Appraisal Framework Module 4.

Surface Access: Gatwick Airport Second Runway Appendices

FINAL FOR CONSULTATION

AIRPORTS COMMISSION

28th October 2014

JACOBS®

Document Control Sheet

Project:	Appraisal Framework Module 4.
Client:	Airports Commission
Document title:	Surface Access: Gatwick Airport Second Runway Appendices
Project No:	B1988000

ORIGINAL	**Originated by**	**Checked by**	**Reviewed by**	
	NAME	NAME	NAME	
	Rosalyn Schaverien **Zaira Caicedo**	**Jon Hale**	**Stephen Rutherford**	
Approved by	NAME	As Project Manager I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**		INITIALS
	Stephen Rutherford			
DATE	**July 2014**	**Document status:**		**DRAFT**

Revision 1	**Originated by**	**Checked by**	**Reviewed by**	
	NAME	NAME	NAME	
	Jon Hale	**Jon Hale**	**Stephen Rutherford**	
Approved by	NAME	As Project Manager I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**		INITIALS
	Stephen Rutherford			
DATE	**October 2014**	**Document status :**		**FINAL**

Contents

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, the Interim 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 work is described as Phase 1. The associated appraisal process identified three short-listed options, two focussed on expanding Heathrow Airport and one on expanding Gatwick through the provision of a second runway. These short-listed options were to be further developed and appraised during Phase 2, with further phases of work programmed in the run-up to the submission of the Final Report in the summer of 2015.

1.1.3 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 Under the terms of the RM1082 support contract, Jacobs were commissioned to develop the aforementioned Phase 2 assessment with respect to surface transport for a potential second runway at Gatwick. This assessment focussed specifically on three key elements as follows:

- estimating the net airport passenger and employee surface transport demand associated with a second runway, accounting for expected growth in demand to and from the airport in its current form;
- identifying surface transport measures to meet net airport-related demand associated with a second runway, 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.

1.2.2 The ultimate aim of the study was to provide guidance to the AC on the feasibility and likely surface transport issues associated with delivering a second runway at Gatwick. The terms of reference covered an assessment of forecast demand in 2030. Reporting for the Phase 2 surface transport assessment was defined as follows:

- the Methodology Statement describes the methodology employed by Jacobs to develop surface transport demand forecasts for the second runway - this summary is supported by:
  - a Technical Appendix, which includes detailed information about the calibration of models used to generate forecasts and assess the capacity/level of service implications;
- the Assumptions Log defines the assumptions used to develop the forecasts;
- the Appraisal Report details the results of the assessment undertaken and draws key conclusions on the impacts of a second runway at Gatwick.

1.2.3 This document includes the Methodology Statement and supporting Technical Appendix, and the Assumptions Log. All documents should be read for a full understanding of the approach employed by Jacobs to deliver the Phase 2 surface transport assessment.

2. Methodology Statement

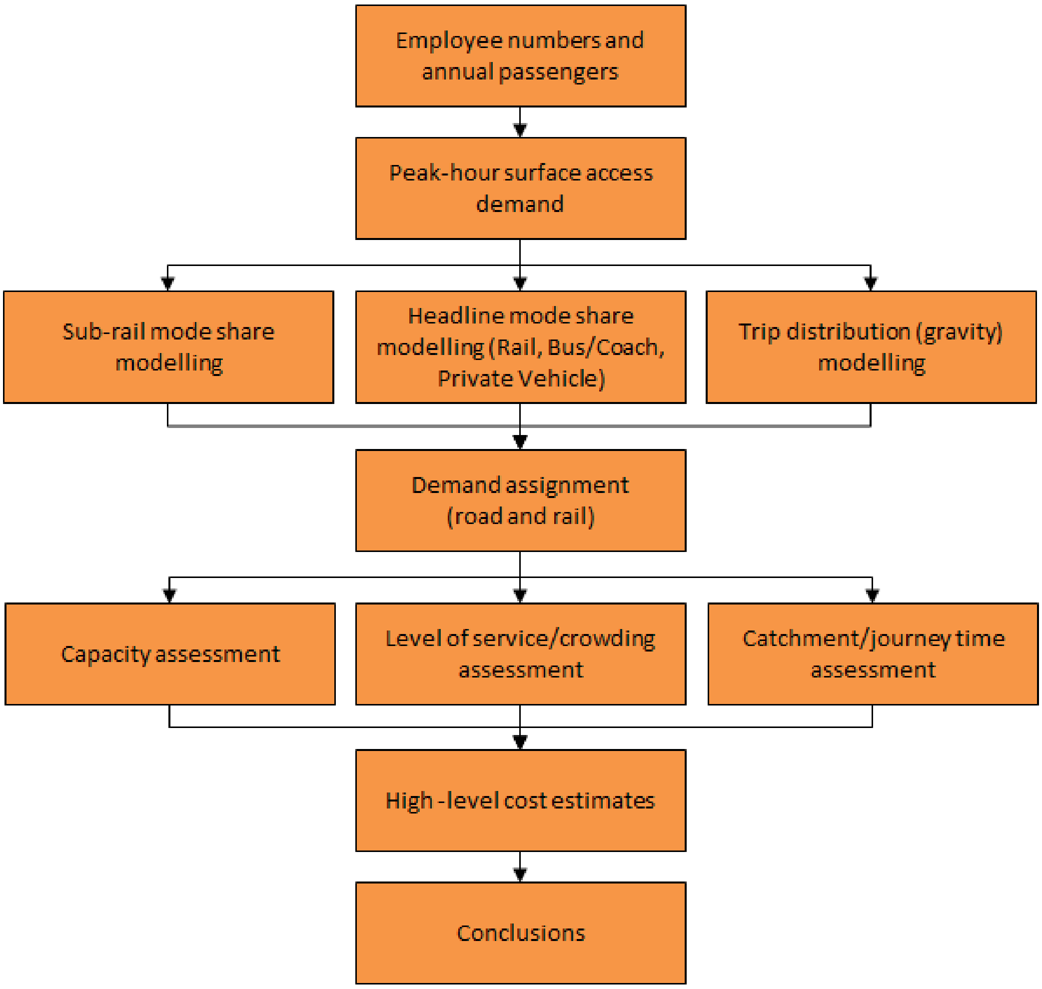
2.1 Overview

2.1.1 The approach to forecasting surface transport demand to and from Gatwick Airport with a second runway was broken down into a number of key stages as follows:

- estimating total peak-hour demand to and from the airport;
- allocating total peak-hour trips to and from the airport to geographic regions in the UK;
- allocating a main mode of travel to each person trip;
- assigning rail trips to and from different geographic regions to rail corridors serving the airport;
- assigning road trips to and from different geographic regions to the strategic road network serving the airport;
- assessing the impact of rail and road trips on capacity and level of service; and
- assessing the road network proposed by Gatwick Airport Ltd (GAL) in the vicinity of the airport.

2.1.2 This methodology is summarised in Figure 1. 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.

Figure 1: Airport surface transport demand forecasting methodology overview



2.1.3 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. Passengers and employees were considered separately before being combined for the analysis of rail mode choice and road capacity.

2.1.4 Audits of the main forecast model and the base year mode choice model were carried out by a separate team of experienced transport modellers within Jacobs who had not been involved in the development of the models.

2.1.5 The primary purpose of the audits was to check the calculations in each worksheet in the demand model spreadsheets. In most cases, the audit team selected several rows on each worksheet and checked the calculations exhaustively across each column for the selected rows. Rows were selected to maximise the data types that were audited (e.g. testing rows with zero values in some cells; testing a range of short and long distance trips etc.). The audit team flagged any inconsistencies or errors using a traffic light approach so that the modelling team could review and correct them as necessary.

2.2 Inputs and headline peak-hour forecasts

2.2.1 A number of input data-sets and referenced sources were used in the development of the surface access demand models. Table 1 presents the headline input assumptions and their source, including forecast million passengers per annum (mppa) and on-airport employees.

2.2.2 In addition to the headline assumptions, a number of sources were used in the development of the surface access model to provide journey times, distances and cost information by mode of transport, and to calibrate the base model. These sources and their uses are as follows:

- Civil Aviation Authority (CAA) passenger survey data 2012 – used in the calibration of the surface access model;
- Google Maps – provided journey times and distances for the development of car Generalised Costs (GC);
- TfL Journey Planner website – provided journey times, frequencies and number of interchanges for bus travel for the development of bus/coach GCs;
- National Express website – provided journey times, frequencies and costs for coach travel for the development of bus/coach GCs;
- Car sub-mode assumptions – various websites including the airport's parking website and long-haul taxi firm websites to provide costs for the development of car-based GCs; and
- National Rail and TfL websites – provided rail and tube times, frequencies and costs for the development of the rail GCs.

2.2.3 All the data provided above was presumed accurate (subject to logic checks), as was any information provided by the AC and other stakeholders. 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.

2.2.4 In addition to the data indicated above, parameter values were selected for the base year and future year surface demand models taken from various sources. Where no appropriate values could be sourced, sensitivity testing was undertaken using values based on professional judgment.

2.2.5 Peak hour demand for travel was estimated for both employees and passengers based on the headline assumptions presented in Table 1 using the process summarised in Figure 2, which illustrates how total annual passengers and total employee numbers were converted to daily demand, then peak hour demand both to and from the airport.

Table 1: 2030 headline input assumptions

Assumption		Passenger Value	Passenger Source	Employee Value	Employee Source
Annual	MPPA/total employees (with second runway)	65,000,000	GAL Surface Access Assessment Appendix A6	29,685	GAL Surface Access Assessment Appendix A6
	MPPA/total employees (with one runway)	46,000,000	GAL Surface Access Assessment Appendix A6	24,026	GAL Surface Access Assessment Appendix A6
	Interliners (transfer passengers)	8%	2012 figure in GAL Surface Access Assessment Appendix A6	-	
	Surface access passengers	92%	See above	-	
	Busy day factor (annual-to-day for passengers; % at work for employees)	0.31%	85th percentile day using Heathrow Airport Traffic Stats 2013 data, to account for increase in business passengers forecast in 2030	57%	Heathrow 2008/9 employee survey (no data available for Gatwick)
Directional flow	From airport	50%	Professional judgment	50%	Professional judgment
	To airport	50%		50%	
Peak-hour flow (with second runway)	From airport	5.78%	Non-transfer passenger forecast for 2040 from GAL Surface Access Assessment Appendix A6	1%	2012 profile from GAL Surface Access Assessment Appendix A6
	To airport	7.96%		15%	
Peak-hour flow (with one runway)	From airport	5.63%	Non-transfer passenger forecast for 2040 from GAL Surface Access Assessment Appendix A6		

Assumption		Passenger		Employee	
		Value	Source	Value	Source
	To airport	7.58%			
Passenger split by purpose (with second runway)	Business	23%	GAL Surface Access Assessment Appendix A6	-	
	Leisure	77%		-	
Passenger split by purpose (with one runway)	Business	15%	GAL Surface Access Assessment Appendix A6	-	
	Leisure	85%		-	
Mode split	Bus/Coach	10.8%	Modelled by Jacobs main mode share logit model	20%	GAL Surface Access Assessment Appendix A6
	Rail	43.0%		20%	
	Private vehicle	46.2%		60%	
Average car occupancy	Business	1.177	Gatwick 2012 CAA passenger survey data	1.2	Current data at existing airports plus assumption about greater car sharing
	Leisure	2.133			
Rail meet and greet %	Business	0.11%	Gatwick 2012 CAA passenger survey data	-	
	Leisure	0.48%		-	
Value of Time (p/min)	Business	69p	SKM (Jacobs) analysis of airport passenger use of HS2[1] - composite of UK and non-UK values	-	
	Leisure	27p		-	

[1] http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/rail/pi/highspeedrail/hs2ltd/appraisalmaterial/pdf/airportdemandmodel.pdf

JACOBS

Figure 2: Gatwick Airport 2030 – headline forecasting assumptions with second runway

PASSENGER ASSUMPTIONS

Interliners	8%
Busy day factor	0.31%

Direction	TO Airport	FROM Airport
Direction Factors	50%	50%

Direction	TO Airport	FROM Airport
Day to Peak Hour Factor	7.96%	5.78%

Headline Mode Split	TO Airport	FROM Airport
Car/Taxi	46%	46%
Bus/Coach	11%	11%
Rail	43%	43%
TOTAL	100%	100%

Meet and Greet	TO Airport	FROM Airport
Rail	0.37%	0.37%

Passenger Vehicle Occupancy	2.08
Taxi + Kiss & Fly Empty Drive-Back Rate	41%

PASSENGERS

Total mppa	65.0
Surface Access mppa	59.8
Daily Surface Transport ODs	186,875

Direction	TO Airport	FROM Airport
Daily surface trips	93,438	93,438

Direction	TO Airport	FROM Airport
Peak Hour Surface Trips	7,438	5,401

Passengers by Mode	TO Airport	FROM Airport
Car/Taxi	3,438	2,497
Bus/Coach	802	582
Rail	3,197	2,321
TOTAL	7,438	5,401

Meet and Greet	TO Airport	FROM Airport
Rail	12	8

Total Passengers + Meet and Greet	TO Airport	FROM Airport
Car/Taxi	3,438	2,497
Bus/Coach	802	582
Rail	3,209	2,330
TOTAL	7,449	5,409

Total Passenger Vehicles	TO Airport	FROM Airport
Car/Taxi	1,650	1,198

Total Passenger Vehicles	TO Airport	FROM Airport
Car/Taxi	2,143	1,877

EMPLOYEES

Total	29,685
Total employee daily two-way trips	16,920

Direction	TO Airport	FROM Airport
Peak Hour Surface Trips	2,538	169

Employees by Mode	TO Airport	FROM Airport
Car/Taxi	1,523	102
Bus/Coach	508	34
Rail	508	34
TOTAL	2.538	169

Total Passenger Vehicles	TO Airport	FROM Airport
Car/Taxi	1,269	85

EMPLOYEE ASSUMPTIONS

Employees at work per day	57%

Direction	TO Airport	FROM Airport
Day to Peak Hour Factor	15%	1%

Headline Mode Split	TO Airport	FROM Airport
Car/Taxi	60%	60%
Bus/Coach	20%	20%
Rail	20%	20%
TOTAL	100%	100%

Employee vehicle occupancy	1.2

OPTION 3 TOTAL TRIPS

Total Trips by Mode	TO Airport	FROM Airport
Car/Taxi	4,961	2,598
Bus/Coach	1,310	616
Rail	3,716	2,364
TOTAL	9,987	5,578

OPTION 3 TOTAL VEHICLES

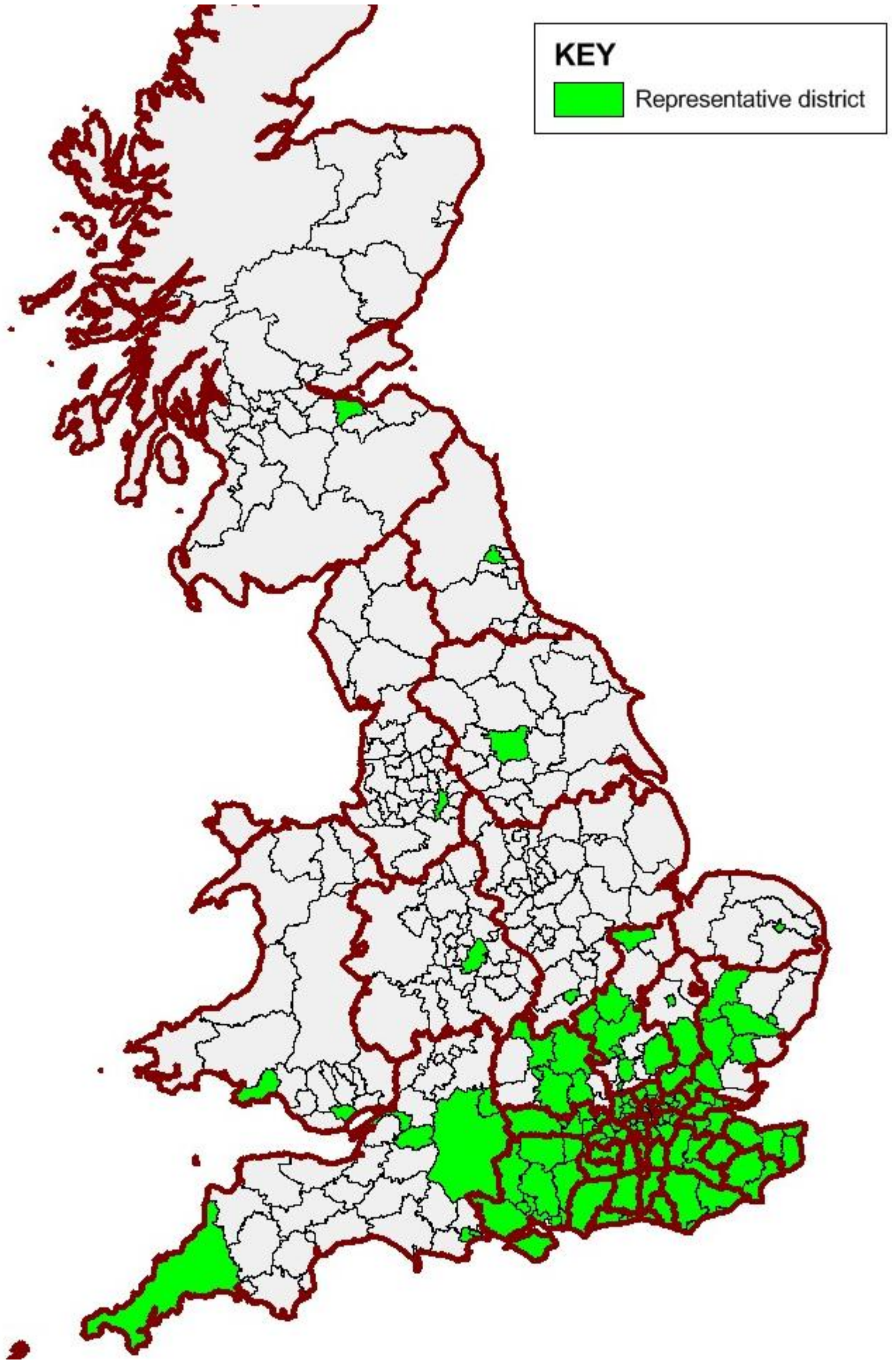
Total Trips by Mode	TO Airport	FROM Airport
Car/Taxi	3,412	1,962

2.3 Trip distribution

Passenger trip distribution

2.3.1 Following the calculation of peak hour demand, the surface access origins of air passengers were derived through the development of a distribution gravity model calibrated with observed data. A district-level zoning system was established at a two-tier level, with parameters defined for 131 representative districts out of the 361 identified in the 2012 CAA passenger survey data. The districts used in the model are illustrated in Figure 3, which indicates that in the vicinity of the airport (including London) all districts were used while for more remote regions a representative district was identified.

Figure 3: Representative model districts



2.3.2 An initial sift was undertaken to select only districts that generated at least 50,000 total passenger trip origins based on at least 50 survey records. This was to ensure that the model calibration was focussed on the key trip generators and was not hampered by observed data based on very few interview records, which could skew the results. However to ensure that all regions in the UK were represented, three additional districts were included that had not met the initial sift criteria: Manchester, Newcastle and Edinburgh. The final selection of districts represented 87% of trips in the full CAA data-set.

2.3.3 The CAA data also included two fields related to air passenger country of residence (categorised as either 'UK' or 'foreign') and overall journey purpose (categorised as either 'business' or 'leisure'), which allowed the data to be sub-divided into four categories.

2.3.4 In order to develop the gravity model, a range of explanatory variables were investigated and the model was then calibrated with the minimum GC of travel by mode selected as a disutility function – GCs were extracted from the main mode choice model described in the next section. The explanatory variables selected were as follows:

- total resident population – mid-year population estimates were sourced from the Office of National Statistics (ONS) Nomis website;
- total employee jobs – sourced from the ONS Annual Business Inquiry, also available on the Nomis website;
- total hospitality jobs – also sourced from the Nomis website and used as a proxy to represent the concentration of hotels and restaurants (key attractors for foreign leisure passengers).

2.3.5 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 was 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.

2.3.6 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 logical since areas with a high number of jobs that generate high volumes of UK-based business air trips are also likely to generate high numbers of foreign business passenger trips.

2.3.7 The development of the gravity model is described in more detail in the Technical Appendix at the end of this document. The calibration results are shown in Table 2. The constant values shown in the table indicate that the distribution of UK leisure passengers was more closely related to the spread of total jobs than of resident population, while business trips were not dependent on resident population. In addition, the low values of the constant for GC related to passenger distribution generally reflected the fact that passenger distributions are spread across a large area of the UK.

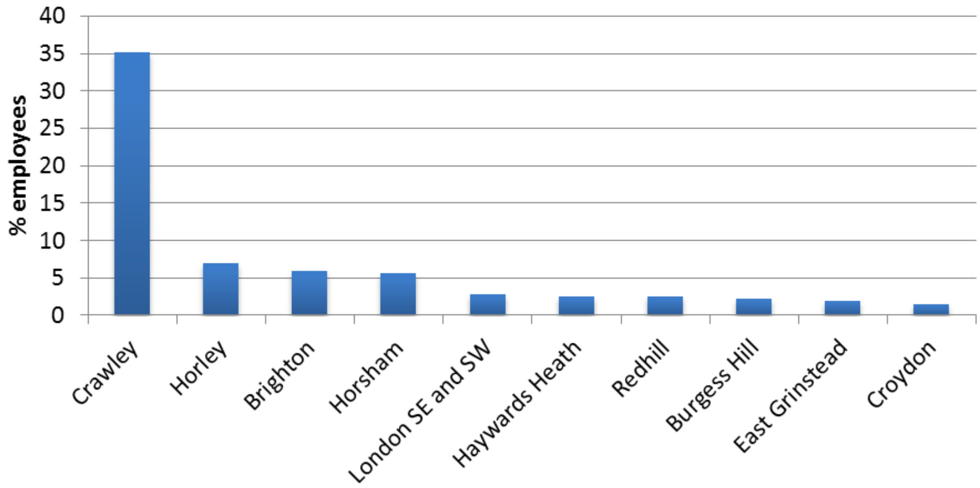
Table 2: Function of accessibility coefficients and RSQ values for Gatwick passenger trip categories

Trip category	Variables/coefficients for f(A)				Resultant RSQ value
	β (population)	α (jobs)	δ (hospitality jobs)	γ (GC)	
Business	0	7.36		0.96	0.67
UK leisure	1.47	1.72		1.12	0.64
Foreign leisure			10	0.86	0.80

Employee trip distribution

2.3.8 Figure 4 shows the 2012 top ten Gatwick employee home locations, representing 68% of staff. Further detailed breakdown of Gatwick employee home locations was not available so a distance-based model of current employee trip distribution to Gatwick was derived based on Heathrow airport employment surveys undertaken in 2008/09. Residual factors were applied to the distribution model to ensure it was consistent with the limited available data for Gatwick.

Figure 4: Top ten Gatwick employee home locations (2012)



Source: GAL (2012), 'Your Journey To Work, Staff Travel Plan 2013-2030' (Table 2, page 23)

2.4 Main mode choice model

2.4.1 A main mode choice logit model was developed at a district level to ensure consistency with the trip distribution model. A base year 2012 model was developed and was calibrated to the 2012 CAA passenger survey data. To avoid sample bias, Olympic-related trips were removed from the database before this analysis was undertaken to minimise the risk of the results being skewed by travel choices related to atypical journeys.

2.4.2 GCs for journeys to Gatwick from each representative district were calculated for the following main mode choices identified from the 2012 CAA data:

- Car;
- Bus and Coach; and
- Rail.

2.4.3 Car demand was apportioned based on the 2012 CAA data across a further 4 sub-categories for each district to provide a better fit of GC. These sub-categories were as follows:

- Kiss and fly passengers;
- Park and fly – short stay;
- Park and fly – long stay; and
- Taxi.

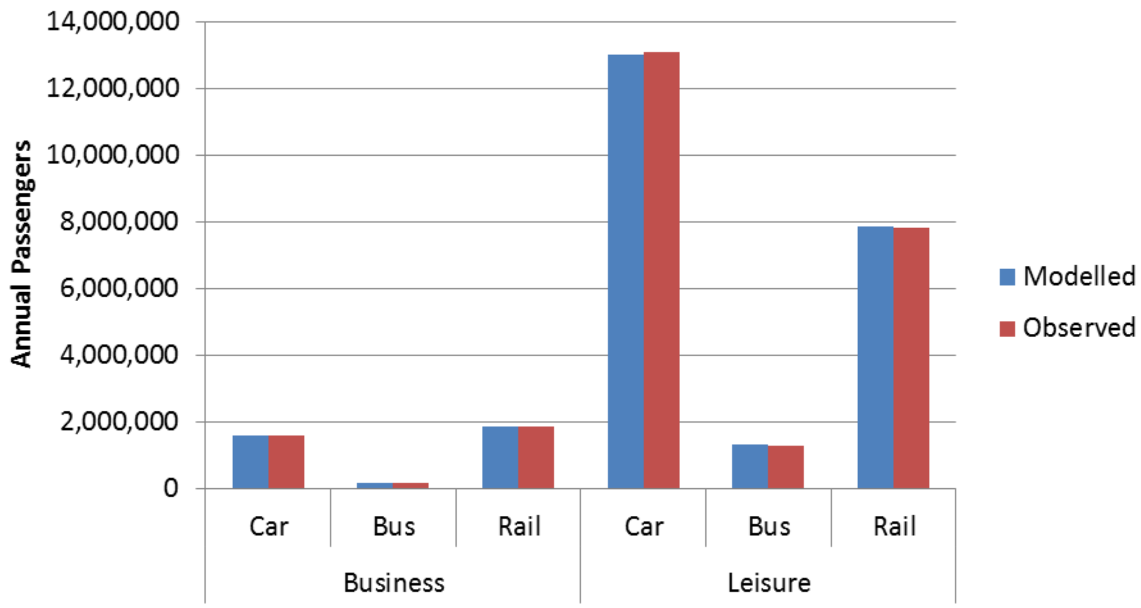
2.4.4 GCs for bus or coach journeys were calculated based on fare and journey time data from National Express, other coach operators, TfL and local bus operators.

2.4.5 A composite GC for rail was calculated based on the costs derived separately for each of the rail sub-modes, described in a later section of this document.

2.4.6 GCs were calculated with additional mode-specific adjustment factors applied to account for non-monetised effects on GCs in London and the rest of the UK. Lambda values were then calibrated to improve the fit to the 2012 CAA data. Some districts with unusual trip patterns in the observed data were excluded from the calibration process to avoid skewing the results.

2.4.7 Figure 5 compares the total modelled and observed passenger demand by mode and purpose across all the representative districts. The graph indicates that overall, the model forecast for total trips by mode is a very good fit to the observed data, with less than 2% error overall for any mode.

Figure 5: Modelled v observed annual passenger demand (2012)



2.4.8 Table 3 presents the calibration results of the main mode choice model, indicating how well the modelled mode shares compare with observed mode shares in each district. There is a very strong correlation between modelled and observed rail trips and a reasonably strong correlation between modelled and observed car trips. Bus and coach trips account for only 7.9% of total mode share, so many districts generated very small numbers of observed coach trips, making the calibration process more difficult. However due to the low total demand it was not considered as important to ensure a strong fit at the district level. Therefore the calibration process focussed on achieving the best fit for observed car and rail data.

Table 3: Main mode calibration results

District	Business			Leisure		
	Car	Bus & Coach	Rail	Car	Bus & Coach	Rail
RSQ London	0.70	0.35	0.99	0.72	0.87	0.94
RSQ All Zone	0.78	0.47	0.98	0.75	0.37	0.94

2.5 Rail sub-mode choice logit model development

2.5.1 The headline logit model also included a sub-rail component to allocate rail passenger proportions to proposed rail services to Gatwick. This was considered particularly important due to the difference in rail fare that applies to Gatwick Express (GEX) compared with standard rail options.

2.5.2 The observed CAA data for Gatwick, which was used to calibrate the base model, reinforces the importance of fare. In total only 35% of rail passengers used the GEX service to access the airport compared to 65% using standard rail. In addition, a significantly higher proportion of business rail passengers (47%) used GEX when compared with leisure passengers (34%).

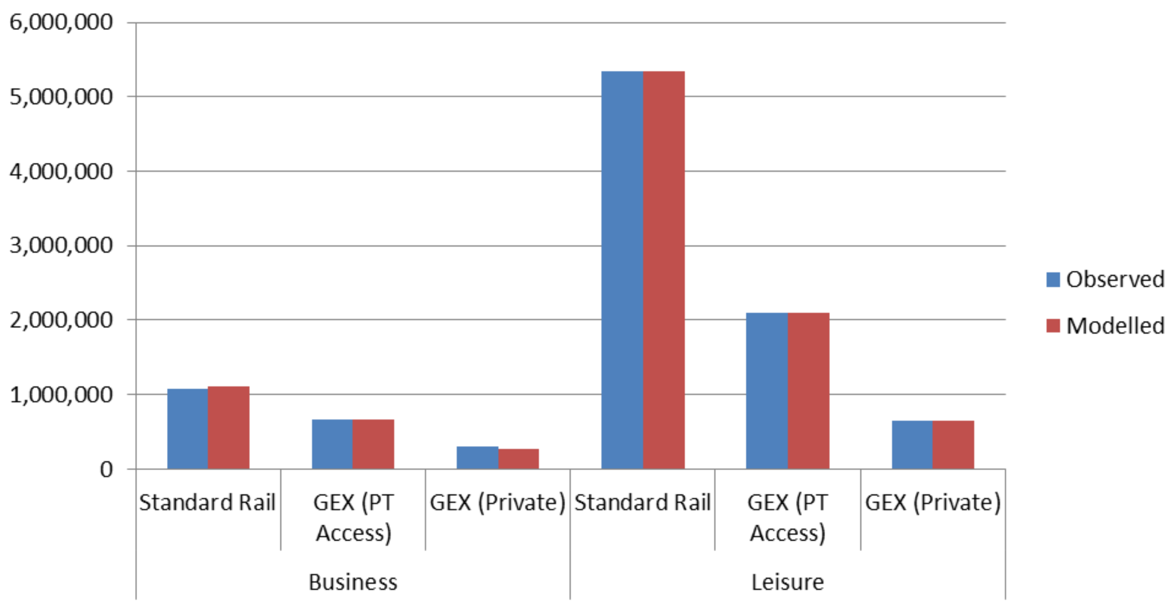
2.5.3 The same districts used in the distribution and main mode choice models, as described earlier, were used for the sub-rail component. A representative 'busy' station was identified in each district based on a qualitative high-level assessment. Wherever possible, a prominent tube station was selected as a representative station in London boroughs, while in other districts, the main railway station in the district was identified.

2.5.4 Three rail sub-modes were identified in the base year and are listed below, accounting for the significant number of GEX trips with a taxi component evident in the 2012 CAA survey data:

- Standard Rail;
- GEX (PT access); and
- GEX (Taxi Access).

2.5.5 Rail sub-mode GCs were derived using the sources listed in section 2.2 with lambda values calibrated to improve the fit of the model to the CAA 2012 survey data. Mode comfort factors were identified to adjust the GCs to account for non-monetised impacts. Figure 6 compares total modelled and observed passenger demand by rail sub-mode in 2012 across all the representative districts.

Figure 6 : Modelled v observed annual rail passengers to Gatwick (2012)



2.5.6 Table 4 presents the R-square results for the rail sub-mode model. The R-square values indicate that there was a very strong correlation between modelled and observed demand at the district level for all sub-modes. Full analysis of the calibration process and results are detailed in the Technical Appendix at the end of this document.

Table 4: Rail sub-mode calibration results

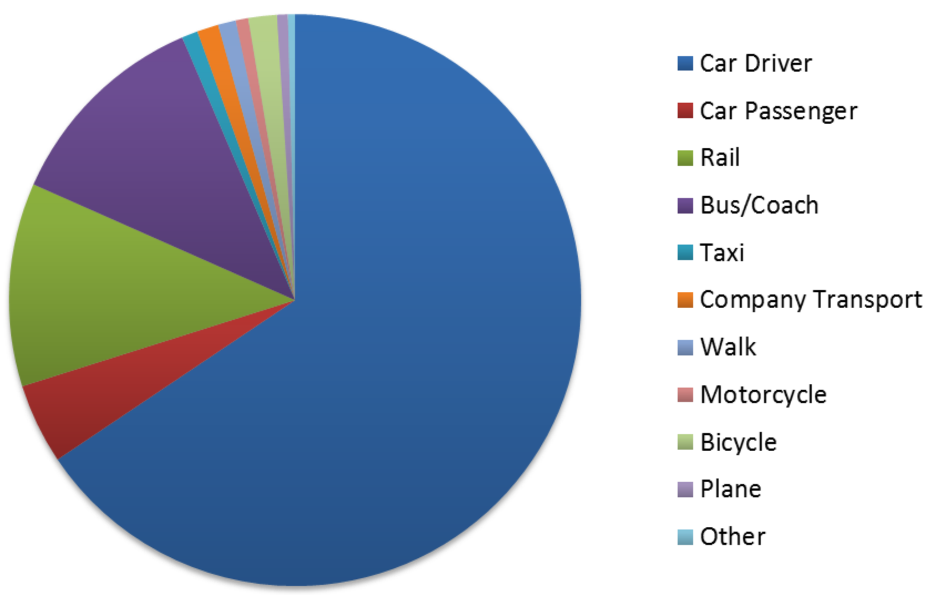
District	Business			Leisure		
	Standard Rail	GEX (PT Access)	GEX (Private)	Standard Rail	GEX (PT Access)	GEX (Private)
RSQ London	0.74	0.97	0.87	0.88	0.98	0.98
RSQ All Zone	0.83	0.97	0.87	0.93	0.98	0.98

2.6 Forecasting passenger and employee trips in 2030

2.6.1 Forecast surface access mode share for passengers was then calculated for 2030 using updated GCs based on committed and proposed rail schemes and bus/coach services. An incremental approach was used, applying the forecast change in modelled mode share by district from 2012 to 2030 to the observed 2012 data to calculate final 2030 demand estimates by mode. This approach was adopted to account for any outlying districts in the calibrated 2012 model.

2.6.2 As shown in Figure 7, the Gatwick staff travel survey in 2012 indicated that 71% of staff travel to the airport in a private vehicle (including car, motorcycle and taxi), including 32.3% as drivers in single occupancy vehicles. Bus/Coach and Rail accounted for 11% and 12% respectively.

Figure 7: Gatwick employee main mode travel to work (2012)



Source: GATWICK (2012), 'Your Journey To Work, Staff Travel Plan 2013-2030' (Table 1, page 23)

2.6.3 Given the clustering of employee home locations in districts in the vicinity of the airport (with 35% of employees in the 2012 Employment Survey recorded as living in Crawley), it was felt that the headline mode share model developed to forecast passenger trips to and from the airport was not detailed enough to assess employee mode share.

2.6.4 As a result Jacobs used the GAL submission 2040 headline mode share for employees for testing purposes as part of this study, as the forecast increase in rail and bus mode share from the 2012 observed data seemed a reasonable assumption in light of planned improvements in rail and bus/coach services and the potential impact of traffic demand management measures on employee car use at the airport.

2.6.5 For both passengers and employees the rail sub-mode proportions were derived directly from the 2030 rail sub-mode choice model. An incremental approach was not applied as an excellent degree of calibration was achieved for all rail sub-mode options, as described earlier in this report.

2.7 Capacity/level of service analysis

Rail assessment

2.7.1 The mode shares derived from the passenger main mode choice model and employee assumptions were applied to the passenger and employee trip distributions to calculate the number of trips to and from Gatwick during the AM peak hour, by mode and location. The rail sub-mode shares derived were applied to the total rail demand to calculate rail trips by sub-mode.

2.7.2 Rail trips were then assigned to sections on the Brighton Main Line (BML) along with background demand estimates provided by NR to calculate Volume/Capacity Ratios (VCRs) on key sections.

2.7.3 The starting point of this assessment was to identify the 2030 rail access scenario. At the time of writing this consisted of services that NR indicated could be provided following delivery of rail infrastructure associated with the post-2018 Thameslink-Southern-Great Northern (TSGN) franchise and additional but uncommitted works included in the AC's Extended Baseline. Further details on the 2030 rail network serving Gatwick can be found in the Appraisal Report.

2.7.4 The rail assessment constituted a static analysis of forecast rail demand compared with but unconstrained by expected available network capacity in 2030. Further assessment is therefore required using a strategic dynamic modelling approach to better understand the impacts of forecast demand on rail network performance and passenger journey time/experience, including:

- the extent to which rail passengers (including those not related to the airport) change their route to avoid over-crowded services, and the associated knock-on impacts on other services;
- the extent to which new rail services related to currently uncommitted infrastructure may induce an increase in background demand;
- the wider impacts of crowding on the rail network providing secondary connections to BML services, notably the London Underground.

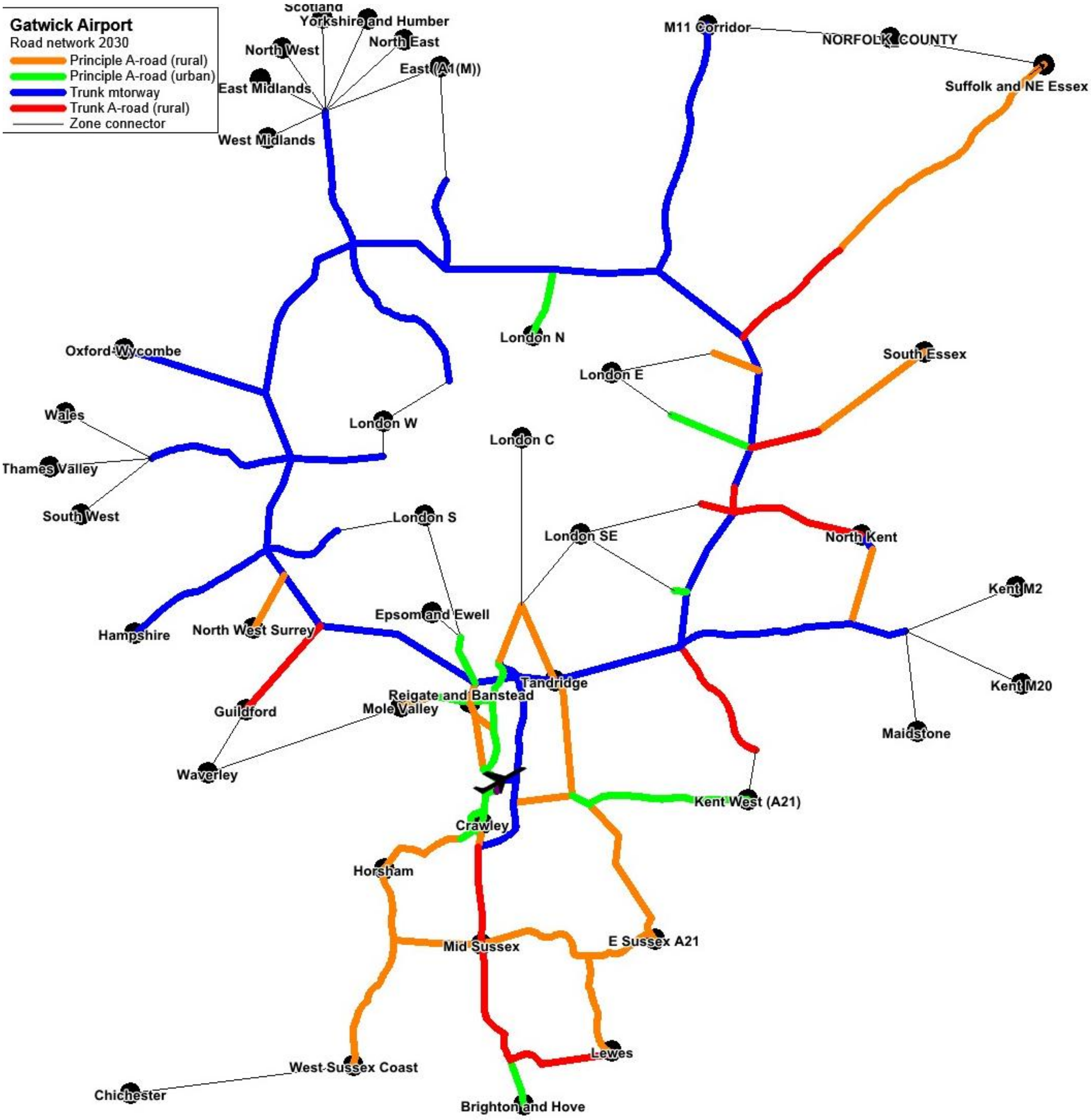
Strategic roads assessment

2.7.5 Car-based demand was generated by the headline mode share model and further adjusted to account for vehicle occupancy and for empty return vehicle trips to and from the airport by taxis and kiss-and-fly journeys. This demand was then manually assigned to routes using the road network and zone system illustrated in Figure 8.

2.7.6 As with the rail assessment, the roads analysis constitutes a static assessment of forecast demand compared with, but unconstrained by, expected available capacity in 2030. Further assessment is therefore required using a dynamic modelling approach to better understand the impacts of forecast demand on road network performance and road user journey time/experience, including:

- the extent to which road users (including those making trips unrelated to the airport) change their route to avoid congested sections of the road network, and the associated knock-on impacts;
- the effect of forecast demand on junction performance and the resulting congestion impacts, both on the strategic road network and the network in the vicinity of the airport (both stages of the assessment focussed on a comparison of forecast demand against theoretical link capacity).

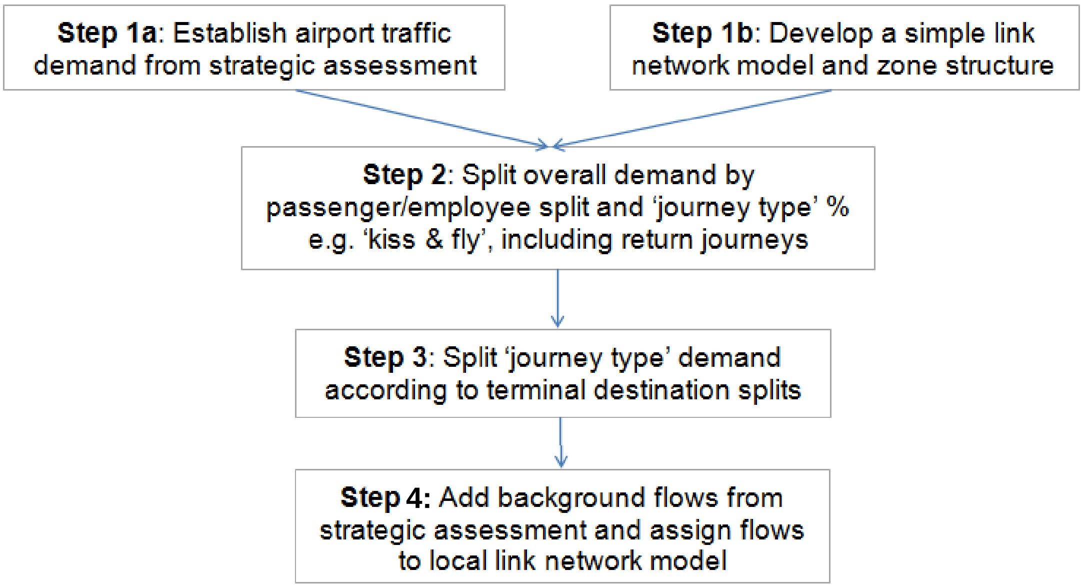
Figure 8 : Road network



Assessment of the road network in the vicinity of the airport

2.7.7 The road network in the vicinity of the airport was assessed based on the outputs from the strategic road network assessment described in the previous section. An outline of the methodology is presented in Figure 9 and further described in the remainder of this section.

Figure 9: Outline methodology for assessment of road network in the vicinity of the airport



2.7.8 The road enhancements in the vicinity of the airport consisted of proposals put forward in the GAL submission, with notable components included the following:

- capacity enhancements at the M23 junction 9;
- the re-alignment of approximately 8km of the A23 around the new runway; and
- a new dual carriageway link from junction 9a to the new terminal building.

2.7.9 The volume of airport-related traffic and total traffic demand in this assessment is shown in Table 5 as derived from the strategic assessment. The total traffic volume is the sum of volumes on the strategic access roads: the M23 Airport Spur, A23 North and A23 South.

Table 5: Forecast vehicle flows (2030) for Gatwick with a second runway

Gatwick with second runway	AM peak-hour forecast flows	
	Inbound	Outbound
Airport traffic (Passenger Car Units - PCUs)	3,412	1,962
Total traffic (PCUs)	6,886	6,570

2.7.10 A simple link network and zone structure model was developed using PTV VISUM software with main carriageway lane capacities defined as 2,000 vehicles per hour for consistency with the strategic assessment.

2.7.11 A zoning system was then developed based on our interpretation of the GAL submission road proposals. The zoning system was defined with 11 zones, with 4 representing the strategic highway network origins and destinations (A23 North and South and M23 North and South), 3 zones representing the kiss & fly drop-off points for each terminal, 3 zones representing the short-stay parking locations, and a single zone representing internal long-stay car parking. The location of parking for staff movements was assumed to be within the short-stay car parking locations for each terminal.

2.7.12 A plan showing the link and zone system for the proposed road network around Gatwick Airport is shown in Figure 10. Modelled links are shown as thick black lines and zones are shown in blue shaded areas identified with blue numbers. Zones 1 - 4 represent the strategic highway access locations, 5 - 7 represent the 'kiss & fly' drop off points at each terminal, 8 - 10 represent the short-stay car parks at each terminal and zone 11 represents the long stay car park.

Figure 10: GAL scheme proposal – model link and zone structure

2.7.13 Airport-related traffic was split down by passengers and employees and then for passengers by a journey-type percentage. The passenger/employee split was derived from the Jacobs strategic assessment and the assumptions are presented in Table 6. The data indicates that a higher percentage of employees arrive at the airport rather than depart during the AM peak hour.

Table 6: Forecast passenger/employee splits

Trip type	AM peak hour %	
	Inbound	*Outbound*
Passenger	56.5%	93.4%
Employee	43.5%	6.6%

2.7.14 The passenger journey-type splits were derived from the 2012 CAA survey data for Gatwick, as shown in Table 7. ‘Unknown’ journey types and those with a very small number of associated movements were excluded from the analysis.

Table 7: Journey-type split for passengers

Journey type	Trips	
	Volume	Percent
Kiss & Fly*	9,566,486	57.2%
Long Stay	4,594,510	27.5%
Long Stay (Valet)	418,610	2.5%
Long Stay (Valet Off Site)	557,725	3.3%
Short Stay	1,053,284	6.3%
Short Stay Rental	541,477	3.2%
Total	**16,732,092**	**100%**

Note: Kiss & Fly journey category includes taxis

2.7.15 The assessment assumed that there would be no change in the proportion of journey type splits from 2012 to 2030, which may occur in practice due to, for example, airport policy changes. Wider forecast changes in mode share associated with travel to and from the airport are captured within the Jacobs strategic assessment data that informs this assessment.

2.7.16 An assumption was required regarding the proportion of trips associated with each terminal. The data obtained for this purpose is taken from Table 8.5 of the ‘*Surface Access Assessment - Technical Report (9th May 2014)*’ submitted to the AC by GAL. The submission sets out a 2040 forecast for passenger and employee trips between 8am and 9am, which is summarised in Table 8.

Table 8: Forecast of passenger and employee destinations by terminal (2040)

Terminal	Trips	
	Volume	Percent
North	2,764	33.3%
South	3,512	42.3%
New	2,017	24.3%

2.7.17 The terminal destination splits are applied to further break down the percentage of trips associated with passenger kiss & fly and short stay journey types as well as for employee trips to short-stay car parking.

2.7.18 The background traffic volumes were added to the airport-related trips to produce an overall traffic demand matrix. This process is presented in Table 9 to Table 11. These flows were assigned in the network model and the results of the assignment are presented in the Appraisal Report. The assigned flows were checked for consistency with the forecast inbound and outbound totals.

2.7.19 The background traffic volumes on individual links in the model were taken from a combination of TRADS count data for the AM peak hour (factored up using DfT National Transport Model (NTM) 2030 growth forecasts) and flows from the strategic assessment model. It should be noted that although the overall forecast traffic volumes are broadly consistent with the overall volumes in the strategic assessment, this assessment incorporated a refinement of the strategic assessment inputs and therefore the totals do not match exactly.

Table 9: Non-airport Traffic Demand Matrix (2030 Forecast)

Zone/Location		1	2	3	4	5	6	7	8	9	10	11	TOTAL
		M23 N	M23 S	A23 N	A23 S	K&F-tNo	K&F-tSo	K&F-tNe	SS-tNo	SS-tSo	SS-tNe	LS	
1	M23 N	0	3790	808	0	0	0	0	0	0	0	0	4598
2	M23 S	3394	0	1284	0	0	0	0	0	0	0	0	4678
3	A23 N	558	464	0	884	0	0	0	0	0	0	0	1906
4	A23 S	0	0	506	0	0	0	0	0	0	0	0	506
5	K&F-tNo	0	0	0	0	0	0	0	0	0	0	0	0
6	K&F-tSo	0	0	0	0	0	0	0	0	0	0	0	0
7	K&F-tNe	0	0	0	0	0	0	0	0	0	0	0	0
8	SS-tNo	0	0	0	0	0	0	0	0	0	0	0	0
9	SS-tSo	0	0	0	0	0	0	0	0	0	0	0	0
10	SS-tNe	0	0	0	0	0	0	0	0	0	0	0	0
11	LS	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		3952	4254	2599	884	0	0	0	0	0	0	0	11689

Note 1: tNo = North Terminal, tSo = South Terminal, tNe = New Terminal

Table 10: Airport Passenger Traffic Demand Matrix (2030 Forecast)

Zone/Location		1	2	3	4	5	6	7	8	9	10	11	TOTAL
		M23 N	M23 S	A23 N	A23 S	K&F-tNo	K&F-tSo	K&F-tNe	SS-tNo	SS-tSo	SS-tNe	LS	
1	M23 N	0	0	0	0	208	264	152	31	40	23	272	989
2	M23 S	0	0	0	0	49	63	36	7	10	5	65	236
3	A23 N	0	0	0	0	58	73	42	9	11	6	75	274
4	A23 S	0	0	0	0	88	112	64	13	17	10	115	420
5	K&F-tNo	253	50	61	63	0	0	0	0	0	0	15	441
6	K&F-tSo	321	63	77	80	0	0	0	0	0	0	18	560
7	K&F-tNe	185	36	44	46	0	0	0	0	0	0	11	322
8	SS-tNo	26	5	6	7	0	0	0	0	0	0	0	44
9	SS-tSo	33	7	8	8	0	0	0	0	0	0	0	56
10	SS-tNe	19	4	5	5	0	0	0	0	0	0	0	32
11	LS	245	48	59	61	0	0	0	0	0	0	0	412
TOTAL		1082	213	260	269	403	512	294	61	77	44	570	3787

Note 1: tNo = North Terminal, tSo = South Terminal, tNe = New Terminal

Table 11: Airport Staff Traffic Demand Matrix (2030 Forecast)

Zone/Location		1	2	3	4	5	6	7	8	9	10	11	TOTAL
		M23 N	M23 S	A23 N	A23 S	K&F-tNo	K&F-tSo	K&F-tNe	SS-tNo	SS-tSo	SS-tNe	LS	
1	M23 N	0	0	0	0	0	0	0	255	324	186	0	765
2	M23 S	0	0	0	0	0	0	0	61	77	44	0	182
3	A23 N	0	0	0	0	0	0	0	71	90	52	0	212
4	A23 S	0	0	0	0	0	0	0	108	137	79	0	325
5	K&F-tNo	0	0	0	0	0	0	0	0	0	0	0	0
6	K&F-tSo	0	0	0	0	0	0	0	0	0	0	0	0
7	K&F-tNe	0	0	0	0	0	0	0	0	0	0	0	0
8	SS-tNo	25	5	6	6	0	0	0	0	0	0	0	43
9	SS-tSo	32	6	8	8	0	0	0	0	0	0	0	55
10	SS-tNe	19	4	4	5	0	0	0	0	0	0	0	31
11	LS	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		76	15	18	19	0	0	0	494	628	361	0	1612

Note 1: tNo = North Terminal, tSo = South Terminal, tNe = New Terminal

2.7.20 The strategic assessment model used count data sourced from the DfT Traffic Count website, which provides Annual Average Daily Flows (AADF) for both directions of a link combined. To convert the AADFs to hourly flows a single global factor for the whole model was applied, a method that was considered appropriate given the strategic nature of the assessment. More detailed analysis of count data from TRADS undertaken for this assessment indicated a significant variation in the ratio of AADF to AM peak hour flows depending on the link. For the M23 and A23 links around Gatwick, it was found that the single global factor used in the strategic assessment model led to a small over-estimate of peak-hour flows.

3. Assumptions Log

3.1 Overview

3.1.1 This section includes a summary of assumptions and inputs used in the Jacobs surface access models. The assumptions and inputs take into account forecast future growth in surface access demand and improved transport accessibility at Gatwick in 2030, and account for a scenario where the airport remains in its current form with one runway and a scenario where a second runway is delivered. Committed and expected enhancements to the road and rail networks by 2030 were considered, as described earlier in this document.

3.2 Headline demand assumptions

3.2.1 The parameters used to calculate passenger and employee peak hour demand for a busy day in 2030 are summarised in Table 12 and Table 13 respectively.

3.2.2 For many of the assumptions, the Jacobs surface access model included key statistics for 2030 from the technical appendix to GAL's submission ('*A Second Runway for Gatwick, Appendix A6 Surface Access*') where data was provided. In other cases, for example with regard to vehicle occupancy assumptions, data was not provided in the submission and other sources had to be used. As with all the short-listed airport expansion options, the initial basis of the analysis for Gatwick was the scheme promoter's own forecasts of MPPA and on-airport employees.

3.2.3 The Jacobs main mode share logit model forecasted a 43% air passenger rail mode share for 2030, which compares to GAL's estimate of 44% in the same year[2]. For the purpose of modelling the 'highest impact' passenger rail use, GAL used a 50% rail mode share in their submission, and a sensitivity test was undertaken applying this mode share in the Jacobs model. Further details of the results of this test are provided in the Appraisal Report.

3.2.4 No data was available for the empty taxi drive-back rate at Gatwick, but data was available from a survey at Heathrow indicating that 78% of taxis are empty on one leg of their journey to and from the airport. This figure was reduced for Gatwick to account for the relatively less urban location of the airport when compared with Heathrow.

3.2.5 For employees, GAL modelled a main mode share of 60% private vehicle, 20% bus/coach and 20% rail in their 2040 assessment. The district-level geographic framework for the Jacobs model meant that it was not considered detailed enough to forecast employee mode share, as observed data indicated that employee home locations tend to be clustered in a small number of districts in the vicinity of the airport. Following a review of the figures developed by GAL, Jacobs concluded that the 2040 assumptions on employee mode share represented a reasonable assumption that could be applied in the 2030 model to assess surface demand impacts.

[2] A mode share estimate for 2030 was not provided in the GAL submission but was confirmed by GAL during discussions with the AC in August 2014.

Table 12: Surface transport headline demand assumptions for passengers

Parameter	GAL assumption	Jacobs assumption	Source/comment
MPPA (one runway)	46	46	Demand forecasts directly from GAL Surface Access Assessment Appendix A6
MPPA (including second runway)	65	65	Demand forecasts directly from GAL Surface Access Assessment Appendix A6
Proportion of interlining (transit) passengers	<10%	8%	Current proportion of interliners at Gatwick, as stated in GAL Surface Access Assessment Appendix A6
Busy day factor	0.33%	0.31% (1/320)	Based on estimated 85^{th} percentile day using Heathrow Airport Traffic Stats 2013 data – applied to account for forecast increase in business passengers at Gatwick with a second runway
To/From airport factor	50%	50%	Professional judgement
Peak hour – time	0800-0900	0800-0900	GAL Surface Access Assessment Appendix 6
Peak hour - % daily trips	5.78% to, 7.96% from	5.78% to, 7.96% from	GAL Surface Access Assessment Appendix A6
Passenger profile by purpose	23% business, 77% leisure	23% business, 77% leisure	GAL Surface Access Assessment Appendix A6
Main mode share	45% car, 11% bus/coach, 44%rail (not in submission but confirmed independently by GAL)	46.2% car, 10.8% bus & coach, 43.0% rail	Modelled by Jacobs main mode share logit model
Car occupancy factor	-	1.17 business, 2.13 leisure	Gatwick 2012 CAA passenger survey data
Taxi + kiss & fly empty drive back rate	-	41%	Based on Heathrow survey data (Heathrow Airport: Taking Britain Further - Volume 1), adjusted to account for Gatwick location
% Meet and Greet by rail	-	0.37%	Gatwick 2012 CAA passenger survey data

Table 13: Surface transport assumptions for employees

Parameter	GAL assumption	Jacobs assumption	Source/comment
Total employees	29,685	29,685	GAL Surface Access Assessment Appendix A6
% Employees at work on busy day	-	57%	Heathrow 2008/9 employee survey (no data available for Gatwick)
% Employees travelling to/from airport during passenger peak hour	15% to, 1% from	15% to, 1% from	GAL Surface Access Assessment Appendix A6
Main mode share	60% private vehicle, 20% rail, 20% bus & coach	60% private vehicle, 20% rail, 20% bus & coach	GAL Surface Access Assessment Appendix A6
Staff car occupancy factor	-	1.2	Current data at existing airports plus assumption about greater car sharing

3.3 Generalised Cost (GC) parameters

3.3.1 Base year and 2030 GC was estimated between the airport and districts in the UK for each mode of transport in the Jacobs model, and GC parameters were calibrated using the Gatwick 2012 CAA passenger survey data.

3.3.2 GC for rail and bus/coach passengers was calculated using components for fare, Value of Time (VoT), in-vehicle time, a comfort factor for the type of service, interchange time and penalty, and wait time and penalty.

3.3.3 GC for private vehicle trips was calculated for different sub-modes including taxi, kiss & fly, and short- and long-stay parking. The components included taxi fare, VoT, in-car time, vehicle occupancy, set-down time, parking costs, and car operating costs. Unlike for rail, the Jacobs model did not forecast private vehicle sub-mode share and the share derived from the 2012 CAA passenger survey data was applied in the 2030 model.

3.3.4 All GCs for the 2030 model were developed with reference to schemes in the AC's Core and Extended Baselines. Further details on these schemes are provided in the Appraisal Report. The GC parameters applied in the Jacobs model are summarised in Table 14. It should be noted that the GCs developed are fixed costs and do not account for the variable impact of congestion or crowding on journey time/experience.

Table 14: GC parameters applied in Jacobs model

Parameter	Jacobs assumption	Jacobs source
Business value of time (p/min)	69p	SKM (Jacobs) analysis of airport passenger use of HS2[3] - composite of UK and non-UK values
Leisure value of time (p/min)	27p	SKM (Jacobs) analysis of airport passenger use of HS2 – composite of UK and non-UK values
Gatwick short-stay parking cost	£32 (1 day business), £83 (3 days leisure)	Prices sourced for Gatwick South terminal *(queried 12th June 2014 effective from 13th June 2014 onwards)*
Gatwick long-stay parking cost	£55 (3 days business), £97 (7 days leisure)	Prices sourced for Gatwick South terminal *(queried 12th June 2014 effective from 13th June 2014 onwards)*
Average interchange time	5 mins * 2 (penalty)	Professional judgment based on research of average bus, coach, train and tube frequencies
Average wait time	Half service frequency * 2 (penalty)[4]	Professional judgment (good practice)
Rail fares	2014 base price	Various sources including the National Rail journey planner
Bus/coach fares	2014 base price	Various sources including the National Express and bus company websites.
Taxi fares	2014 base price	Various sources including taxi firms currently serving Gatwick
Car operating cost (£/km)	£0.12 business, £0.05 leisure	LASAM Model

3.4 Rail assessment assumptions

3.4.1 The Gatwick rail capacity assessment was undertaken assuming the following changes to the rail network serving the airport by 2030:

- full delivery of the post-2018 high-peak Thameslink-Southern-Great Northern (TSGN) timetable – the latest timetable assumed by NR indicates 22 standard and 4 Gatwick Express (GEX) train paths through Gatwick Airport station, including 8 paths through the Thameslink Core via London Bridge – it should be noted that the TSGN franchise holder will have some scope to determine the actual timetable that is operated on the BML and that at the time of writing the 2018 timetable and track access rights had not been finalised;
- an additional 4 train paths to Victoria and 2 to London Bridge, made feasible by a number of uncommitted infrastructure schemes listed in the AC's Extended Baseline – NR's current proposal is that 3 of these services would terminate at Haywards Heath or Wivelsfield, with 2 terminating at Hove and 1 at Eastbourne (although these are preliminary proposals and are subject to change), and all are expected to operate in 12-car formation utilising Class 377 rolling stock.

3.4.2 Background demand estimates and capacity figures for the aforementioned services were supplied by NR, and the net impact of the second runway was added to background demand to determine second runway-related impacts on rail capacity and network performance. Further details of the 2030 rail network assumptions and the capacity/performance assessment are provided in the Appraisal Report.

[3] http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/rail/pi/highspeedrail/hs2ltd/appraisalmaterial/pdf/airportdemandmodel.pdf
[4] The average wait time was capped at 10 minutes for the initial service used to reflect journey planning practices

3.5 Road assessment assumptions

3.5.1 A summary of the parameters used in the roads assessment of a second runway at Gatwick in 2030 is provided in Table 15.

Table 15: Highway performance analysis parameters

Parameter	Jacobs assumption	Jacobs source
Theoretical link capacity (PCUs)	2,000	Industry standard assumption for strategic road lane capacity
Day-to-peak-hour flow factor	7.21%	TRADS Website (https://trads.hatris.co.uk/)
Background traffic growth factor	1.33 (average)	DfT NTM regional traffic growth and speed forecasts

3.5.2 Background traffic flows for a base year were factored up using the growth factors indicated in the table, and net second runway traffic was then added on top and compared with theoretical link capacity. The resulting VCRs were used to identify links on the strategic road network that may require capacity improvements to accommodate forecast demand. The following thresholds were applied:

- VCR above 85% = potential requirement for capacity enhancement;
- VCR above 100% = definite requirement for capacity enhancement.

Appendix A. Technical note

A.1 Development and calibration of trip distribution model

This analysis was undertaken at district level, including the 33 London boroughs and the remaining districts and unitary authority areas in the UK. The CAA Gatwick passenger survey 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 four categories to refine the analysis.

An initial sift was undertaken to remove districts that generated less than 50,000 total annual passenger trip origins, or were based on less than 50 survey records. This was to ensure that the model calibration was focussed on the key trip generators and was not hampered by observed data based on very few interview records, which could skew the results. Olympic-related trips were removed from the database before this analysis was undertaken to minimise the risk of the results being skewed by travel choices related to atypical journeys. Three districts that failed the initial sift were added back into the representative district list to ensure that all regions in the UK had a representative district, these were: Manchester (representing the North West), Newcastle (representing the North East) and Edinburgh (representing Scotland).

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 was logical 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.

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 logical since areas with a high number of jobs that generate high volumes of UK-based business air trips are also likely to generate high numbers of foreign business air trips as well.

Airport passenger trip origins

In any gravity model, accessibility from the destination is a key determining factor of trip origin. In this model, accessibility for passengers was represented by the shortest GC of a journey to the airport from each district by any of the main modes: Car, Bus/Coach and Rail. For employees, only the current top ten district home locations (representing 68% of all Gatwick staff) could be identified from publicly-available survey summaries. As a result, the employee trip distribution model was calibrated using Heathrow survey data, with factors applied to ensure the forecasts for the top ten Gatwick districts were consistent with the observed data.

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.

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 residential areas generating more trips than poorer areas).

However, developing a model to this level of complexity was outside the scope of this study and consequently 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 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, also sourced from the ONS Nomis website.

In the 2030 model, population and job forecasts provided by the GLA (for London) and DfT NTM (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

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 for each district to Gatwick Airport:

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

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

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

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

Where:
C = minimum GC to the airport;
D =crow-fly distance to the airport
J = total jobs;
P = total population; and
H = hospitality jobs
f(a) = function of attraction to Gatwick

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 available survey data. Minimum GC was extracted from the mode share model calculations as described later in this document.

Base model calibration

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 passenger and employee trip origins by district. The final constant values and corresponding R-Squares, assuming an intercept of 0, are summarised in Table 16.

Table 16: Function of accessibility co-efficients and RSQ values for Gatwick passenger trip categories

Trip category	Variables/coefficients for f(A)				Resultant RSQ value
	β (population)	α (jobs)	δ (hospitality jobs)	γ (Gen cost)	
Business	0	7.36		0.96	0.67
UK leisure	1.47	1.72		1.12	0.64
Foreign leisure			10	0.86	0.80

The constant values shown in the table indicate that the distribution of business trips was dependent on the spread of total jobs and the spread of UK leisure passengers was more closely related to the spread of total jobs than to resident population. In addition, the low values of the constant for GC related to passenger distribution generally reflect the fact that passenger distributions are spread across a large area of the UK.

The employee distribution model, based on 2008/09 Heathrow employee distributions, has a coefficient of 1.00 for population and 2.15 for distance. This reflects a high level of clustering of employees in the vicinity of the airport site. Factors were applied to the raw forecast distribution to match the current distribution of 68% of staff to the top ten areas identified in the Gatwick staff travel survey of 2012.

The graphs in Figure 11 to Figure 14 illustrate the strength of the relationship derived with f(a) for each of the four trip types, demonstrating reasonable correlations for both business and leisure passengers.

Figure 11: Trip origin v accessibility for Gatwick business passengers (2012), by UK district

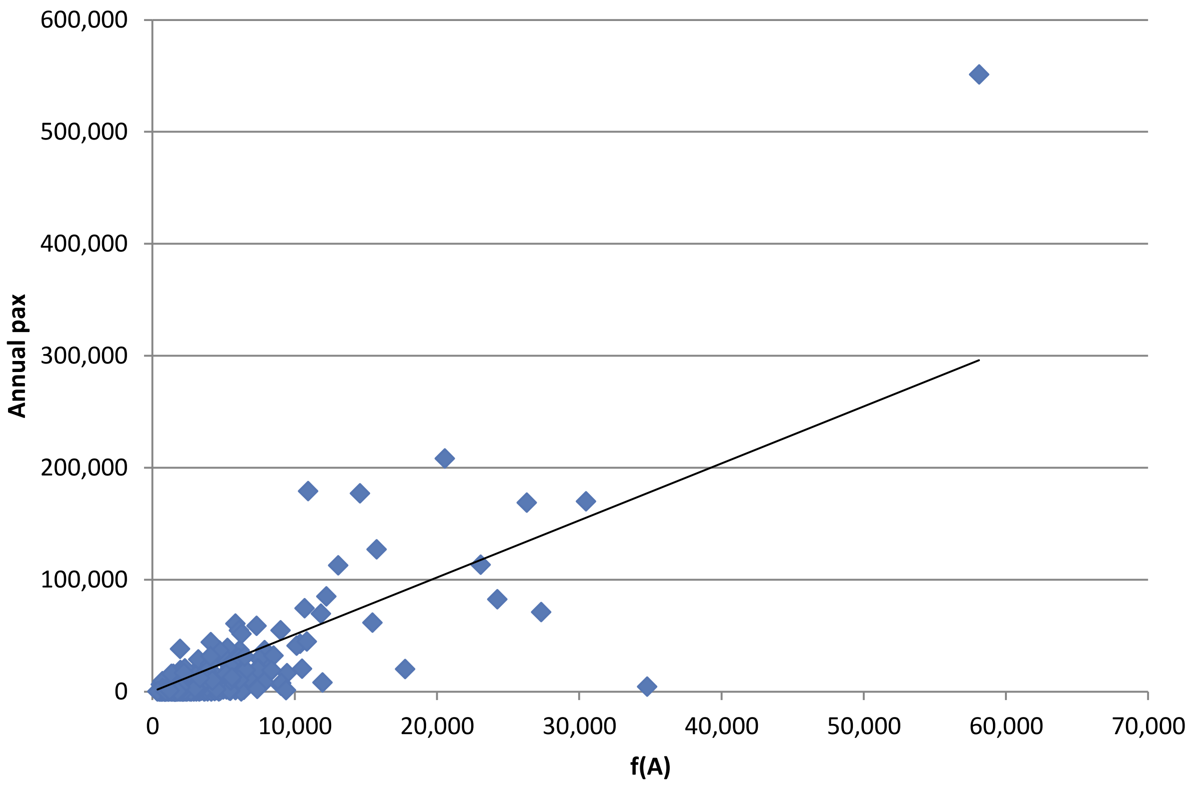


Figure 12: Trip origin v accessibility for UK resident Gatwick leisure passengers (2012), by UK district

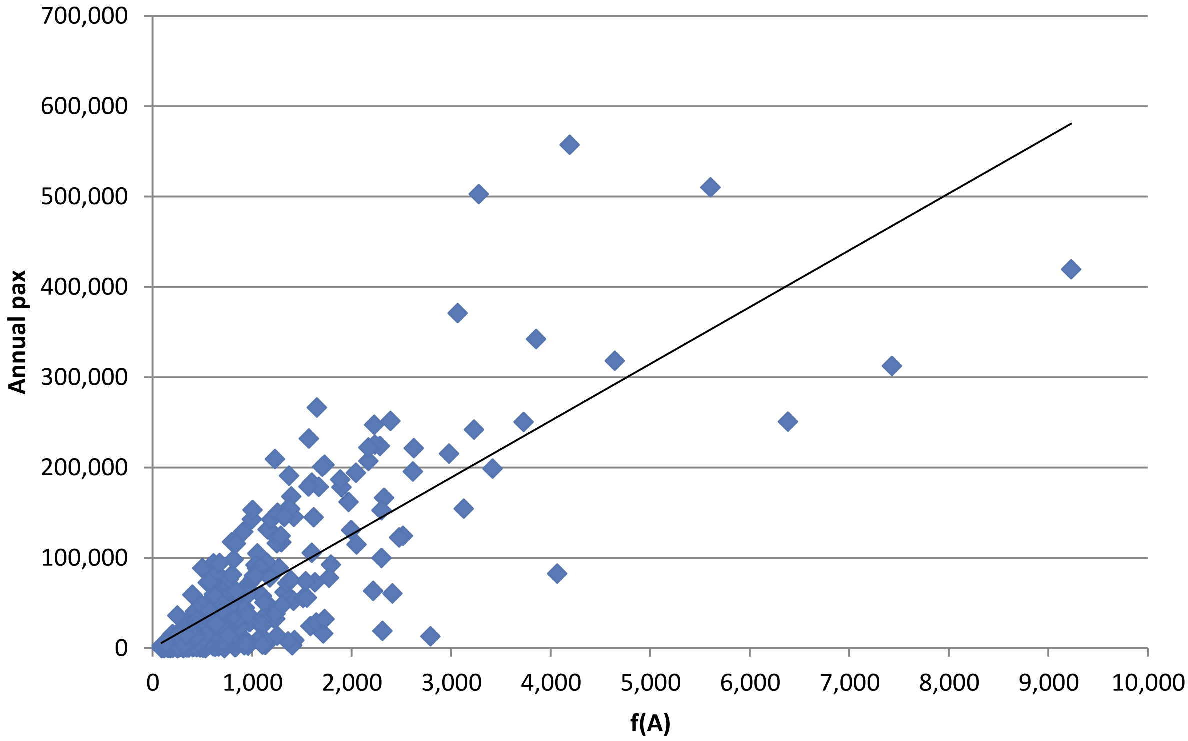


Figure 13: Trip origin v accessibility for foreign resident Gatwick leisure passengers (2012), by UK district

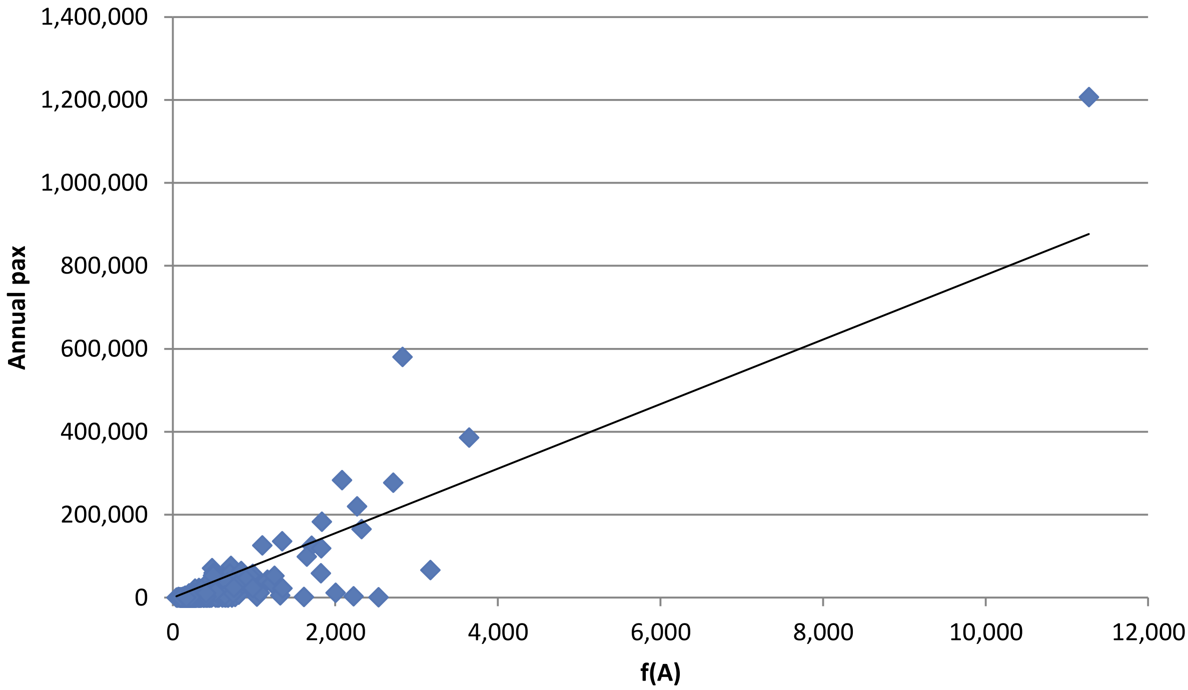
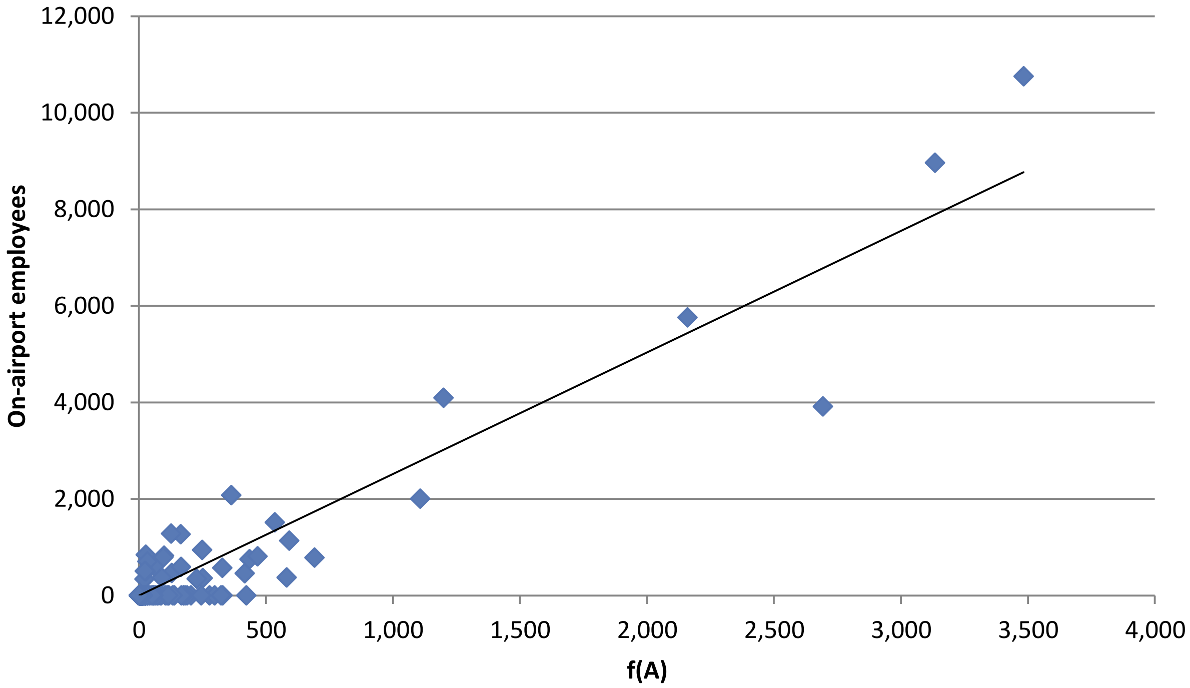


Figure 14: Trip origin v accessibility for Heathrow employees (2008), by UK district



To account for the outliers in the derived passenger relationships, residual values were calculated for each of the districts using the equations identified on the graphs. These values were then re-applied to each district in the Gatwick forecasts. For example, 36,986 business passenger trips were recorded in the 2012 survey originating in Hackney, 18% higher than the predicted value of 31,270 using the formula derived above. As a result, the business passenger forecasts between Gatwick and Hackney in 2030 were uplifted by 18% to account for this discrepancy.

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 Gatwick model to the 2030 forecasts is that the characteristics of districts that influence air passenger volumes will remain relatively similar in future.

The relationships calculated above to explain passenger and employee trip origins were considered sufficiently robust for the purposes of forecasting future trip distribution to Gatwick, 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 Gatwick in 2030

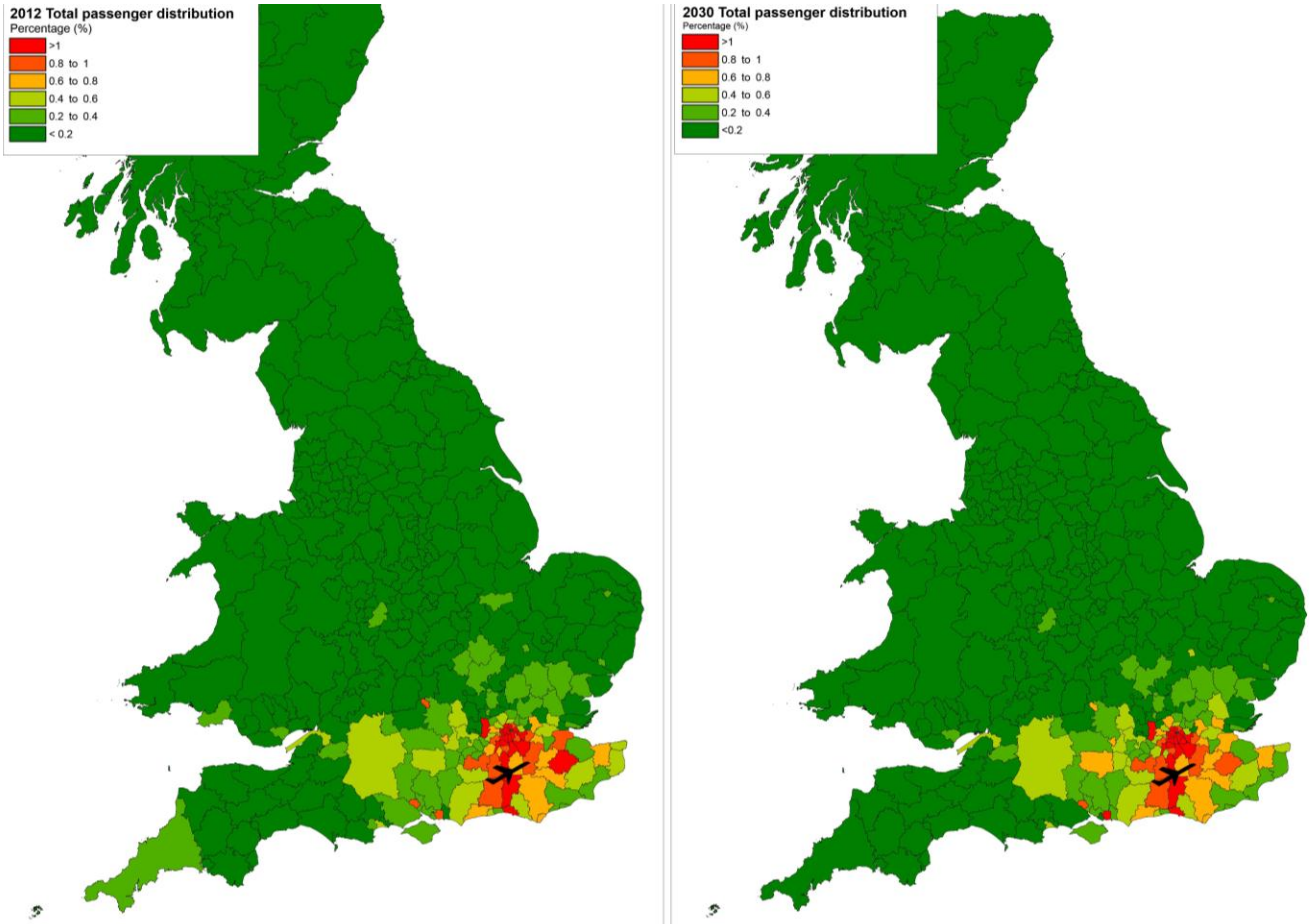
The formulae and residual calculations described above were then applied to generate trip distribution forecasts for passengers and employees to Gatwick in 2030. DfT Tempro population and job growth factors were applied to the base population and employment numbers to generate forecasts for districts outside London while within London, GLA population and job estimates were used. It was assumed that in 2030, the proportion of total jobs in the hospitality sector remained similar to the 2012 proportion in each district.

Further changes to the future passenger distribution are derived from changes in the GC of travel resulting from the changes assumed in the 2030 main mode share model.

The initial resulting forecasts of passenger and employee trips for Gatwick derived from this process were based on the total number of passenger and employee trips recorded during the Gatwick surveys. These were then converted to percentages and multiplied by the peak-hour Gatwick trip forecasts described earlier in this document.

The map in Figure 15 illustrates the resulting change in trip distribution for passengers forecast by the model for 2030 compared with the Gatwick 2012 data. The two distributions are very similar, which would be expected without substantial changes to the underlying population and employment distributions that drive trip demand. The highest demand originates in the districts nearest to the airport and very little demand originates outside of the South East.

Figure 15: Comparison of Gatwick 2012 and forecast 2030 total passenger distribution



A.2 Development and calibration of main mode share model

Structure of headline mode share model

The base logit model was developed at a district level to ensure consistency with the trip distribution model. GCs for journeys to Gatwick airport from each representative district were calculated for the following main mode choices identified from the 2012 CAA data:

- Car;
- Bus and Coach; and
- Rail.

Car demand was apportioned based on the 2012 CAA data into a further 4 sub-categories for each district to provide a better fit of GC, these were:

- Kiss and fly passengers;
- Park and fly – short stay;
- Park and fly – long stay; and
- Taxi.

GCs were calculated for each car sub-mode using the following formulae:

$$\mathrm{GC}_{\mathrm{Taxi}} = \text{In-car time} + \text{Taxi wait time} + \frac{\text{Generalised Taxi fare}}{\text{Occupancy}}$$

$$\mathrm{GC}_{\mathrm{Parked}} = \text{In-car time} + \frac{\text{Operating cost}}{\text{Occupancy}} + \frac{\text{Parking cost}}{\text{Occupancy}}$$

$$\mathrm{GC}_{\mathrm{Kiss\text{-}Fly}} = \text{In-car time} + \text{Set down time} + \frac{\text{In-car time}}{\text{Occupancy}} + \frac{2 * \text{Operating cost}}{\text{Occupancy}}$$

A single composite cost for car was generated by applying the 2012 observed car sub-mode shares to GCs calculated for each of the above car sub-modes using a 'sum product' calculation.

Separate GC calculations were undertaken for each of the rail sub-modes, described in more detail later in this document. GCs calculated for the rail sub-modes were combined by means of a 'logsum' calculation to generate a single overall composite cost for rail. The formula for calculating the composite rail GC across the three sub-modes (Standard rail, GEX with a public transport secondary mode, and GEX with a taxi secondary mode) for each district is shown below:

$$GC_{composite} = \frac{1}{\lambda} \ln\left(\sum_{i=1}^{3} m_i \exp(-\lambda GC_i)\right)$$

where λ = sub rail mode share factor

m_i = Mode share i

GC_i = GC for sub mode i

GCs for bus or coach journeys were calculated in a similar way as for the rail sub-modes, based on fare and journey time data from National Express, other coach operators and local bus operators.

The following components were also included for all GC calculations:

- Values of time of 69p per minute for business trips and 27p per minute for leisure trips were applied to convert total fare estimates and car operating costs for each journey to generalised minutes;
- A factor was applied to wait times and interchange times for public transport trips.

Mode constants were applied to the total GC derived for each mode by journey purpose to account for variables not included in the modelling. The values derived for these parameters are described in the following section on model calibration.

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

Unlike the sub-rail component described in the following section, comfort factors were not applied in the headline mode share model. Therefore the key variables 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.

The final derived lambda values were 0.039 for business passengers and 0.048 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 17.

Table 17: Mode constants applied in calibrated 2012 Gatwick main mode choice logit model

Main Mode factors	London		Rest of UK	
	Business	Leisure	Business	Leisure
Car	0.867	0.896	0.787	0.854
Bus	0.967	0.939	0.965	0.839
Rail	1.000	1.000	1.000	1.000

Figure 16 summarises the differences between observed annual passenger trips to Gatwick by main 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 less than 2% error overall for any mode.

Figure 16 : Modelled v observed annual passengers to Gatwick (2012)

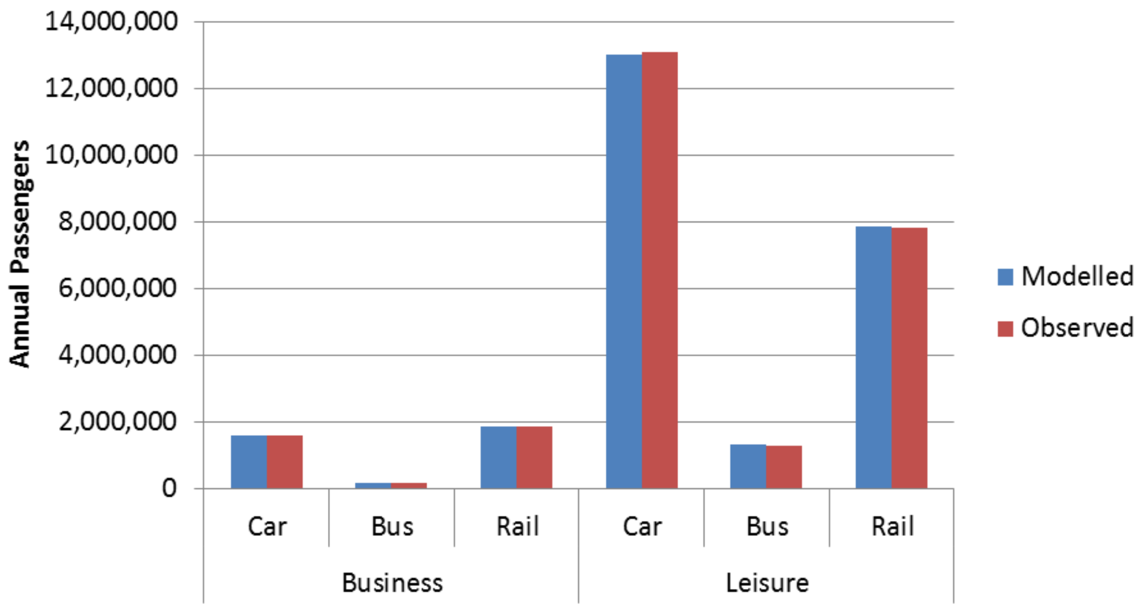


Table 18 presents the calibration results of the main mode choice model, indicating how well the modelled mode shares compare with observed mode shares across all districts. There is a very strong correlation between modelled and observed rail trips and a reasonably strong correlation between modelled and observed car trips. Bus and coach trips account for only 7.9% of total mode share, so many districts generated very small numbers of observed coach trips, making the calibration process more difficult. However due to the low total demand it was not considered as important to ensure a strong fit at the district level. Therefore the calibration process focussed on achieving the best fit for observed car and rail data.

Table 18: Main mode calibration results

Region	Business			Leisure		
	Car	Bus and Coach	Rail	Car	Bus and Coach	Rail
RSQ London	0.70	0.35	0.99	0.72	0.87	0.94
RSQ All Zone	0.78	0.47	0.98	0.75	0.37	0.94

Figure 17 compares the modelled and observed passenger car trips for each district and demonstrates that the model provides a reasonably strong correlation at district level.

Figure 17: Modelled v observed person car trips to Gatwick (2012)

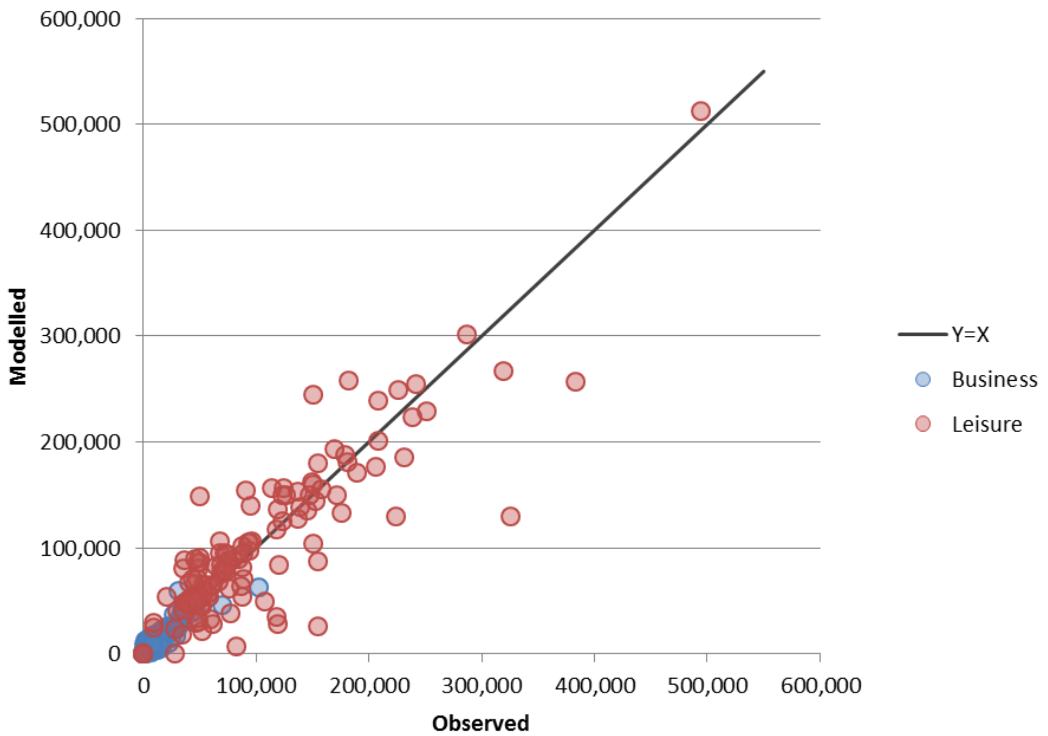


Figure 18 compares the modelled and observed passenger bus/coach trips for each district and shows the weak correlation between the two.

Figure 18: Modelled v observed bus/coach trips to Gatwick (2012)

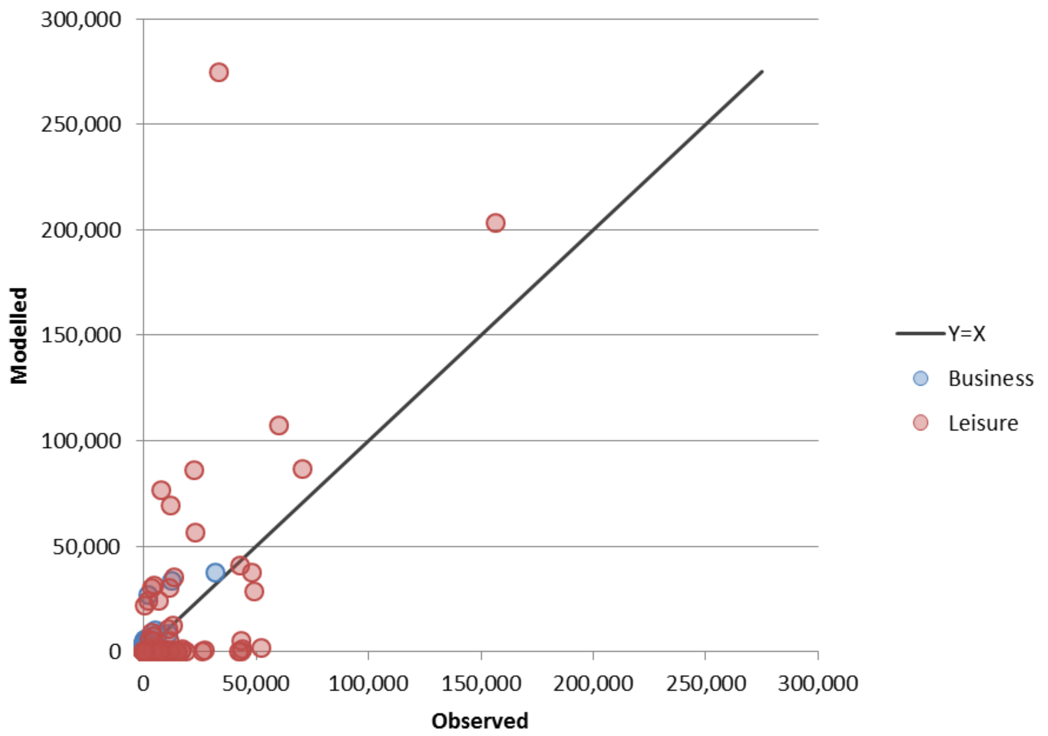
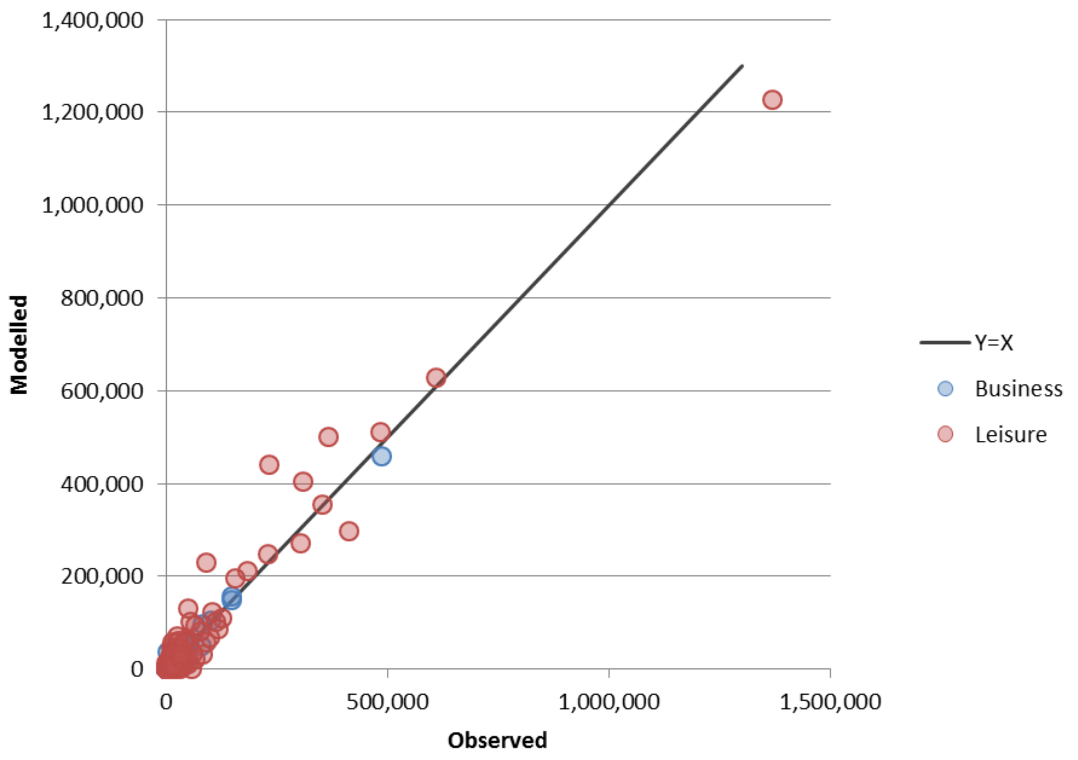


Figure 19 compares the modelled and observed passenger rail trips for each district and shows the very strong correlation between the two.

Figure 19: Modelled v observed rail trips to Gatwick (2012)



Future model assumptions

GCs to Gatwick in 2030 were calculated for each mode option using the same approach as applied in the base model. The following key assumptions in the base model were assumed to be unchanged in the 2030 model:

- Value of Time and value of distance parameters;
- Parking duration and cost assumptions;
- Vehicle occupancy;
- Interchange and wait penalty factors; and
- Interchange and wait time assumptions.

The observed 2012 sub-car mode share derived from the CAA passenger survey data was applied for air passengers in the 2030 model. Forecasting sub-car mode share is a highly complex process based on a wide range of variables, and it was deemed unnecessary for this study.

Future GC calculations for the rail sub-modes are described in the following section. Composite costs for rail were calculated in the same way as in the base model.

For Bus/Coach, future services included in the model are as follows:

- Kent route providing direct services from Margate, Ramsgate, Canterbury and Maidstone;
- Essex route providing direct services from Ipswich, Colchester, Chelmsford and Basildon;
- Additional South London stops on Central London express services, providing direct access from Streatham and Balham.

A.3 Development and calibration of rail sub-mode share model

Rail sub-mode model structure

The base logit model was developed at a district level to ensure consistency with the trip distribution model, using the same set of districts as described earlier.

The resulting districts and observed rail mode shares by journey purpose are shown in Table 19 and provided the framework for the development of the model. As indicated, the data revealed that a significant number of trips made on GEX 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 GEX did not indicate a secondary mode (including some within walking distance of Victoria Station) and these were allocated to PT and Taxi proportionally in each borough.

A representative ‘busy’ station was 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 19: Gatwick rail passenger trip origins by final mode and journey purpose (2012)

Origin District	Area	Business			Leisure		
		Standard Rail	GEX (PT Access)	GEX (Private)	Standard Rail	GEX (PT Access)	GEX (Private)
City of London	London	100%	0%	0%	86%	4%	10%
Barking and Dagenham	London	0%	100%	0%	60%	40%	0%
Barnet	London	87%	13%	0%	56%	42%	2%
Bexley	London	N/A	N/A	N/A	100%	0%	0%
Brent	London	50%	50%	0%	71%	23%	6%
Bromley	London	96%	4%	0%	96%	4%	0%
Camden	London	18%	71%	11%	41%	45%	14%
Croydon	London	100%	0%	0%	99%	1%	0%
Ealing	London	28%	72%	0%	48%	48%	4%
Enfield	London	92%	8%	0%	35%	59%	6%
Greenwich	London	100%	0%	0%	90%	9%	0%
Hackney	London	39%	23%	37%	47%	50%	3%
Hammersmith and Fulham	London	32%	49%	20%	44%	50%	7%
Haringey	London	38%	49%	12%	35%	47%	18%
Harrow	London	24%	76%	0%	90%	10%	0%
Havering	London	N/A	N/A	N/A	100%	0%	0%
Hillingdon	London	69%	28%	3%	44%	48%	8%
Hounslow	London	3%	10%	88%	62%	38%	0%
Islington	London	59%	36%	5%	55%	40%	5%
Kensington and Chelsea	London	7%	42%	51%	25%	54%	21%
Kingston upon Thames	London	100%	0%	0%	95%	1%	4%
Lambeth	London	87%	12%	1%	83%	12%	5%
Lewisham	London	100%	0%	0%	96%	2%	1%
Merton	London	100%	0%	0%	87%	13%	1%
Newham	London	24%	6%	70%	76%	23%	1%
Redbridge	London	0%	100%	0%	84%	16%	0%
Richmond upon Thames	London	93%	7%	0%	91%	9%	0%
Southwark	London	59%	36%	5%	81%	17%	2%
Sutton	London	72%	28%	0%	99%	1%	0%
Tower Hamlets	London	59%	17%	24%	60%	33%	7%
Waltham Forest	London	0%	100%	0%	77%	19%	4%
Wandsworth	London	77%	19%	4%	90%	8%	2%
Westminster	London	13%	63%	25%	25%	51%	24%
Birmingham	Rest of UK	48%	52%	0%	73%	27%	0%
Leeds	Rest of UK	100%	0%	0%	75%	25%	0%
Bath and North East Somerset	Rest of UK	100%	0%	0%	99%	1%	0%
Bristol, City of	Rest of UK	100%	0%	0%	98%	2%	0%
Cornwall	Rest of UK	100%	0%	0%	86%	14%	0%
Bournemouth	Rest of UK	100%	0%	0%	100%	0%	0%
Poole	Rest of UK	100%	0%	0%	100%	0%	0%
Swindon	Rest of UK	100%	0%	0%	94%	6%	0%
Wiltshire	Rest of UK	100%	0%	0%	96%	4%	0%
Peterborough	Rest of UK	36%	64%	0%	88%	12%	0%
Luton	Rest of UK	100%	0%	0%	99%	1%	0%
Bedford	Rest of UK	100%	0%	0%	100%	0%	0%
Central Bedfordshire	Rest of UK	0%	0%	100%	100%	0%	0%
Southend-on-Sea	Rest of UK	100%	0%	0%	100%	0%	0%
Thurrock	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Medway	Rest of UK	100%	0%	0%	100%	0%	0%
Bracknell Forest	Rest of UK	100%	0%	0%	100%	0%	0%
West Berkshire	Rest of UK	100%	0%	0%	100%	0%	0%

Origin District	Area	Business			Leisure		
		Standard Rail	GEX (PT Access)	GEX (Private)	Standard Rail	GEX (PT Access)	GEX (Private)
Reading	Rest of UK	100%	0%	0%	99%	1%	0%
Windsor and Maidenhead	Rest of UK	N/A	N/A	N/A	66%	0%	34%
Wokingham	Rest of UK	100%	0%	0%	100%	0%	0%
Milton Keynes	Rest of UK	0%	100%	0%	100%	0%	0%
Brighton and Hove	Rest of UK	100%	0%	0%	99%	0%	0%
Portsmouth	Rest of UK	100%	0%	0%	100%	0%	0%
Southampton	Rest of UK	100%	0%	0%	99%	1%	0%
Isle of Wight	Rest of UK	91%	9%	0%	100%	0%	0%
Swansea	Rest of UK	100%	0%	0%	100%	0%	0%
Cardiff	Rest of UK	100%	0%	0%	89%	11%	0%
Aylesbury Vale	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Wycombe	Rest of UK	100%	0%	0%	95%	5%	0%
Cambridge	Rest of UK	91%	9%	0%	78%	22%	0%
Eastbourne	Rest of UK	100%	0%	0%	100%	0%	0%
Hastings	Rest of UK	100%	0%	0%	100%	0%	0%
Lewes	Rest of UK	100%	0%	0%	100%	0%	0%
Rother	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Wealden	Rest of UK	100%	0%	0%	100%	0%	0%
Basildon	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Braintree	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Brentwood	Rest of UK	100%	0%	0%	100%	0%	0%
Castle Point	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Chelmsford	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Colchester	Rest of UK	59%	41%	0%	N/A	N/A	N/A
Epping Forest	Rest of UK	0%	100%	0%	61%	39%	0%
Uttlesford	Rest of UK	61%	39%	0%	59%	17%	23%
Basingstoke and Deane	Rest of UK	100%	0%	0%	100%	0%	0%
East Hampshire	Rest of UK	100%	0%	0%	100%	0%	0%
Eastleigh	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Fareham	Rest of UK	100%	0%	0%	100%	0%	0%
Hart	Rest of UK	100%	0%	0%	94%	6%	0%
Havant	Rest of UK	100%	0%	0%	100%	0%	0%
New Forest	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Rushmoor	Rest of UK	100%	0%	0%	100%	0%	0%
Test Valley	Rest of UK	100%	0%	0%	100%	0%	0%
Winchester	Rest of UK	100%	0%	0%	100%	0%	0%
East Hertfordshire	Rest of UK	100%	0%	0%	33%	67%	0%
St Albans	Rest of UK	100%	0%	0%	100%	0%	0%
Watford	Rest of UK	100%	0%	0%	100%	0%	0%
Ashford	Rest of UK	N/A	N/A	N/A	95%	5%	0%
Canterbury	Rest of UK	100%	0%	0%	91%	9%	0%
Dartford	Rest of UK	N/A	N/A	N/A	85%	15%	0%
Dover	Rest of UK	100%	0%	0%	63%	37%	0%
Gravesham	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Maidstone	Rest of UK	N/A	N/A	N/A	93%	7%	0%
Sevenoaks	Rest of UK	100%	0%	0%	100%	0%	0%
Shepway	Rest of UK	100%	0%	0%	100%	0%	0%
Swale	Rest of UK	N/A	N/A	N/A	85%	15%	0%
Thanet	Rest of UK	100%	0%	0%	47%	53%	0%
Tonbridge and Malling	Rest of UK	100%	0%	0%	81%	19%	0%
Tunbridge Wells	Rest of UK	100%	0%	0%	100%	0%	0%
Norwich	Rest of UK	100%	0%	0%	88%	12%	0%
Northampton	Rest of UK	100%	0%	0%	87%	13%	0%
Cherwell	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Oxford	Rest of UK	100%	0%	0%	94%	6%	0%
South Oxfordshire	Rest of UK	100%	0%	0%	100%	0%	0%
Babergh	Rest of UK	0%	100%	0%	100%	0%	0%

Origin District	Area	Business			Leisure		
		Standard Rail	GEX (PT Access)	GEX (Private)	Standard Rail	GEX (PT Access)	GEX (Private)
Ipswich	Rest of UK	100%	0%	0%	100%	0%	0%
St Edmundsbury	Rest of UK	0%	100%	0%	100%	0%	0%
Elmbridge	Rest of UK	100%	0%	0%	95%	5%	0%
Epsom and Ewell	Rest of UK	100%	0%	0%	100%	0%	0%
Guildford	Rest of UK	100%	0%	0%	100%	0%	0%
Mole Valley	Rest of UK	100%	0%	0%	100%	0%	0%
Reigate and Banstead	Rest of UK	100%	0%	0%	100%	0%	0%
Runnymede	Rest of UK	100%	0%	0%	100%	0%	0%
Spelthorne	Rest of UK	N/A	N/A	N/A	100%	0%	0%
Surrey Heath	Rest of UK	100%	0%	0%	100%	0%	0%
Tandridge	Rest of UK	100%	0%	0%	100%	0%	0%
Waverley	Rest of UK	100%	0%	0%	100%	0%	0%
Woking	Rest of UK	100%	0%	0%	100%	0%	0%
Adur	Rest of UK	100%	0%	0%	100%	0%	0%
Arun	Rest of UK	100%	0%	0%	100%	0%	0%
Chichester	Rest of UK	100%	0%	0%	100%	0%	0%
Crawley	Rest of UK	100%	0%	0%	100%	0%	0%
Horsham	Rest of UK	100%	0%	0%	100%	0%	0%
Mid Sussex	Rest of UK	100%	0%	0%	100%	0%	0%
Worthing	Rest of UK	100%	0%	0%	100%	0%	0%
Manchester	Rest of UK	100%	0%	0%	70%	30%	0%
Newcastle upon Tyne	Rest of UK	N/A	N/A	N/A	86%	14%	0%
Edinburgh, City of	Rest of UK	100%	0%	0%	97%	2%	2%

Source: CAA 2012 Gatwick passenger survey, analysed by Jacobs

GCs were then calculated from each representative station to Gatwick 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 the single Anytime ticket prices found on the National Rail website;
- Taxi journey times were estimated to Victoria 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.

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 GEX;
- 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.

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

A number of tests were used in the process of calibrating the base logit model, which was undertaken using the MS Excel Solver tool. The first was to ensure that the correlation between modelled and observed annual passenger numbers by mode and journey purpose, represented by the 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.

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 2030 model 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 and London commuter rail services;
  - 0.8 for long-distance rail services;
  - 0.65 for GEX;
  - 0.5 for Taxi;
- Platform wait time factor: 2.0;
- Interchange time factor: 2.0.

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. GEX was assumed to be the next most comfortable mode, with long-distance rail identified as the third most comfortable option.

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.

The final derived lambda values were 0.05 for business passengers and 0.0317 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 20.

Table 20: Mode constants applied in calibrated 2012 Gatwick rail mode choice logit model

Mode Factors	Business	Leisure
Standard Rail	1	1
GEX (PT Access)	0.905	0.941
GEX (Taxi Access)	0.880	0.987

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 GEX, 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.

Figure 20 summarises the differences between observed annual passenger trips to Gatwick by rail mode and the outputs from the calibrated 2012 base model. The graph indicates that the total forecast trips were very close to the total observed trips for each mode.

Figure 20: Modelled v observed annual rail passengers to Gatwick (2012)

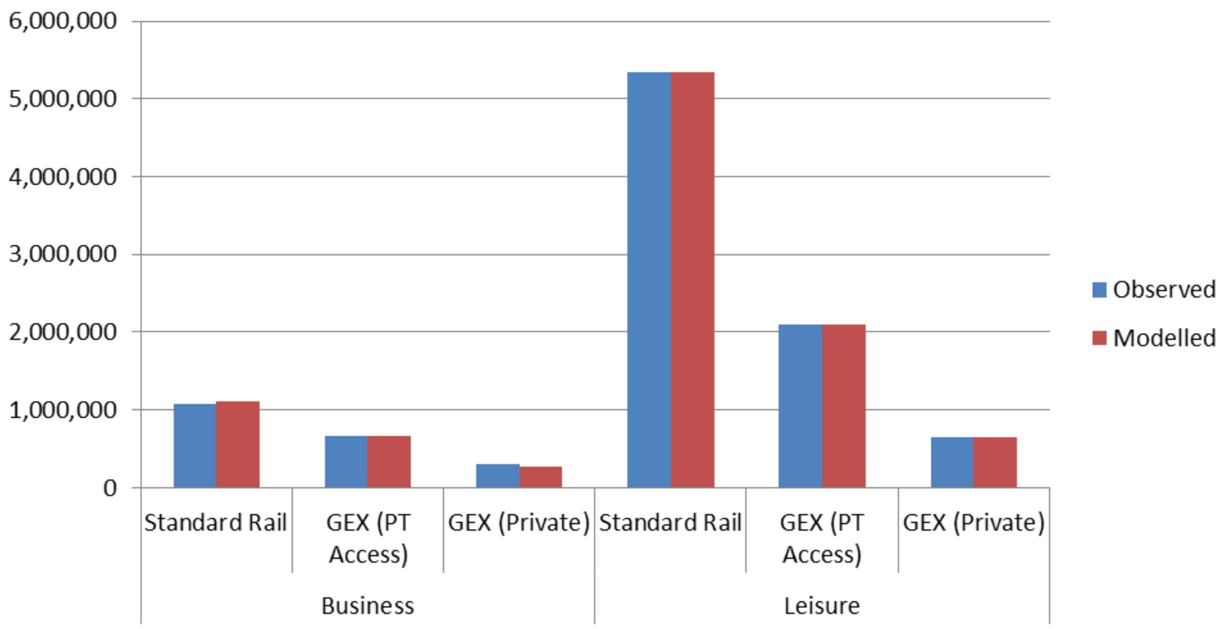


Table 21 and the graphs in Figure 21 to Figure 23 summarise the other element of the calibration process – the relationship between modelled and observed passenger forecasts by district for each mode. There is a very strong correlation between modelled and observed mode share for Leisure trips, with R-Square values of 0.93 or above for all rail modes. For Business trips there is also a strong correlation between modelled and observed mode share, with R-Square values of 0.83 and above across all zones.

Table 21: Rail mode share model calibration results

Region	Business			Leisure		
	Standard Rail	GEX (PT Access)	GEX (Private)	Standard Rail	GEX (PT Access)	GEX (Private)
RSQ London	0.74	0.97	0.87	0.88	0.98	0.98
RSQ All Zone	0.83	0.97	0.87	0.93	0.98	0.98

Figure 21: Modelled v observed annual Standard Rail passengers to Gatwick (2012)

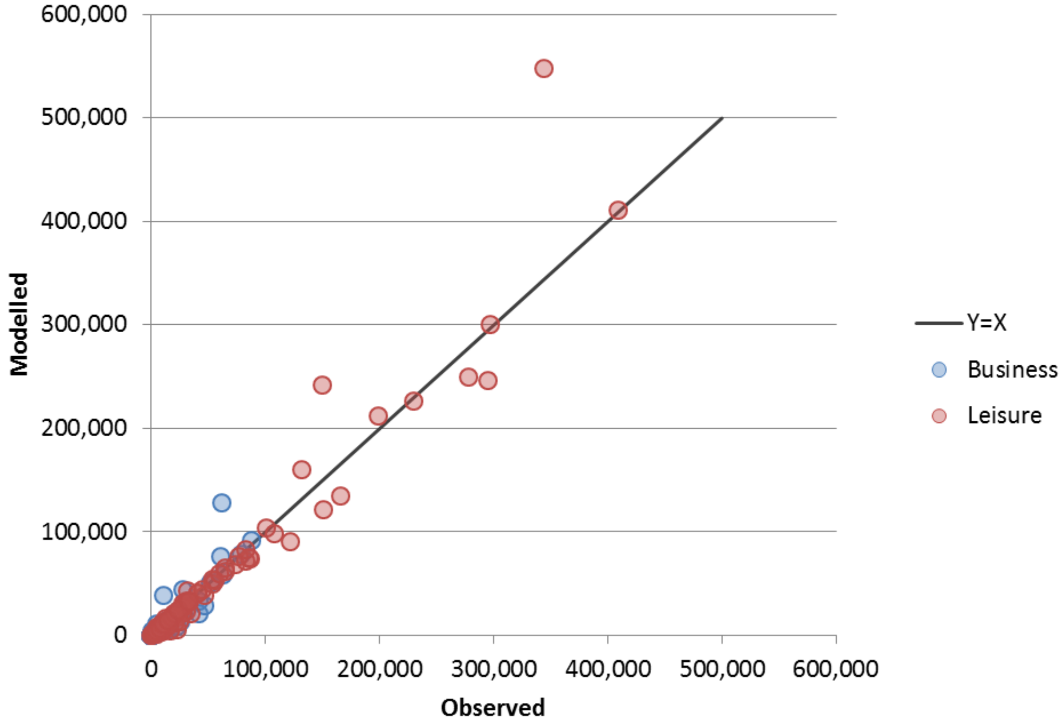


Figure 22: Modelled v observed annual GEX (with secondary PT) to Gatwick (2012)

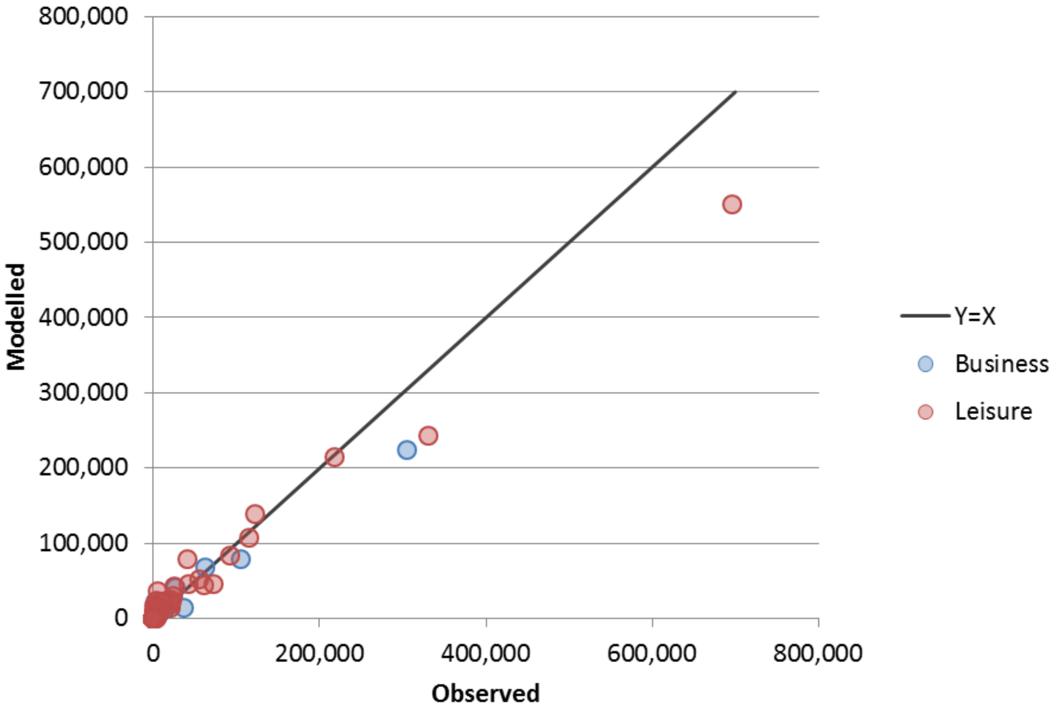
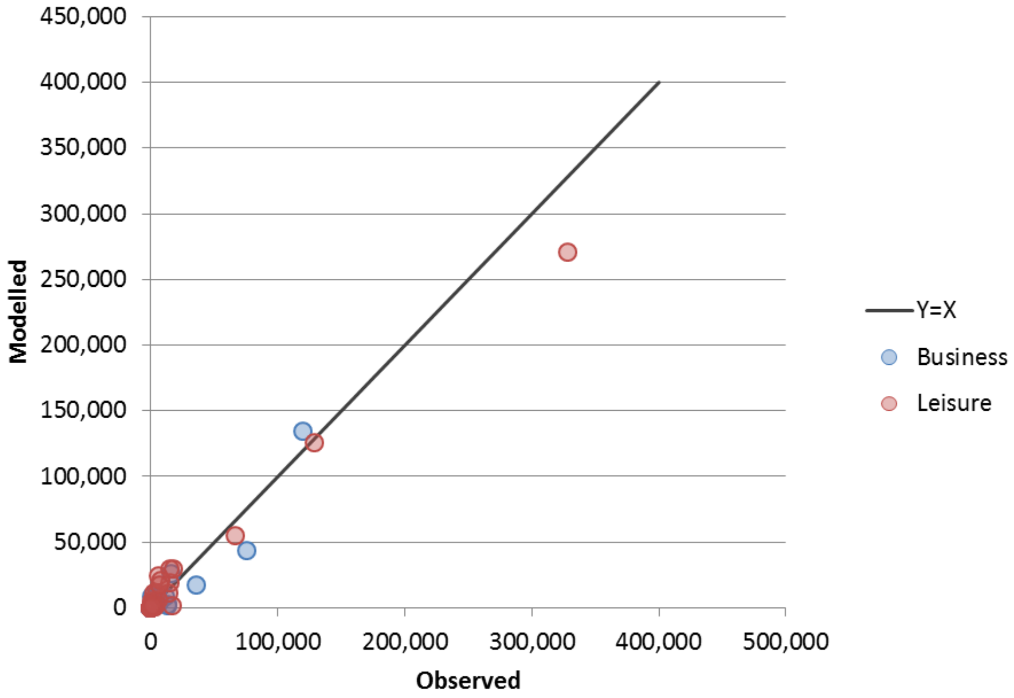


Figure 23: Modelled v observed annual GEX (with secondary taxi) to Gatwick (2012)



Forecasting assumptions

The parameters developed for the base model were subsequently applied to GC calculations developed for future rail options to Gatwick to estimate rail mode share for each option. Further details on the assumed 2030 rail network serving Gatwick are provided in the Appraisal Report. GCs to Gatwick in 2030 were calculated for each rail option using the same approach as applied in the base model. The following key assumptions in the base model were assumed to be unchanged in the 2030 GC calculations:

- Value of time;
- Taxi occupancy;
- Rail mode comfort factors;
- Interchange and wait penalty factors;
- Interchange and wait time assumptions.

All fares were based on current values and no attempt was made to account for changes in fare up to 2030. 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 the premium GEX service.

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 GEX to standard National Rail services.

The same parameters calibrated for current Gatwick 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.

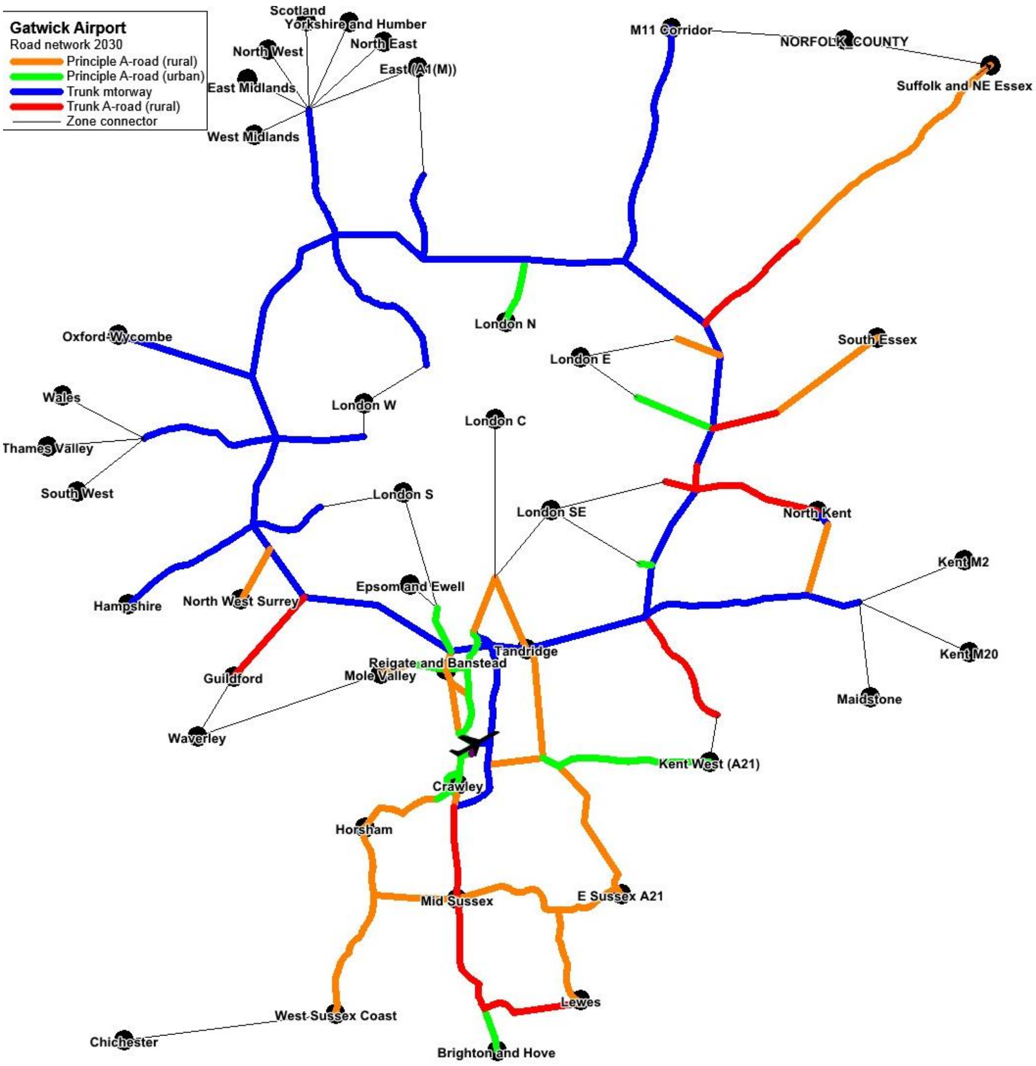
The district-level geographic framework for the Jacobs model meant that it was not considered detailed enough to forecast employee mode share, as observed data indicates that employee home locations tend to be clustered in a small number of districts in the vicinity of the airport. As a result, the headline figures of 20% rail, 20% coach, 60% private vehicle from the GAL submission for 2040 were applied to all districts generating employee trips to Gatwick Airport in the 2030 model.

A.4 Assessment of road demand and capacity

Road capacity was assessed by firstly identifying the strategic network links that serve Gatwick and are likely to carry a significant level of airport-related traffic. These links are shown in Figure 24. 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 M23 and A23 in Sussex were included in the model, along with other major roads on key corridors linking the airport to key destinations.

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 Gatwick 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 Gatwick 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 Gatwick were assumed to use the M4.

Figure 24: Gatwick road network

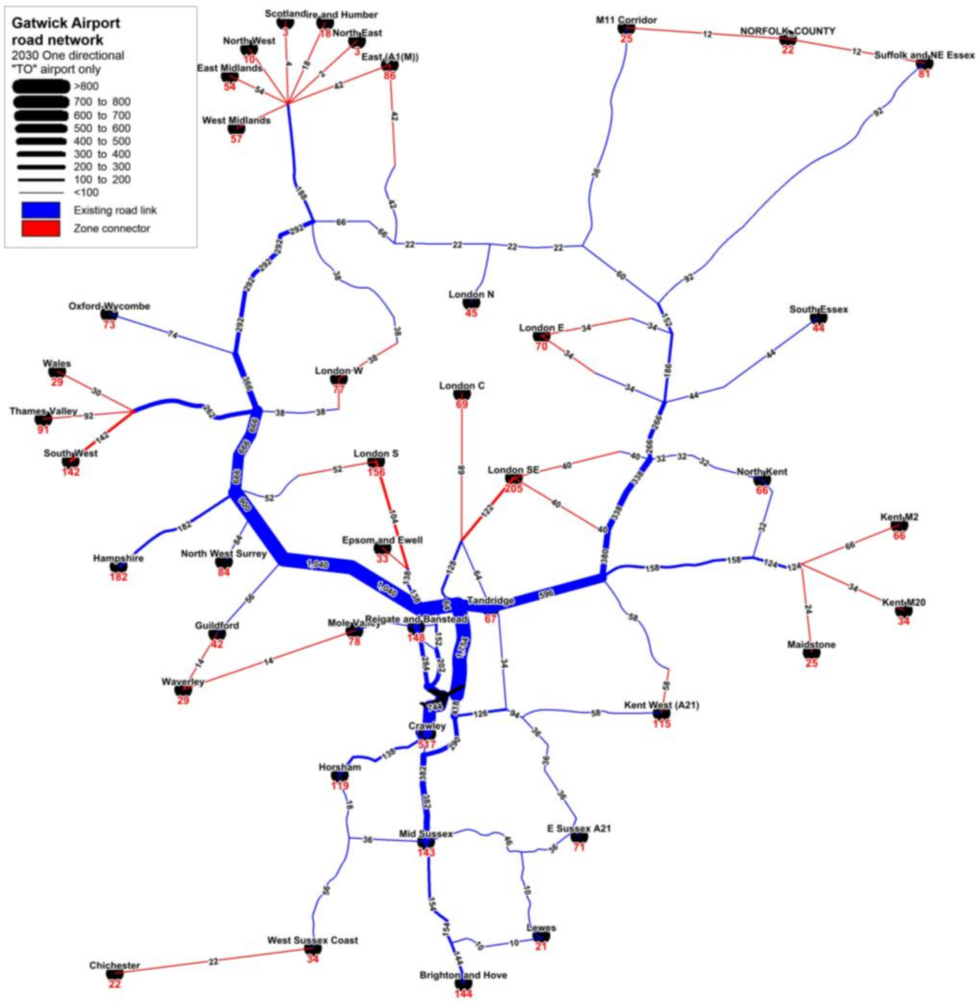


Once the zone system and road network had been established as described above, road trips were then allocated to network links as follows:

- Passenger car trips were calculated by applying the 2030 modelled private vehicle mode share to the 2030 passenger trip distribution, and employee car trips were calculated by applying the headline private vehicle mode share to the employee trip distribution;
- Car person trips were then converted to car vehicle trips using the headline car occupancy factors for passengers and employees;
- Routing options between each zone and the airport were then defined manually – in many cases, there was only one self-evident route that the vast majority of drivers would take, while in others, multiple routes were identified (for example a choice between using the A23 or M23 if arriving from south of the airport);
- Car vehicle trips calculated by zone were then allocated to network links cumulatively 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.

Figure 25 illustrates the result of the methodology described above for all passenger and employee-related car trips ***to*** Gatwick in 2030. 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.

Figure 25: Forecast peak-hour vehicle demand to Gatwick airport in 2030 (with second runway)



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 AADF data for a base year from the DfT's Traffic Counts website[5] - 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[6];
- Base year AADFs were then converted to 2030 estimates using factors derived from Regional Traffic Forecasts from the DfT's NTM;
- Single direction AADF was then converted to a peak-hour using a factor 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;

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

- The number of lanes per link were then adjusted in the 2030 scenario to account for the schemes identified by the HA in the AC's baselines – in the case of smart motorway schemes, the capacity impact was replicated in the model by adding a lane to each affected link;
- 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;
- VCRs were then calculated for each link for forecast background demand in 2030 if the second runway was not delivered;
- The net impact on VCRs in 2030 with the second runway in operation were then calculated by reducing background link flows by the demand that was forecast to be generated in 2030 with a single runway, and then adding on the airport impacts with two runways to avoid double-counting of airport trips.

The VCRs calculated using the methodology described above are summarised in the Appraisal Report. A key point to note is that the identified peak hour for Gatwick 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.

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.