren SAC is adjacent to the improvements on the M2 between Junction 4 and the local authority boundary. This upgrade has only been identified as 'maybe' required for the 2050 extended base case.

7.6.15 There are 35 SSSI within 1km of the proposed highways improvements for the extended base case. This would include lengths of road passing through SSSI designations in four locations including 2.8km at Chattenden Woods and Lodge Hill SSSI and 3km of South Thames Estuary and Marshes. The improvements between the junctions with A1306 and M26 would affect 2.9km of the Inner Thames Estuary SSSI.

7.6.16 Of these 35 SSSI there are six which are within 1km of road improvements which have been identified as only ‘maybe’ being required. These are Kingcup Meadows & Oldhouse Wood; Purfleet Chalk Pits; Purfleet Road, Aveley; Queendown Warren; Purple Hill and Inner Thames Marshes.

7.6.17 There would be a large number of ancient woodlands within 1km of the proposed improvements. This would include 163 ancient woodlands within 100m of the proposed improvements of which 49 are within 100m of improvements which have been identified as only ‘maybe’ being required.

7.6.18 Figure 55 below shows the location of the designated sites.

Extended Base Case - Cultural Heritage

7.6.19 There are 49 Scheduled Monuments within 1km of the road capacity improvements required for the extended base case, see . Of these four are within 1km of roads that have been identified as only ‘maybe’ requiring capacity improvements. These are the Site of moated manor house E of St Michael's Church, Aveley, Fort Halstead, Moated site 200m north west of Chalfont Lodge, Medieval moated site and earlier earthwork south of Boughton Hall.

7.6.20 There are 1358 listed buildings within 1km of the proposed capacity improvements, of which 286 are adjacent to roads which are identified as ‘maybe’ requiring capacity improvement under the extended base case. The cultural heritage designations are shown on Figure 7 below.

7.6.21 There are 17 Registered Parks and Gardens within 1km of the road improvements within the extended base case

Extended Base Case - Noise

7.6.22 At this stage the numbers of properties close to the new roads needed for the airport have been considered as potential receptors that could experience increased noise. There are 424 residential properties within 500m of the proposed new roads which could be potential noise receptors. This includes a concentration of properties at High Halstow. There are 72 properties within 100m of the new link road and so potential directly affected by construction. These are shown on Figure 8.

Extended Base Case - Carbon

7.6.23 An assessment has been made of the likely embedded carbon associated with the road improvements. This is 130975 tCO_2e.

Core Base Case - Air

7.6.24 The core base case scenario is very similar to the extended base case with the same 33 AQMAs within 1km including the AQMA where the new airport link road joins the A2 / M2. The difference compared with the extended base case is that Thurrock AQMA would be adjacent to a road which would definitely need to be upgraded in the core base case.

Core Base Case - Landscape

7.6.25 The Chilterns AONB, Kent Downs AONB and Surrey Hills AONB are all located in close proximity to roads identified for capacity improvements in the core base case. The Chilterns AONB, Kent Downs AONB and Surrey Hills AONB are all consistent with the extended base case with the Chilterns AONB within 1km of improvement work identified as only ‘maybe’ required for the core base case for 2030, (junction 16 and 17 on the M25).

Core Base Case - Ecology

7.6.26 No difference has been identified for the potential impacts on international sites and SSSI from the core base case compared with the extended base case.

7.6.27 There are slightly fewer ancient woodlands within close proximity to the road improvements within the core base case compared with the extended base case. This includes 145 ancient woodlands within 100m of the core base improvements compared with 163 for the extended base case. Of these 145 there are 40 which would be witin 100m of road improvements identified as only ‘maybe’ being required.

Core Base Case - Cultural Heritage

7.6.28 There are 46 Scheduled Monuments within 1km of the road capacity improvements required for the core base case. This is three less than the extended base case with the following Scheduled Monuments not within 1km of the core base case road improvements: Bletchingley castle (ringwork and bailey), Moated site and associated earthworks on Pound Hill, 700m east of Gatwick Stream and Thunderfield Castle medieval moated site. None of these are on routes identified as only maybe needing improvement.

7.6.29 There are 1301 listed buildings within 1km of the proposed capacity improvements of which 210 are adjacent to a road which are identified as ‘maybe’ requiring capacity improvement under the core base case. The cultural heritage designations are shown on Figure 7 below.

7.6.30 The same 17 Registered Parks and Gardens are within 1km of the core base case as the extended base case.

Core Base Case - Noise

7.6.31 The new link road from the A2 to the indicative airport site is included in both the extended base case and core base case and so the potential noise receptors identified at this stage is the same for the core base case as the extended base case.

Core Base Case - Carbon

7.6.32 An assessment has been made of the likely embedded carbon associated with the road improvements. This is 130975 tCO_{2e}.

7.7 Environmental Summary

7.7.1 The rail option 3(a) comprises Crossrail Southern Extension, HS1 Extension, Strood Stopper, Gray’s Shuttle and Waterloo Stopper and these are also included in option 3(b) and option 4.

7.7.2 The key potential impacts from option 3 (a) are:

- A total of 28,497 residential properties lie within 500m of all the rail routes in option 3(a) of which 5500 properties are within 100m. These properties are likely to be directly affected by construction and operation and there would be a risk of loss of some of these properties.
- Impacts on internationally designated sites: the Medway Estuary and Marshes SPA/Ramsar site and the Thames Estuary SPA/Ramsar site. The five rail routes passs through or close to these international sites on the Hoo Peninisula. The impacts would be from direct loss of habitat along the infrastructure corridors but also with additional effects on the function of the habitat through severance and fragmentation as well as disturbance.
- The Medway Estuary and Marshes area affected is close to the indicative airport site and may be affeced by airport disturbance impacts. However the routes also pass through the western part of the Thames Estuary and Marshes and for airport options on the Isle of grain side this would be a clear additional impact. Direct habitat loss within this designated site for a single route is estimated to be around 74 ha but the overall losses for all the routes combined and the fragmentation effect would be greater. There may be potential to avoid the impacts on the Thames Estuary and Marshes SPA/Ramsar through tunnelling.
- Four SSSIs are likely to be affected by direct impacts as they are within 100m of the proposed new routes.
- Cultural heritage impacts include listed buildings at Church Street and Buckland Farm which are very close to the proposed new railway. The Scheduled Monument at St Mary's Priory is also within 100m of the new routes.
- The rail infrastructure is likely to be visible from the AONB and the Waterloo stopper could encroach into the AONB designated area although there may be potential for mitigation through route alignment and design.

7.7.3 There are additional impacts arising from the Crossrail Northern Extension in option 3(b) and the Airport Express for option 4 compared with option 3(a).

7.7.4 Option 3(b) would potentially affect in addition to the option 3(a) impacts:

- an additional 3700 properties within 500m of the Crossrail northern extension route;
- tunnel construction close to an SPA/Ramsar site;
- two additional SSSIs directly affected; and
- greater embedded Carbon than option 3(a) with the additional route construction.

7.7.5 Option 4 would potentially affect in addition to the option 3(a) impacts:

- An additional 2000 properties lie within 500m of the Airport Express
- Potentially additional impacts on SSSIs including passing through the Inner Thames Marshes SSSI; and
- Higher embedded carbon that option 3(a) due to the additional route construction and this is also higher than for option 3(b).

7.7.6 Roads impacts relate to a new road proposed to link the airport to the A2 and capacity improvements needed on the existing road network to increase capacity. The two main scenarios considered are the Extended base case and the core base case and an extended base case, with the latter including the effects on capacity from the lower Thames crossing.

7.7.7 Key potential road related impacts for the extended base flows:

- A new link road to the A2 is within the Kent Downs AONBs
- Road improvements include sections of the M25 through the Thames Basin heaths SPA
- Potential road improvements pass through 4 SSSIs
- The capcity improvements are close to 33 AQMAs including capacity improvements on the M25.
- Approximately 424 properties lie within 500m of proposed new link road and 72 properties within 100m.
- A number of scheduled monuments and listed buildings are located within the road corridors and could be at risk from construction depending on the detailed alignments or capacity improvements.

7.7.8 The impacts for the core base flow scenario is very similar to the extended base case in terms of where road improvements or additional capcity is required. The main differences are the number of additional carriage ways that would need to be constructed on existing roads and the effects of widening would need to be considered at a later stage of assessment if the Thames Estuary option is taken forward.

7.7.9 For all the rail options, the rail route corridor on the Hoo peninsula is likely to add further to the airport impacts on international sites. Also for all road traffic scenarios, there is potential for impacts on international sites from road capacity improvements outside the Hoo peninsular, distant from the airport.

7.7.10 Under the Conservation of Habitats and Species Regulations, the transport proposals would need to be subject to Habitats Regulations Assessment (HRA). The HRA steps and requirements are explained in more detail in the Estuary Feasibility Study No 1: Environment/Natura 2000 impacts. Appropriate assessment of the effects on the international designated sites would need be undertaken. This might be undertaken separately for individual routes but would still need to take account of the in-combination effects with the other planned transport developments and the airport itself. The potential for route alignments and design options to avoid or minimise impacts on the Natura 2000 sites would need to be fully explored as part of the appropriate assessment and consideration of alternatives. Where likely significant adverse effects on the Natura 2000 sites are identified and it is demonstrated that there are no alternatives and that the development was needed for imperative reasons of overriding public interest (IROPI), then compensatory measures would be required to maintain the integrity of the Natura 2000 network.

7.7.11 The effects of the surface access routes on habitat loss and fragmentation are likely to increase the total area of compensatory habitat that would need to be provided for the airport development. This is particularly the case, where the impacts on the international sites occur outside areas already affected by the airport. The compensatory measures would need to capture the overall effects of the proposals on the function of the Thames Estuary and Marshes and Medway Estuary and Marshes SPA and Ramsar sites to support the species they are designated for.

7.7.12 Mitigation measures would also be required to minimise potential impacts on other designated sites such as SSSIs, NNRs and sensitive receptors, this would include detailed routing and option design, increased tunnelling lengths, restrictions on construction, screening and other measures to reduce disturbance such as noise barriers.

7.7.13 Even with mitigation, it is likely that the proposed surface transport access routes would generate new environmental impacts and increase the cumulative effects from the development of a hub airport on the Hoo Peninsula. In addition, the road capacity improvements would result in environmental impacts on designations and sensitive receptors some distance from the airport development.

Figure 53: AQMAs and Flood zones: Road Improvements

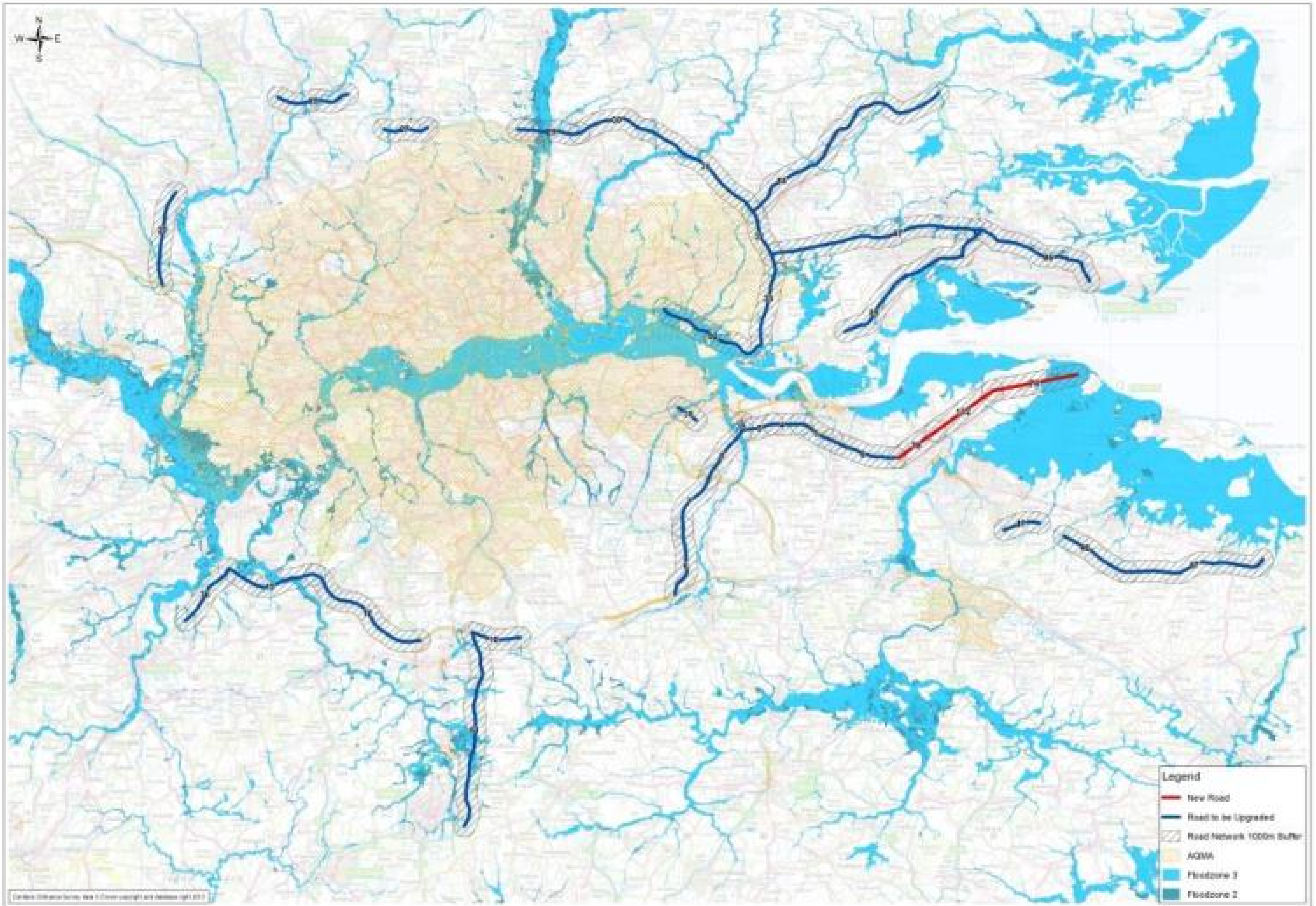


Figure 54: Ecology and Landscape Designated Sites: Road Improvements

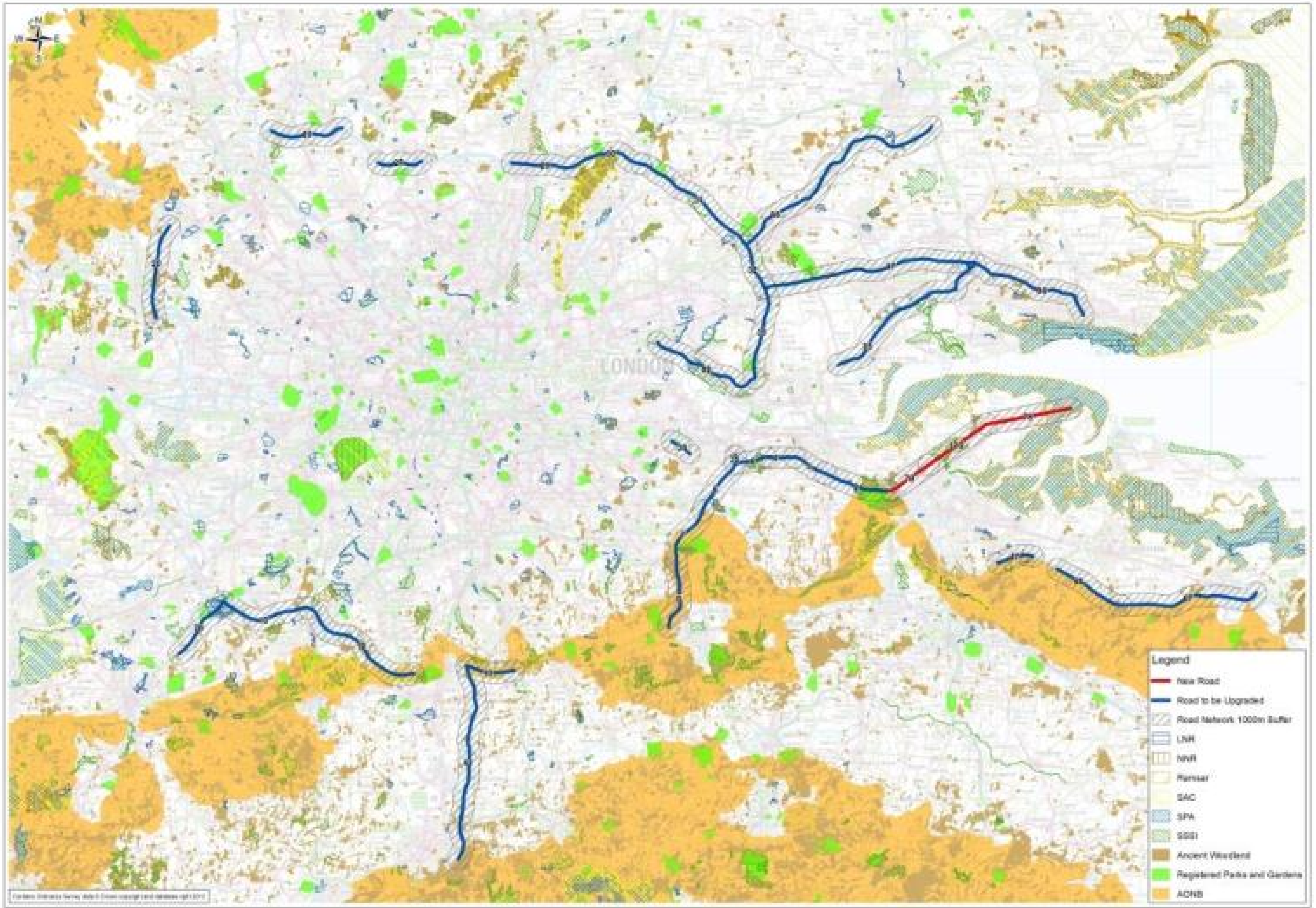


Figure 55: Road and rail Improvements intersecting designated sites

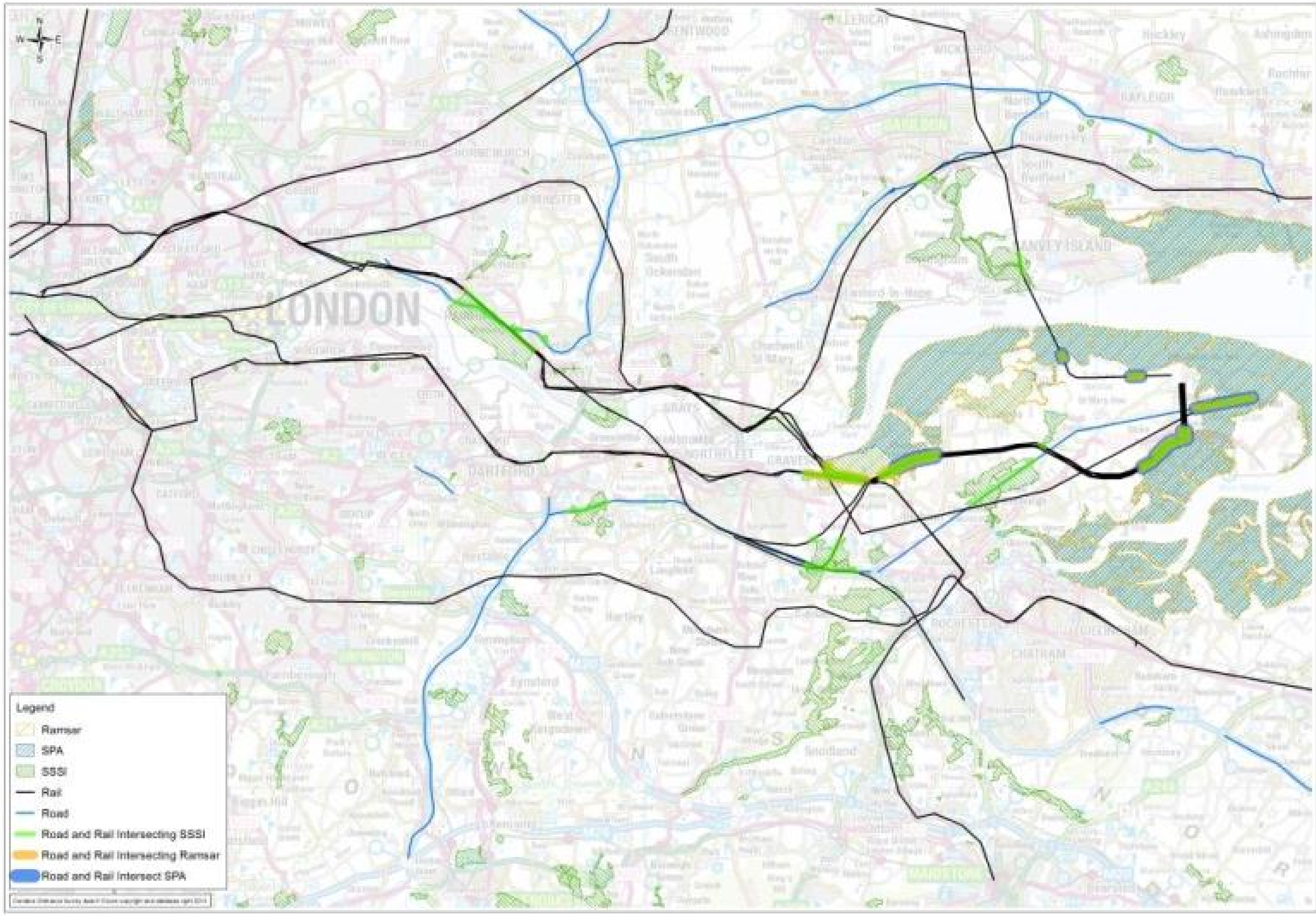


Figure 56: Cultural Heritage Designated Sites: Road Improvements

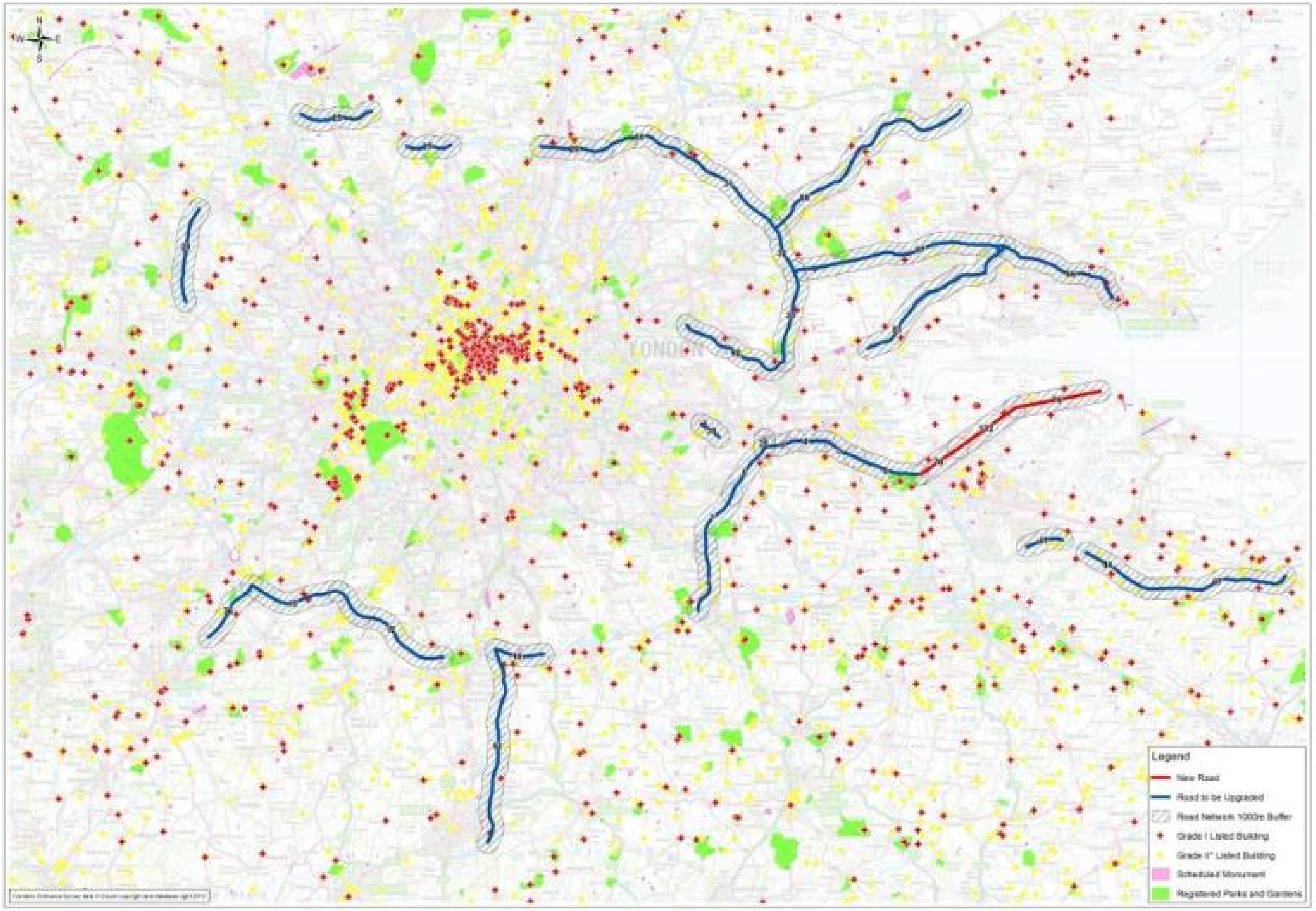
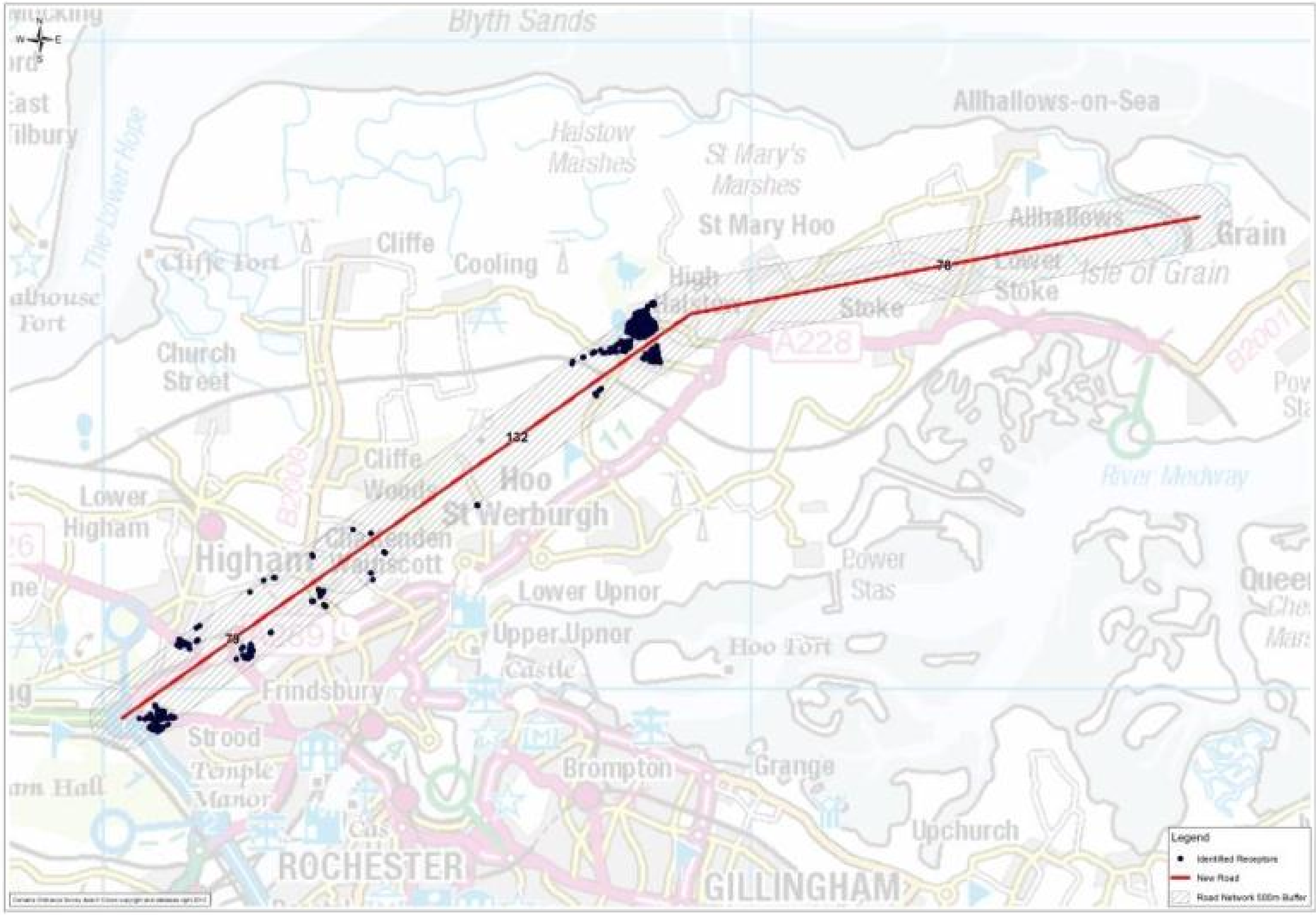


Figure 57: Potential Noise receptors for new airport link road



8. Summary and conclusions

8.1 Approach

8.1.1 In its Interim Report, issued in December 2013, the AC stated that additional analysis was required to determine whether the proposal for a new hub airport in the ITE should be added to the shortlisted options for more detailed assessment. A number of studies were commissioned, including this one assessing the surface transport impacts of an ITE airport.

8.1.2 The objectives of this ITE surface transport study were four-fold: estimating airport passenger and employee surface transport demand; identifying surface transport measures to meet airport-related demand; assessing the engineering feasibility and high-level cost of the surface transport measures identified to meet forecast travel demand; and assessing the environmental cost of the identified surface transport measures. Assessments were undertaken for an 'opening year' of 2030 and a 'mature year' of 2050. A core baseline and an extended baseline of infrastructure schemes that would be developed irrespective of the ITE were defined, and infrastructure packages required to cater for the ITE airport-related demand were devised and assessed.

8.1.3 Demand/capacity assessments are required to be undertaken at peak hour level rather than annual or daily level. Thus, from assumptions on million passengers per annum (mppa) at an airport in the ITE and current observed factors at a number of comparator airports (notably Heathrow), we were able to derive peak hour ITE airport-related passenger and employee demand levels.

8.1.4 The next key task was to determine the private/public transport mode share and the rail sub-mode share. Currently, 59% of passengers at Heathrow travel to the airport by car or taxi, and of the 41% who travel by public transport, 28% use rail and 13% bus/coach. Similarly, around 50% of employees at Heathrow currently commute to the airport by car/taxi, with the 47% public transport mode share split between 35% using bus and 12% using rail.

8.1.5 All the ITE proposals received by the AC appear to be optimistic regarding the predicted public transport (and particularly rail) ITE airport mode shares, with passenger rail mode shares of around 60%-65% and employee mode shares of around 60%-75% assumed.

8.1.6 We challenged these assumptions and undertook benchmarking studies against other European and global hub airports. Although three European airports currently achieve passenger rail mode shares of above 40% (Copenhagen 58%, Zurich 42% and Oslo 39%), these are small airports located close to city centres. Comparisons against other larger hub airports in Europe and globally revealed similar passenger rail mode shares at Heathrow (for example at Schipol and Hong Kong). Taking into account the likely feasible level of rail provision to the ITE airport, the impact of further travel demand measures and these international comparisons, we derived our key assumptions of 40% passenger rail mode share and 25% employee rail mode share.

8.1.7 We then had to define the surface access trip distribution of passengers and employees at the new ITE airport. To do this, we developed and calibrated a trip distribution model for Heathrow (based on CAA 2012 passenger survey data), assumed the calibrated parameters remained constant, and used the model to predict passenger and employee trip distribution at the ITE airport. Despite the distribution model having a relatively simple structure, the model calibrated well and the predicted trip distributions for the ITE airport appeared realistic in an end-state scenario, not accounting for any transitional impacts. London was still the main orgin/destination but more trips were drawn from Kent and Essex than the Thames Valley. A key assumption is that the trip distribution pattern of employees observed at Heathrow (with around 50% of employee trips drawn from the six nearest boroughs) is maintained at the ITE airport, with around 50% of employees drawn from the nearest towns in Kent and Essex.

8.1.8 The next task was to assign the ITE airport surface transport trips to the respective rail and highway networks.

8.1.9 To assign the rail trips, we developed and calibrated a logit rail assignment model for Heathrow (based on CAA 2012 passenger survey data), assumed the calibrated parameters remained constant, and used the model to predict the rail sub-mode share for the various rail options defined. It was important to develop this logit model to predict the mode share of rail services with different pricing structures (airport express premium fares v standard fares), different service levels (including service frequency) and different journey times. The rail logit model calibrated well to the base Heathrow data and was used to predict flows on the different rail services identified to the airport. We held discussions with Network Rail and TfL to derive the non-airport related background demand that was predicted to use each rail service in 2030 and 2050, to determine whether additional capacity was required to cater for airport-related demand and to assess the impact of background demand on passenger level of service.

8.1.10 To assign the car/taxi trips, we defined a strategic road network of the motorways and major A-roads that car trips would use to access the airport. We extracted 2012 daily observed flows on each of the links from the TRADS database and used DfT National Traffic Model (NTM) outputs to forecast the increase in background non-airport related demand in 2030 and 2050. This enabled us to identify capacity issues not related to the ITE airport. We then manually assigned the ITE airport-related demand and identified capacity issues on individual links caused by ITE airport-related traffic.

8.1.11 Once the demand models had been set up, we derived a series of infrastructure options in order to determine the level of new infrastructure required to support the ITE airport.

8.1.12 From our own analysis of the schemes likely to be suitable to serve the ITE airport, and an analysis of the schemes put forward in the ITE submissions received by the AC (some of which were included and some of which were excluded for either rail network capacity or demand-related issues), we defined four rail options to test. These can be summarised as follows:

- Rail Option 1 - minimum requirements - consisting of the HS1 express spur, the Crossrail southern extension, and rail shuttle services from Grays and Strood;
- Rail Option 2 - enhanced National Rail connections - consisting of Option 1 plus the addition of a direct service to Waterloo calling at Bromley South and Swanley;
- Rail Option 3 - Crossrail northern extension - consisting of Option 2 plus the extension of the northern branch of Crossrail from Shenfield through Billericay to the airport;
- Rail Option 4 - enhanced express connections - consisting of Option 2 plus the addition of the Mayor of London's express service to Waterloo via Barking Riverside, Canary Wharf, and London Bridge.

8.1.13 The rail logit model predicted that in option 1, 34% of the rail demand would use the HS1 express spur, 43% would use Crossrail and 22% would use the various National Rail services. The addition of the Waterloo stopper service in option 2 is predicted to take 15% of rail demand, derived almost equally from the HS1 and Crossrail services. The additional of the Crossrail northern extension in option 3 is predicted to increase the Crossrail demand only marginally, as the Crossrail southern extension is far quicker from central London. The additional of the Airport Express Railway in option 4 is predicted to take 23% of rail demand, derived mostly from Crossrail but also from HS1 and National Rail services.

8.1.14 The key questions are how does the predicted (background and airport-related) demand compare to the capacity, and what package of rail services are required to meet the level of predicted demand, whilst providing for different levels of service quality?

8.2 Conclusions

Rail assessment

8.2.1 Following an assessment of the ITE submissions received by the AC and discussions with relevant organisations, four rail options were assembled to be assessed as part of this study. These were as follows:

- Rail Option 1 – minimum requirements – consisting of the HS1 express spur, the Crossrail southern extension, and rail connections from South Essex and North Kent via shuttle services from Grays and Strood stations (Network Rail advised during the study that running direct services to the airport from the Chatham Main Line and Fenchurch Street Line would be difficult due to severe line utilisation issues);
- Rail Option 2 – enhanced National Rail connections – consisting of Option 1 plus the addition of a direct service to Waterloo calling at Bromley South and Swanley (the 'Waterloo Stopper');
- Rail Option 3 – Crossrail northern extension – consisting of Option 2 plus the extension of the northern branch of Crossrail from Shenfield through Billericay to the airport;
- Rail Option 4 – enhanced express connections – consisting of Option 2 plus the addition of the Mayor of London's express service to Waterloo via Barking Riverside, Canary Wharf, and London Bridge.

8.2.2 Generalised Cost estimates (accounting for the impact of rail journey times, wait times, interchange times and assumed fares) were developed for each identified scheme and the parameters from a calibrated sub-rail mode share model were used to forecast sub-rail mode share to the ITE in each option, indicated in the table below. This rail mode share forecast was then assigned to rail corridors serving the airport and was compared with background demand estimates provided by TfL and Network Rail, and the following conclusions were drawn.

Table 29: Overall forecast rail mode share for the ITE Airport

Rail mode	Option 1	Option 2	Option 3	Option 4
HS1	34%	29%	28%	21%
AEX	~	~	~	23%
Crossrail	43%	36%	39%	28%
Network Rail	22%	35%	33%	28%
North Kent Lines	*12%*	*11%*	*11%*	*9%*
South Essex Lines	*10%*	*10%*	*7%*	*7%*
Waterloo Stopper	*~*	*15%*	*15%*	*11%*
TOTAL	**100%**	**100%**	**100%**	**100%**

8.2.3 In 2030, from a purely demand/capacity viewpoint, rail option 1 provides sufficient rail capacity to cater for the predicted demand. Loadings of just under 50% are predicted on HS1, between 26%-93% on the various sections of Crossrail (much of these loadings are non-airport related background demand), between 25%-110% on the North Kent lines (with the one line section which is over-capacity - Swanley-Strood - predicted to be close to capacity in 2020 without the ITE airport) and between 14%-93% on the South Essex Lines. This option would provide passenger choice between a premium, uncrowded, HS1 service to St Pancras, a crowded (in the central sections) Crossrail service to Central London, and generally uncrowded local services to Kent and Essex. It represents the "minimal acceptable" option and there appears to be little difference when compared with the current situation experienced by rail passengers travelling to and from Heathrow. The disadvantages of the option are that there is not a direct link to south and west Central London, with passengers required to interchange at St Pancras or the central Crossrail stations – there would therefore be negative impacts for rail passengers who currently access Heathrow via rail termini in south and west Central London.

8.2.4 The introduction of the Waterloo stopper in option 2 reduces the predicted loadings on HS1, Crossrail and other Network Rail services, but the predicted loadings on the Waterloo stopper service itself are between 120%-145% (assuming 2 tph). Of this total demand, the vast majority (90%-115%) is predicted to come from non-airport related background demand, rather than ITE airport demand. Discussions with Network Rail indicated that capacity limitations on this line are severe, with a flat rail junction at Herne Hill. However, there is the possibility of opening up the ‘Bromley North Branch Line’ via London Bridge, which could accommodate some local demand and leave sufficient capacity for ITE airport demand on the route to Waterloo. If this link can be constructed and if other local capacity issues can be resolved, the advantage of option 2 over option 1 is that it provides a direct connection between the ITE airport and Waterloo.

8.2.5 The introduction of the Crossrail northern extension in option 3 is predicted to carry almost zero demand as it is a much longer route from central London than the Crossrail southern extension so it was logical to assume that Crossrail passengers boarding in the core section would wait on platforms for southern branch services rather than incur a longer journey time. In addition, due to the assumption that the line would run on the surface between Canvey Island and Shenfield, few stations have been defined in Essex between Shenfield and the ITE airport. The cost of changing this alignment to provide a direct connection to Basildon station appear to be significant and therefore option 3 would appear to have negligible benefits.

8.2.6 The introduction of the airport express rail link in option 4 is predicted to reduce the loadings on HS1 by around 10%, and only slightly reduce the loadings on Crossrail (by 1%), the Network Rail services (by 1%) and the Waterloo stopper (by 8%). The loadings on the AEX service itself are predicted to be between 27%-34%. Thus the AEX does not significantly reduce the loadings on the other services which are close to (Crossrail 91%) or over capacity (Waterloo stopper 136%). What it does do is to provide a premium, direct, high quality service to Waterloo. It therefore represents an "optimal option" in terms of passenger level of service. Furthermore, if 4tph paths are not available on HS1, an alternative premium service to Central London would be required.

8.2.7 In 2050, while the predicted loadings on HS1 are between 61%-67% in option 1, this option does not provide sufficient capacity for background demand plus airport-related demand on other key links. The loadings due to background demand on the central sections of Crossrail are predicted to be over capacity (106%) and the addition of the ITE airport demand increases the loadings to 115%. The loading due to background demand on the key London-bound section of the Chatham Main Line (Rochester -Swanley) is also predicted to be overloaded (at up to 125%) and the addition of the ITE airport demand is predicted to increase this loading to 133%. Thus option 1 is not feasible in 2050. Neither is option 2, unless (as in 2030) additional capacity is provided between Bromley and Central London. The comments for option 3 stated above in 2030 apply equally well in 2050 and option 3 provides negligible benefits.

8.2.8 Thus in 2050, we would recommend that option 4 is the best solution. Loadings of between 38%-42% are predicted on HS1 and 38%-48% on AEX. However, the central section of Crossrail is still predicted to be overloaded (at over 110%) and the Rochester-Swanley section of the Chatham Main Line is also predicted to be overloaded (at up to 130%), primarily due to the growth in background demand as London grows as a city.

8.2.9 Our analysis also suggested that Options 1 and 4 provided shorter average rail journey times than Options 2 and 3. However, the overall average rail journey time weighted by forecast passenger demand in all four options ranged between 80 and 90 minutes, and the analysis indicated that the average rail passenger would have a shorter rail journey to Heathrow in 2030 than they would to the ITE (accounting for the trip distribution/mode share assumptions and rail options tested for the ITE as part of this study) – this included trips from many key locations such as Westminster and Kensington & Chelsea. This simply reflects the fact that in general terms, Heathrow is likely to be located closer to key population and employment centres across the UK in 2030 and 2050 than the ITE. A test was also run to calculate rail journey times to the ITE using the Heathrow 2030 distribution of rail passengers, which indicated that in this instance average rail time would be even longer to the ITE, reflecting the potential transitional impacts that may be experienced at the ITE immediately after opening.

8.2.10 Thus in summary, while rail Option 1 would accommodate predicted demand in 2030, it is dependent on 4 rail paths per hour being available on HS1 and a significant proportion of ITE passengers (around 45%) would experience crush capacity loadings of above 90% on the central sections of Crossrail. The rail elements of this option would cost around £5bn, rising to around £10bn with rail and optimism bias included.

8.2.11 In comparison, rail Option 4 would provide an additional express rail service to London (the AEX), which would both improve the resilience on relying on available HS1 train paths, and provide faster connections to south and west central London. The predicted Crossrail sub mode share of this option reduces to 27%, so fewer ITE airport users would have to experience Crossrail crush capacities in the core sections. However, the rail elements of this option would cost around £13bn, rising to around £27bn with rail and optimism bias included. By 2050, rail option 4 is the only credible option, due to the predicted growth of London, and even then some capacity issue still remain.

Roads assessment

8.2.12 The roads assessment involved using a route assignment model to forecast the impact of road trips to the ITE accounting for the impacts on capacity related purely to expected growth in background traffic. The costs of mitigating for these background traffic-related impacts have not been assigned to the airport.

8.2.13 The analysis detailed the following road widening requirements due to the ITE airport, covering works required in both 2030 and 2050 – our model indicated that these links exceed 100% of capacity as a result of airport-related traffic:

- 88km widening of the M25 (73km single lane widening and 15 km double lane widening);
- 17km single lane widening of the M2;
- 17km widening of the A2 (2km single lane widening and 15km double lane widening);
- Around 30km single lane widening of the A12/A127/A13 roads on their approach to the M25 from outside London.

8.2.14 Additionally, the construction of the ITE airport brings the predicted Volume/Capacity Ratios (VCRs) above the critical 85% threshold on the following links, and additional road widening may be required as follows:

- 20km single lane widening of the M25;
- 3km single lane widening of the M2;
- Around 55km single lane widening of the A12/A127/A13 in various locations.

Engineering costs

8.2.15 A summary of the costs calculated for each of the rail options is shown in the table below, and a summary of the methodology used to develop these costs is provided in Chapter 6 of this report.

Table 30: Summary scheme costs for rail packages (£)

Scheme	Option 1	Option 2	Option 3	Option 4
	Do minimum	**Waterloo Stopper**	**Crossrail Northern extension but not AEX**	**AEX but no Crossrail Northern extension**
Common Tracks into Airport	920,000,000	920,000,000	920,000,000	920,000,000
Shuttle to Strood	100,000,000	100,000,000	100,000,000	100,000,000
Shuttle to Grays Station	1,600,000,000	1,600,000,000	1,600,000,000	1,600,000,000
Waterloo Stopper		510,000,000	510,000,000	510,000,000
Southern Crossrail Extension	1,710,000,000	1,710,000,000	1,710,000,000	1,710,000,000
Northern Crossrail Extension			1,030,000,000	
HS1 Extension	235,000,000	235,000,000	235,000,000	235,000,000
Additional HS1 platform at St Pancras	110,000,000	110,000,000	110,000,000	110,000,000
Airport Express				7,660,000,000
Rail costs total	**4,675,000,000**	**5,185,000,000**	**6,215,000,000**	**12,845,000,000**
Risk and optimism bias	5,140,000,000	5,700,000,000	6,840,000,000	14,130,000,000
RAIL TOTAL (inc. risk and optimism bias)	**9,820,000,000**	**10,890,000,000**	**13,050,000,000**	**26,970,000,000**

Note: excludes land costs

8.2.16 For highway costs, overall out-turn unit road widening costs of £35m-£50m per km were used to estimate total costs associated with the ITE of between £4.8bn and £8.2bn. As well as the range in unit costs, this variation also accounted for the criteria applied to identify whether capacity issues could be related to airport traffic (links where demand exceeded 100% capacity as opposed to those where it exceeded 85% capacity). These costs excluded risk and optimism bias, which when included bring the total estimate up to between £10.1bn and £17.2bn.

8.2.17 In addition, if the DfT took the decision to adopt Lower Thames Crossing Option A, and subsequently the ITE airport is approved, the location of the LTC at Option A would be sub-optimal. Under this scenario, the case might be made for the ITE airport to include the incremental cost of LTC Option C over Option A. This incremental cost is estimated to be £2bn.

8.2.18 In terms of engineering feasibility and overall deliverability, there would be significant challenges to overcome to provide a successful rail package for the ITE airport, especially for option 4. For example, the four-tracking of the Abbey Wood to Hoo Junction line to accommodate a southern branch Crossrail extension would present significant issues in terms of land acquisition, while the AEX scheme (if required) would involve providing four new subterranean stations (connected via an underground tunnel around 18km in length), three of which would need to be connected to existing heavily used underground stations. The feasibililty of the HS1 spur is also dependent on securing 4 train paths on the line (which has been identified as unfeasible by HS1 Ltd although consultation elsewhere in the rail industry suggests it could be achieved) and would require the construction of an additional platform at St. Pancras. In addition to these major strategic challenges, a range of more local issues would need to be addressed, some of which (such as the provision of new platform capacity at central London termini and resolving line utilisation issues in the Medway area) are likely to require costly solutions.

Environmental impacts

8.2.19 The new transport links would introduce new impacts on international and nationally designated sites in addition to the ITE airport itself. All of the surface transport access requirements for the ITE airport are likely to lead to significant additional environmental impacts.

8.2.20 All of the rail options are generally similar in terms of their overall potential impact on the environment within the Hoo Peninsula. This is because all have the same new routes proposed through this location. There are also additional impacts arising from the Crossrail Northern Extension and the Airport Express in other locations.

8.2.21 There is very little difference between the potential environmental risks and impacts associated with the two road improvement scenarios, related to the aforementioned core and extended baselines. This is because the differences in the roads likely to be upgraded in the core baseline compared with the extended baseline are limited to two road lengths. The main differences are the number of additional carriage ways that would need to be constructed on existing roads in the core baseline without the impact of the LTC Option C alignment and the effects of widening would need to be considered at a later stage of assessment if the ITE option is taken forward as a fourth short-listed option.

8.2.22 The Thames Estuary and Marshes and Medway Estuary and Marshes SPA and Ramsar sites, internationally designated sites, would be directly affected by rail access routes involving habitat loss, severance and fragmentation. This could include for example, up to 4km of new rail within the Thames Estuary Ramsar site. There are likely to be additional disturbance impacts as a result of construction and operation where both road and rail run adjacent to designated areas. Compliance with the Conservation of Habitats and Species Regulations would need to be demonstrated. This would involve undertaking a Habitats Regulations Assessment (HRA). This would include an appropriate assessment of the in-combination effects of the surface access routes. The effects of the surface access routes are likely to increase the total area of compensatory habitat that would need to be provided for the airport development. This would add to the costs of the scheme.

8.2.23 In addition, there would be potential impacts on nationally designated sites including SSSIs. Routes running through a small number of sites including the SSSI designations which also form the internationally designated sites identified above. Compliance with National Planning Policy Framework would need to be demonstrated regarding nature conservation, heritage and other environmental planning constraints including AQMA objectives for the road improvements and planning policy relating to AONB.

8.2.24 Mitigation measures for ecological purposes would be required to minimise potential impacts on designated sites, this would include detailed routing and option design, increased tunnelling lengths, potentially restrictions on construction, screening and other measures to reduce disturbance such as noise barriers. Compensatory habitat would also be required and together these requirements could add significantly to the cost of the proposals.

8.2.25 Even with mitigation the proposed surface transport access routes would generate new environmental impacts and increase the cumulative effects from the development of a hub airport in the ITE. In particular, there would be wider ranging impacts extending long distances from the proposed airport development..

Appendix A. Airports Commission surface transport baselines

A.1 Core baseline

A.1.1 Rail infrastructure (excluding high speed)

In addition to the existing network and services, the rail core baseline will include all of the schemes identified in the Network Rail Control Period 5 (2014-19) Enhancement Delivery Plan, with the exception of Western Rail Access to Heathrow, which does not yet have a fully secured funding package. This is available online at http://www.networkrail.co.uk/publications/delivery-plans/control-period-5/cp5-delivery-plan/.

Elements of relevance to proposals may include (but not be limited to):

- Crossrail;
- Reading Area Station redevelopment;
- Thameslink programme;
- ERTMS in-cab signalling roll-out;
- East Coast Main Line capacity enhancements;
- West Anglia Main Line enhancements;
- Great Eastern Main Line capacity enhancement (Bow Junction);
- East Kent resignalling;
- Redhill Station additional platform;
- London Victoria Station capacity improvements;
- London Waterloo Station capacity improvements;
- Great Western Main Line electrification;
- Intercity Express Programme roll-out;
- Thames Valley branch line enhancements;
- Oxford Corridor capacity improvements;
- Swindon to Kemble redoubling; and
- Birmingham Gateway development.

Scheme promoters are encouraged to consult the Enhancement Delivery Plan for the full details and delivery timescales for schemes.

A.1.2 Rail services (excluding high speed)

The Department for Transport is responsible for the design and procurement of new and replacement rail franchises on the national rail network for which it is the franchising authority. The DfT is in the process of tendering a number of rail franchises, details of the rail franchise schedule can be found at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/301976/rail-franchise-schedule.pdf. This includes information on the timing and scope of competitions for future franchises. Each individual franchise has its own specific requirements and addresses a particular set of challenges and so the requirements set out in each franchise competition are tailored to meet the needs of the areas they serve. The DfT has moved towards more output-based specifications to give greater flexibility to bidders while recognising the need for Government to protect essential service levels for all passengers. Details of the Department's activities during each of the stages of a franchise competition can be found at https://www.gov.uk/government/publications/franchise-competition-process-guide.

In developing the baseline the Commission will assume that service levels will be broadly similar as they are today unless an infrastructure scheme or introduction of new rolling stock triggers a change. Details of the investment programme for 2014-19 can be found at http://www.networkrail.co.uk/publications/delivery-plans/control-period-5/cp5-delivery-plan/.

The Commission will monitor the results of current franchise competitions and, when the outcomes of these competitions become known, will discuss the implications of the franchise with scheme promoters. The Commission recognises that dialogue on this issue will need to continue after the receipt of revised scheme proposals.

The outcome of the competition for the Thameslink, Southern and Great Northern franchise is clearly of particular relevance to scheme promoters and understanding and discussing the components of this will be a priority for the Commission.

A.1.3 Rail – High Speed

In respect of the High Speed 1 link and the Channel Tunnel, the Commission will assume for its baseline no fundamental changes to infrastructure or services, though it will use existing demand forecasts for both passenger and freight traffic to inform its baseline for capacity utilisation.

In respect of the High Speed 2 link, the Commission has noted that the "phase 1" route between London Euston and Birmingham and the "phase 2" route from Birmingham to Manchester and Leeds represents stated Government policy and has cross-party support. The Commission has, therefore, decided to include these elements of the scheme in its core baseline. The Commission has also noted, however, the Secretary of State for Transport's statement that he will delay a decision on whether to proceed with a spur from HS2 to Heathrow Airport until after the Airports Commission's Final Report. This spur will not, therefore, form part of the core baseline.

For an overview of the HS2 programme, scheme promoters are encouraged to consult the following documents:

- https://www.gov.uk/government/publications/hs2-strategic-case
- https://www.gov.uk/government/publications/high-speed-rail-investing-in-britains-future-phase-two-the-route-to-leeds-manchester-and-beyond

The Commission has also noted that the recent review by Sir David Higgins made a number of recommendations regarding the delivery of HS2. On the basis of this, the Government has already taken the decision not to proceed with a link between HS2 and HS1. This link will not, therefore, form part of either baseline. It is possible that the Government may suggest further changes to the timing and phasing of the HS2 delivery programme on the basis of Sir David's report; the Commission will monitor developments and incorporate any material changes into the baseline. Sir David's report is available at: http://assets.hs2.org.uk/sites/default/files/inserts/Higgins%20Report%20-%20HS2%20Plus.pdf.

A.1.4 London Underground, London Overground and Docklands Light Railway

The Commission has taken advice from TfL on the status of various forthcoming enhancements to the London Underground, Overground and DLR networks. On the basis of information provided, the Commission will include the following schemes in the core baseline:

- London Underground Subsurface upgrade – Signalling and rolling stock replacement, complete by 2018;
- Croxley link – Metropolitan line link to Watford Junction, planned to complete by 2021;
- Northern line upgrade – planned to complete by 2020;
- Victoria line upgrade – planned increase in service frequency to 36tph;
- Piccadilly line upgrade – planned for completion by 2026;
- Bakerloo line upgrade – planned for completion by 2031;

- Central line upgrade – planned for completion by 2031;
- London Underground station redevelopments – eg. Bank and Victoria;
- Waterloo & City Line Upgrade – Planned for completion by 2031;
- London Overground extension of class 378s to 5 car – deployed by end 2015;
- Gospel Oak to Barking electrification – complete by 2019;
- DLR 3-car upgrade Poplar to Stratford – complete by 2026; and
- DLR Interpeak service enhancements (base service plan A) – due September 2014.

A.1.5 Strategic roads network

Following discussions with the Highways Agency, the Commission's view is that the following schemes should be included in the core baseline:

- M25 Junction 23 to 27 "smart motorway" (all lanes running) – complete by 2015;
- M25 Junction 5 to 6/7 "smart motorway" (all lanes running) – complete by 2014; and
- M3 Junction 2 to 4a "smart motorway" (all lanes running) – complete by 2016.

A.2 Extended Baseline

A.2.1 Rail infrastructure (excluding high speed)

The Commission has held discussions with Network Rail, the Department for Transport and other parties with an interest in the process regarding rail schemes which are likely – but not certain – to be funded in the coming years to meet growth in background demand regardless of decisions on airport expansion. These include:

- Western Rail Access to Heathrow: which forms part of the Control Period 5 settlement (meaning it is highly likely to progress) but does not yet have a fully agreed funding package. Should the funding package be secured, this scheme would become part of the core baseline.
- Gatwick Airport Station redevelopment: recommended as part of the Commission's interim report. Discussions are ongoing between Government, Network Rail and the airport regarding the nature and scale of the redevelopment.
- Proposed capacity enhancements to the Brighton Main Line: Currently under development and may potentially be identified for funding as part of the CP6 (2019-2024) programme. Components include:
- Windmill Bridge Junction area re-modelling
  - New flyover for Up London Bridge Fast line
  - New flyover carrying the Down London Bridge Fast over the Wallington and Victoria Slow lines
  - Reusing the current dive under for realigned Up London Bridge Slow services removes pathing conflicts of current flat junction
  - New 6th track between East Croydon and Windmill Bridge
  - East Croydon Station remodelling and additional platforms
  - Selhurst Spurs lengthened to provide 12-car signal standing – removes current conflicts
- Stoats Nest Junction grade separated junction for Up Redhill trains to join the Up Fast line
- London Victoria re-designation of platform 8 and new access from platform 9 approach

- Clapham Junction area alterations to allow for additional train paths (no feasibility work yet undertaken)
- Keymer Junction – third track to enable Up Lewes train to join main line whilst an Up train is passing and enables the Brighton Main Line to remain open when the junction is unusable.
- Potential outcomes of the Wessex, Sussex and East Sussex route studies: which will inform the future development of infrastructure and services on those routes.
- London Victoria: further redevelopment beyond 2019, subject to business case.
- Clapham Junction: further redevelopment beyond 2019, subject to business case.
- Crossrail 2 – subject to significant further specification and assessment.

A.2.2 Rail Services (excluding high speed)

As with the development of the core baseline, the Commission will monitor progress on the Department for Transport's refranchising programme. Where the outcomes of franchise competitions are not known, but the Invitation to Tender gives clear indications regarding the probable contents of the franchise, these will be incorporated into the extended baseline.

A.2.3 High Speed Rail

The Government has deferred a decision regarding a spur from HS2 to Heathrow Airport until after the Airports Commission publishes its final report. This spur will, therefore, be placed within the extended baseline. The Commission notes, however, that the need to progress the HS2 hybrid bill through Parliament may result in changes in Government policy in this area and will keep any such developments under review, in respect of the relationship of the spur to the baselines.

A.2.4 London Underground, London Overground and Docklands Light Railway

The Commission has taken advice from TfL on the status of various forthcoming enhancements to the London Underground, Overground and DLR networks. On the basis of information provided, the Commission will include the following schemes in the extended baseline:

- Jubilee line upgrade: increase to 34tph, requires additional stock;
- Northern line extension to Battersea: subject to TWA approval, potentially open in 2020;
- Northern line full separation: potentially by 2026;
- Bakerloo line southern extension: aspirational only at present;
- London overground additional 2 tph all day between Clapham Junction and Stratford via West / North London Lines – planned for 2019, but dependant on additional rolling stock;
- London overground additional 2tph on East London Line – dependant on additional rolling stock;
- London overground Gospel Oak to Barking extended to Barking Riverside – possible by 2021;
- London overground 6 and 8 car operation on East, North and West London Lines – possible in 2020s / 2030s;
- DLR new franchise service plan – by 2016/17;
- North route double tracking phase 2 – requires additional rolling stock;
- DLR Royal Rocks initial capacity enhancements – requires additional rolling stock;
- DLR full 3-car operation – requires additional rolling stock;
- DLR extension to Catford – aspirational only at present; and
- DLR extension to Bromley – aspirational only at present.

A.2.5 Strategic Roads

Following discussions with the Highways Agency, the Commission's view is that the following schemes should be included in the core baseline:

- M4 Junction 3 to 12 "smart motorway" (all lanes running) – subject to value for money and deliverability assessment;
- M23 Junction 8 to 10 "smart motorway" (all lanes running) – subject to value for money and deliverability assessment; and
- Lower Thames Crossing – work progressing, but no decision yet as to nature of any option that might proceed.

Appendix B. Environmental analysis

B.1 Methodology

The analysis of the environmental constraints and risks included:

- Review of proponent submissions and responses to questions
- Compilation of available data on designations and other key environmental constraints though GIS mapping and using GIS based data analysis
- Sections of existing track that were to be utilised by new services were excluded from the scope of the environmental analysis;
- Sections of proposed tunnel were excluded from the scope of the environmental analysis.

The review was undertaken with reference to the approach taken to the environmental analysis for the Phase 1 assessment of the Airport Options.

Review of Submissions and Question responses

Key information from proponent submissions on potential impacts and mitigation approaches has been considered and commented on where relevant.

Spatial Environmental Constraints - Airport outlines

Geographical Information system software has been used to compile environmental constraints within and around the surface transport links. A list of the sources of information is provided in section 1.3.

The route for each of the new transport links is based on either the existing rail or road corridor (if the specific link follows an existing transport corridor) or, for completely new transport links the alignments detailed in the *Surface Access Feasibility Report (2014).*

B.2 Limitations and Assumptions

Detailed impact assessments have not been undertaken and no assessment has been made for noise and air quality impacts arising from the modelled traffic flows. This would not be appropriate for this level of study and more detailed consideration of air and noise impacts on the wider transport network would be part of future assessment phases if the Thames Estuary option was taken forward.

Therefore, the air quality assessment is limited to the identification of Air Quality Management Areas intersected by the surface transport routes.

The noise assessment is limited to the identification of potential numbers of receptors in close proximity to the routes.

Loss of habitat is based on likely construction footprint rather than permanent footprint of the rail / road corridor. A 1km corridor of potential habitat loss has been identified to reflect the uncertainty in alignment and construction techniques.

A number of the rail corridors follow the same alignment from Lower Higham to the Hoo Peninnisula therefore, the number of designated features provided in the tables below include duplications of the same designated sites and this is why total numbers have not been provided. A summary of the designated features for each route is provided below.

B.3 Sources of Information

Table 31: List of data sets and sources

Data set	Source	Date
Special Area of Conservation (SAC)	Natural England	May 2014
Ramsar	Natural England	May 2014
Special Protection Area (SPA)	Natural England	May 2014
World Heritage Site	English Heritage	May 2014
SSSI	Natural England	May 2014
Listed building	English Heritage	May 2014
Scheduled monument	English Heritage	May 2014
Flood Zone 2	Environment Agency	May 2014
Flood Zone 3	Environment Agency	May 2014
National Nature Reserve (NNR)	Natural England	May 2014
Area of Outstanding Natural Beauty (AONB)	Natural England	May 2014
National Park	Natural England	May 2014
Registered Park and Garden	English Heritage	May 2014
Local Nature Reserve (LNR)	Natural England	May 2014
Ancient Woodland	Natural England	May 2014
Agricultural Land Classification (ALC)	Natural England	1976
Residential Properties	OS Address Base Plus	2013
Air Quality Management Area (AQMA)	Defra	2013
Resident Population	OS Address Base Plus and Official of National Statistics	2013

B.4 Environmental constraints for rail options

Table 32 to Table 38 provide a summary of the constraints identified for each of the rail options considered in options 3(a), 3(b) and 4.

Table 32: Crossrail southern extension

Designation	Within 100m	Within 1km
AONB	None.	None.
SSSI	1. Medway Estuary and Marshes, and 2. South Thames Estuary and Marshes.	1. Bakers Hole; 2. Chattendon Wood and Lodge Hill 3. Dalham Farm; 4. Medway Estuary and Marshes; 5. Northward Hill; 6. South Thames Estuary and Marshes; and 7. Swanscombe Skull Site.
SPA	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
SAC	None.	None.
Ramsar site	1. Thames Estuary and Marshes, and 2. Medway Estuary and Marshes	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes
Ancient Woodland	None.	1. Fishers Wood; 2. Lesnes Abbey Woods; 3. Lodge Hill Wood; and 4. Wybornes Wood.
NNR	1. Swanscombe Skull Site	1. High Halstow; and 2. Swanscombe Skull Site.
AQMA	Data for 1km only: 1. Bexley AQMA 2. Dartford AQMA No.1 3. Dartford AQMA No.2 4. Dartford AQMA No.3 5. Gravesham A226 One-way system AQMA 6. Gravesham A227 Wrotham Road/ B261 Old Road West AQMA 7. Gravesham B262/B261 Pelham Arms Junction AQMA 8. Gravesham Echo Junction AQMA 9. Gravesham Parrock Street AQMA 10. Northfleet Industrial Area AQMA	

Designation	Within 100m	Within 1km
Grade 1 Listed Building	1	8
Grade II* Listed Building	2	19
Grade II Listed Building	21	238
Scheduled Monuments		1. Aspdin's kiln; 2. Cooling Castle and its associated landscaped setting; 3. Gravesend blockhouse; 4. Howbury moated site; 5. Lodge Hill Anti-aircraft Battery; 6. Neolithic sites near Ebbsfleet; 7. New Tavern Fort, Gravesend, including Milton Chantry; 8. Palaeolithic sites near Baker's Hole; 9. Slough Fort and wing batteries; 10. St Mary's Priory: an alien Benedictine priory 100m east of St Mary's Church.
Registered Parks and Gardens: Grade II*		Gravesend Cemetery

Table 33: Crossrail northern extension

Designation	Within 100m	Within 1km
AONB	None.	None.
SSSI	1. Canvey Wick; 2. Holehaven Creek; 3. South Thames Estuary and Marshes.	1. Canvey Wick: 2. Holehaven Creek; and 3. South Thames Estuary and Marshes.
SPA	Thames Estuary and Marshes.	Thames Estuary and Marshes.
SAC	None.	None.
Ramsar site	Thames Estuary and Marshes.	Thames Estuary and Marshes.
Ancient Woodland	1. Devils/Crays Woods.	1. Devils/Crays Woods; 2. Meepshole Wood; and 3. Nevendon Bushes.
NNR	None	None
AQMA	None.	
Grade 1 Listed Building	0	1
Grade II* Listed Building	0	4
Grade II Listed Building	0	17
Scheduled Monuments		1. Heavy Anti-aircraft gunsite, 380m east of Northwick Farm; and 2. Slough Fort and wing batteries.
Registered Parks and Gardens	None.	None.

Table 34: HS1 extension

Designation	Within 100m	Within 1km
AONB	None.	1. Kent Downs
SSSI	1. Medway Estuary and Marshes; 2. Shorne and Ashenbank Woods; and 3. South Thames Estuary and Marshes.	1. Medway Estuary and Marshes; 2. Shorne and Ashenbank Woods; 3. South Thames Estuary and Marshes; 4. Northward Hill; 5. Dalham Farm; and 6. Chattenden Woods and Lodge Hill.
SPA	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
SAC	None.	None.
Ramsar site	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes
Ancient Woodland	1. 1 x Unnamed.	1. Claylane Wood; 2. Fishers Wood; 3. Lodge Hill Wood; 4. Shorne/Brewers Woods; 5. Wybornes Wood; and 6. 4 x Unnamed.
NNR	None.	High Halstow.
AQMA	Data for 1km only: Gravesham A2 AQMA.	
Grade 1 Listed Building	0	6
Grade II* Listed Building	0	4
Grade II Listed Building	2	49
Scheduled Monuments		1. Cooling Castle and its associated landscaped setting; 2. Lodge Hill Anti-aircraft Battery; 3. Slough Fort and wing batteries; and

Designation	Within 100m	Within 1km
		4. St Mary's Priory: an alien Benedictine priory 100m east of St Mary's Church.
Registered Parks and Gardens	None.	None.

Table 35: Grays shuttle

Designation	Within 100m	Within 1km
AONB	None.	None.
SSSI	1. Dalham Farm; 2. Medway Estuary and Marshes; and 3. South Thames Estuary and Marshes.	1. Chattenden Woods and Lodge Hill; 2. Dalham Farm; 3. Globe Pit; 4. Gray's Chalk Pit; 5. Medway Estuary and Marshes; 6. Northward Hill; and 7. South Thames Estuary and Marshes.
SPA	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
SAC	None.	None.
Ramsar site	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
Ancient Woodland	None.	1. Fishers Wood; 2. Lodge Hill Wood; and 3. Wybornes Wood.
NNR	None.	High Halstow
AQMA	Data for 1km only: Northfleet Industrial Area AQMA Thurrock AQMA	
Grade 1 Listed Building	0	6
Grade II* Listed Building	1	6
Grade II Listed Building	6	39
Scheduled Monument		1. Cooling Castle and its associated landscaped setting; 2. Earthworks near church, West Tilbury; 3. Lodge Hill Anti-aircraft Battery;

Designation	Within 100m	Within 1km
		4. St Mary's Priory: an alien Benedictine priory 100m east of St Mary's Church; and 5. Tilbury Fort.
Registered Parks and Gardens	None.	None.

Table 36: Strood shuttle

Designation	Within 100m	Within 1km
AONB	None.	None.
SSSI	1. Medway Estuary and Marshes; and 2. South Thames Estuary and Marshes.	1. Dalham Farm; 2. Northward Hill; 3. Chattenden Woods and Lodge Hill; 4. Medway Estuary and Marshes; and 5. South Thames Estuary and Marshes.
SPA	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
SAC	None.	None.
Ramsar site	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
Ancient Woodland	None.	1. Fishers Wood; 2. Lodge Hill Wood; and 3. Wybornes Wood.
NNR	None.	High Halstow.
AQMA	Data for 1km only: Central Medway AQMA	
Grade 1 Listed Building	1	4
Grade II* Listed Building	0	2
Grade II Listed Building	1	27
Scheduled Monument	1. St Mary's Priory: an alien Benedictine priory 100m east of St Mary's Church.	1. Cooling Castle and its associated landscaped setting; 2. Lodge Hill Anti-aircraft Battery; 3. Slough Fort and wing batteries; and 4. St Mary's Priory: an alien Benedictine priory 100m east of St Mary's Church.
Registered Parks and Gardens	None.	None.

Table 37: Waterloo Stopper

Designation	Within 100m	Within 1km
AONB	1. Kent Downs	1. Kent Downs
SSSI	1. Dalham Farm; 2. Medway estuary and marshes; 3. Shorne and Ashenbank Woods; and 4. South Thames Estuary and Marshes.	1. Dalham Farm; 2. Northward Hill; 3. Chattenden Woods and Lodge Hill; 4. Medway Estuary and Marshes; 5. Shorne and Ashenbank Woods; and 6. South Thames Estuary and Marshes.
SPA	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
SAC	None.	None.
Ramsar site	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
Ancient Woodland	1. Shorne/Brewers woods; and 2. 2 x Unnamed.	1. Claylane Wood; 2. Fishers Wood; 3. Lodge Hill Wood; 4. Shorne/Brewerswoods 5. Wybornes Wood; and 6. 5 x Unnamed.
NNR	None.	High Halstow
AQMA	Data for 1km only: Gravesham A2 AQMA	
Grade 1 Listed Building	1	7
Grade II* Listed Building	1	6

Designation	Within 100m	Within 1km
Grade II Listed Building	4	59
Scheduled Monuments		1. Bowl barrow in Ashenbank Wood south of Cobham Park reservoir; 2. Cooling Castle and its associated landscaped setting; 3. Lodge Hill Anti-aircraft Battery; 4. Romano-British villa and 19th century reservoir in Cobham Park; 5. Slough Fort and wing batteries; and 6. St Mary's Priory: an alien Benedictine priory 100m east of St Mary's Church.
Registered Parks and Gardens Grade II*	Cobham Hall	Cobham Hall

Table 38: Airport Express

Designation	Within 100m	Within 1km
AONB	None.	None.
SSSI	1. Inner Thames Marshes; 2. Medway Estuary and Marshes; and 3. South Thames Estuary & Marshes.	1. Chattenden Woods and Lodge Hill; 2. Dalham Farm; 3. Ingrebourne Marshes; 4. Northward Hill; 5. Purfleet Chalk Pits; 6. Purfleet Road, Aveley; 7. Inner Thames Marshes; 8. Medway Estuary and Marshes; and 9. South Thames Estuary and Marshes.
SPA	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
SAC	None.	None.
Ramsar site	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.	1. Thames Estuary and Marshes; and 2. Medway Estuary and Marshes.
Ancient Woodland	None.	1. Fishers Wood; 2. Lodge Hill Wood: 3. Watts Wood; and 4. Wybornes Wood.
NNR	None.	High Halstow
AQMA	Data for 1km only: 1. Barking and Dagenham AQMA 2. Bexley AQMA 3. City of London AQMA 4. Greenwich AQMA 5. Havering AQMA	

Designation	Within 100m	Within 1km
	6. Lambeth AQMA 7. Lewisham AQMA 8. Newham AQMA 9. Northfleet Industrial Area AQMA 10. Southwark AQMA 11. Thurrock AQMA 12. Tower Hamlets AQMA 13. Westminister AQMA	
Grade 1 Listed Building	0	8
Grade II* Listed Building	0	8
Grade II Listed Building	1	50
Scheduled Monument		1. Cooling Castle and its associated landscaped setting 2. Lodge Hill Anti-aircraft Battery 3. Purfleet magazine; 4. Slough Fort and wing batteries; and 5. St Mary's Priory: an alien Benedictine priory 100m east of St Mary's Church.
Registered Parks and Gardens	Only RPG are in Tunnelled section	

Table 39: Extended list of designations relevant to road improvement

Designation	SSSI*	AQMA	Scheduled Monuments (1km)	RPG (1km)
Details	1. Basildon Meadows ; 2. Benfleet & Southend Marshes; 3. Bookham Commons; 4. Bricket Wood Common; 5. Chattenden Woods And Lodge Hill; 6. Cobham Woods; 7. Cornmill Stream & Old River Lea; 8. Curtismill Green; 9. Dalham Farm; 10. Darenth Wood;	1. AQMA No 11 2. AQMA No. 8 (Swanley Town Centre) 3. AQMA No.1 (M20) 4. AQMA No.1 (M25) 5. AQMA No.2 (M25) 6. AQMA No.3 (M26) 7. AQMA No.4 (A20(T)) 8. AQMA No.6 9. AQMA No.6 (M25-PM10) 10. Barking and Dagenham AQMA 11. Bexley AQMA 12. Brentwood	1. Anglo-Saxon cemetery at Darenth Park 2. Bell barrow on Cockcrow Hill; 3. Bishop Bonner's Palace, Orsett 4. Bowl barrow at the north end of Hilly Field 5. Bowl barrow in Ashenbank Wood south of Cobham Park reservoir; 6. Bowl barrow west of Cockcrow Hill; 7. Causewayed enclosure and Anglo-Saxon cemetery 500m ENE of Heath Place; 8. Colney Chapel moated site; 9. Dovecote at	1. Cobham Hall (II*) 2. Lullingstone Castle (II) 3. Chevening (II)* 4. Lower Gatton Park (II) 5. Painshill Park(I) 6. Napsbury Hospital (II) 7. Wrotham Park (II) 8. Myddleton House (II) 9. Weald Park (II) 10. Hill Hall (I) 11. Warley Place (II) 12. Belhus Park (II) 13. Hall Place (II) 14. Royal Horticultural Society's Gardens, Wisley (II*) 15. Thorndon Hall (II*) 16. Hylands Park (II*) 17. Copped Hall

Designation	SSSI*	AQMA	Scheduled Monuments (1km)	RPG (1km)
	11. Epping Forest; 12. Epsom & Ashtead Commons; 13. Farningham Wood; 14. Garrold's Meadow; 15. Great Crabbles Wood; 16. Inner Thames Marshes; 17. Kingcup Meadows & Oldhouse Wood; 18. Lullingstone Park; 19. Mole Gap to Reigate Escarpment; 20. Moor Mill Quarry West;	AQMA No.1 13. Brentwood AQMA No.2 14. Brentwood AQMA No.3 15. Brentwood AQMA No.4 16. Brentwood AQMA No.5 17. Brentwood AQMA No.6 18. Broxbourne AQMA No. 1 19. Broxbourne AQMA No. 2 20. Dartford AQMA No.1 21. Dartford AQMA No.2 22. Dartford AQMA No.3 23. Dartford AQMA No.4 24. Enfield AQMA	Hawley Manor; 10. Earthworks near church, West Tilbury; 11. Eleanor Cross, Waltham Cross 12. Former parish church and churchyard of St Nicholas; 13. Fort Farningham: a London mobilisation centre; 14. Fort Halstead; 15. Fosterdown or Pilgrim Fort: a London mobilisation centre; 16. Hall Place; 17. Hengi-form monument at Red Hill; 18. Hill Hall, brick kiln and deserted manorial settlement of	

Designation	SSSI*	AQMA	Scheduled Monuments (1km)	RPG (1km)
	21. Northward Hill; 22. Ockham & Wisley Commons; 23. Pitsea Marsh; 24. Purfleet Chalk Pits; 25. Purfleet Road, Aveley; 26. Quarry Hangers; 27. Shorne & Ashenbank Woods; 28. South Thames Estuary & Marshes; 29. Thorndon Park; 30. Thundersley Great Common; 31. Vange &	25. Gravesham A2 AQMA 26. Havering AQMA 27. Hertsmere AQMA No. 1 28. Hertsmere AQMA No. 2 29. Hertsmere AQMA No. 3 30. St Albans AQMA No. 7 31. Thurrock AQMA 32. AQMA (Epping Forest District Council) no2 33. South Bucks AQMA	Mount Hall; 19. Large multivallate hillfort at War Coppice Camp; 20. Late Roman bath house at Chatley Farm; 21. Lodge Hill Anti-aircraft Battery; 22. Medieval moated site and earlier earthwork south of Boughton Hall; 23. Medieval moated site with associated fishponds, Flower Lane; 24. Medieval moated site, The Mounts, Pachesham Farm; 25. Medieval woodland boundary in Darenth Wood; 26. Moated site 200m north west	

Designation	SSSI*	AQMA	Scheduled Monuments (1km)	RPG (1km)
	Fobbing Marshes; 32. Wansunt Pit; 33. Woldingham & Oxted Downs; 34. Purple Hill; 35. Queendown Warren.		of Chalfont Lodge; 27. Moated site at Watton Farm; 28. Moated site known as Killigrews; 29. Neolithic sites near Ebbsfleet; 30. Old Thorndon Hall and gardens; 31. Prittlewell Priory; 32. Reigate Fort: a London mobilisation centre; 33. Roman enclosure SE of Vagniacae; 34. Romano-British site N of Pound Wood, Thundersley; 35. Romano-British villa and 19th century reservoir in Cobham Park;	

Designation	SSSI*	AQMA	Scheduled Monuments (1km)	RPG (1km)
			36. Site of moated manor house E of St Michael's Church, Aveley; 37. Slight univallate hillfort 300m west of Calcott Hall Farm; 38. Springfield style enclosure and Iron Age enclosures south of Hill House, Baker Street; 39. Springhead Roman site; 40. Stane Street; 41. The Mound, Walton Place; 42. Theobalds Palace, Waltham Cross; 43. Waltham Abbey Royal Gunpowder Factory; 44. Waltham Abbey, including	

Designation	SSSI*	AQMA	Scheduled Monuments (1km)	RPG (1km)
			gatehouse and Stoney Bridge; 45. Ambresbury Banks slight univallate hillfort; 46. Bletchingley castle (ringwork and bailey) (Extended base case only); 47. Moated site and associated earthworks on Pound Hill, 700m east of Gatwick Stream.(Extended base case only); 48. The Temple, Temple Hill, Warlies Park 49. Thunderfield Castle medieval moated site. (Extended base case only);	