



# HEATHROW COMMUNITY NOISE FORUM

---

3Villages flight path analysis report

January 2016

# Contents

---

1. Executive summary
  2. Introduction
  3. Evolution of traffic from 2005 to 2015
  4. Easterly departures
  5. Westerly departures
  6. Easterly arrivals
  7. Westerly arrivals
  8. Changes from August to September 2015
  9. Focus on specific flights
- 
- A. Analysis approach



# EXECUTIVE SUMMARY

---

# 1

## Executive summary

---

As part of the engagement between Heathrow Airport Limited and the Community Noise Forum, flight paths through a series of penetration gates around the airport are being analysed. One of the gates that has been analysed was centred on Lightwater, extending approximately 12km from north west of Bagshot at its north west extreme to Old Woking at the south eastern end. Following on from the publication and discussion of a draft report describing this gate, local residents requested a more detailed analysis of the north western half of the gate extending approximately 3km either side of Lightwater, focusing on the area around the three villages of Bagshot, Windlesham and Lightwater. The analysis cover the years 2005, and 2010 to 2015 inclusive and addresses departures and arrivals on easterly and westerly operations. This report describes the analysis and associated conclusions relating to this 3Villages gate.

During the analysis period, for departures the gate operated in the westerly direction on average for between 70% and 80% of days and operated in the easterly direction on between 20% and 30% of days. For arrivals, the gate operated in the westerly direction for approximately 60% of the time and on easterlies between 20% and 30% of days. For the remainder of the time, the gate was either not crossed by arrival traffic or operated in a mix of directions.

For **easterly departures**, the 3Villages gate is crossed by traffic using the easterly Compton (CPT) standard instrument departure route (SID). The average daily volume of easterly departure traffic was at a consistent level from 2005 to 2013 at approximately eight departures per easterly day. In 2014 this volume started to decrease and has now reduced to an average of approximately two departures per day due to the realignment of the Compton route. The residual flight paths are randomly distributed across the gate and show no SID structure. The lateral centre of gravity (mean position) of the traffic has remained at the centre of the gate, reflecting the random distribution of traffic. However, the average vertical centre of gravity (mean height) appears to have increased over the period from approximately 6400 feet in 2005 to approximately 7200 in 2015. There is, however, considerable day-to-day variation on this height, from circa 5000 feet to approximately 10000 feet. The minimum height for easterly departures shows an upwards trend from 2005 to 2015 from 5500 feet to 6700 feet respectively.

## Executive summary

---

The **easterly departure** traffic crossing the gate is made up of large aircraft (75%) of which 3% are A380s, and 25% medium aircraft. The proportion of ultra long and long-haul destinations served by these easterly departure traffic is consistent with the proportion of large aircraft in the mix, at around 75%.

Easterly departures are now distributed evenly across the day from around 07:00 to 23:00 hours at a very low level whereas previously before the realignment of the CPT SID there were a series of definite peaks in the traffic across the day with the volume being greatest across the afternoon.

For **westerly departures**, the 3Villages gate is crossed by the Midhurst (MID) SID. This traffic is distributed across the south eastern three quarters of the gate with a lower intensity of traffic in the remainder of the gate. Other than during the trial period, the lateral centre of gravity (average position) of the westerly departures crossing the gate has remained consistent at is approximately 400m to the south east of the gate centre near to Lightwater and Windlesham. There is considerable day-to-day variation in this lateral centre of gravity. There is a slight upward trend on the vertical centre of gravity from approximately 7400 feet in 2005 to approximately 7900 in 2015 with wide daily variation. There is a cyclical pattern in the vertical centre of gravity indicating westerly departures are generally lower in summer than in winter. The minimum height for westerly departures shows a slight downward trend for 2005 to 2015 from 5600 feet to 5200 feet. During the trial periods, the minimum height was reduced from approximately 5300 feet to around 3700 feet.

The 2015 average daily departure traffic through the gate on westerly days is approximately 44 flights per day, similar to the 2005 and 2013 levels but reduced from approximately 50 flights per westerly day in 2011, 2012 and a peak of approximately 68 flights per day in 2014. This large peak in 2014 is associated with the departure trials. During the trial period from December 2013 to November 2014, the traffic was concentrated into three swaths, one slightly to the south of the gate centre, over Lightwater and Windlesham, a lower peak at the gate centre and one to the north of the gate centre in the Bagshot direction. The south and north trial swaths were of order six times the normal intensity with a factor of four reduction, compared to other years, in the levels of traffic outside of these swaths. Traffic returned to pre-trial structures and levels after the trial.

## Executive summary

---

Except during the trial period, the **westerly departure** traffic mix has remained consistent at approximately 90% medium aircraft and 10% large aircraft, a few of which (<1%) are A380s. During the trial period in 2014, the proportion of medium aircraft decreased by approximately 5% to be replaced by heavy aircraft, reverting to the normal pattern after the trials ended.

The destination mix for westerly departures comprised approximately 9% to 11% long-haul destinations except during the trial period, when the proportion of long-haul traffic in the mix increased to 15%, then reverting back to 9% afterwards.

Across the day, the main traffic peak for departures is in the morning between 06:00 and 11:00 and comprises mainly medium sized aircraft. During the trials the evening peak increased in size compared to non-trial periods and the proportion of heavy aircraft departing late at night, after 21:00, increased compared to the non-trial periods. Patterns reverted to pre-trial structures after the end of the trials.

For **easterly arrivals** traffic crosses the gate flowing west from the Ockham and Biggin stacks to loop round to approach the easterly runways. The daily volume of this traffic crossing the gate shows a general upward trend, with a plateau in 2014, increasing from 2010 at 64 flights per easterly day to 96 flights per easterly day in 2015. Easterly arrivals are broadly distributed across the gate but at lower heights towards the north western end. From 2010 to 2012 the distribution showed slightly increasing intensity to the right hand side whereas the 2015 distribution peaks slightly in the centre of the gate.

The average lateral centre of gravity for easterly arrivals is just to the right of the centre of the gate but with large day-to-day fluctuations. There is a trend for this to shift towards the centre of the gate, towards the centre of Lightwater. There is no perceptible trend on the vertical centre of gravity for easterly arrivals, which has remained constant at approximately 6600 feet. There is again large day-to-day variation in the vertical centre of gravity from around 5500 feet to above 9000 feet. The average minimum height for easterly arrivals is constant approximately 5000 feet but ranging from 4000 feet and sometimes below to 6000 feet and sometimes above.

---

## Executive summary

---

The mix of **easterly arrival** traffic crossing the gate has remained roughly constant with large aircraft comprising approximately 40%, with A380s making up 1%. Medium aircraft make up the other 60%. The proportion of long-haul origins for easterly arrival traffic has remained consistent at approximately 38% of the total with the remainder of the traffic arriving from short- and medium-haul origins.

Easterly arrival traffic is spread across the day with a morning peak of heavy aircraft between 06:00 and 08:00. Arrivals are dominated by medium aircraft for the remainder of the day. A peak around midday has grown during 2015.

**Westerly arrivals** traffic crosses the gate flowing east to join the Ockham stack. The average daily arrival traffic through the gate on westerly days reduced from approximately four per westerly day in 2005 to approximately 2.5 per day in 2015. The overall underlying trend is slightly downwards. Westerly arrivals are of low intensity and randomly distributed across the gate.

The daily lateral centres of gravity for westerly arrivals are spread across the gate with slight bunching towards the south east end resulting in an average centre of gravity approximately 500m to the south east of gate centre. Similarly, the daily vertical centres of gravity for westerly arrivals are randomly distributed in height from approximately 7000 feet and occasionally lower to above 14000 feet. Minimum heights are rarely below 7000 feet.

The traffic mix is consistent at approximately 85% large aircraft, including 2% A380s, and 15% medium aircraft. This traffic is predominantly (~87% to 88%) arriving from ultra long and long-haul origins. The traffic is strongly peaked in the morning, between 06:00 and 09:00 and can also include very early morning arrivals starting at 04:00.

## Executive summary

---

The residents of the 3 Villages also requested that a detailed analysis was done to identify the causes of observed changes that occurred at the beginning of September 2014 as well as asking for a set of specified departures to African countries to be analysed.

The analysis indicates that there were significant changes to westerly departure flight profiles at the **beginning of September 2014**. Comparison of the traffic characteristics between August and September 2014 show a step increase in volume of westerly departures crossing the gate coupled with concentration of the traffic at the gate centre. This is associated with the second trial period. The traffic pattern shows that traffic was concentrated in two very closely spaced swaths during the second trial whereas during the first trial the traffic swaths were further apart. Outside of the trial periods the westerly departure traffic swath is dispersed across the gate. Around about September 2014 the easterly departure traffic swath disappears from the gate, corresponding to the realignment of the SID. There appears to be little change in easterly and westerly arrivals traffic before and after September 2014.

Investigation of the **specific flights to Africa** does not reveal any single systematic pattern or trend although, with exceptions, the flights tend to have become concentrated on the trial SIDs during the trial period and cross the gate at lower than normal heights during the trial periods. There is a downward trend on the height at the gate for some but not all of the African flights.





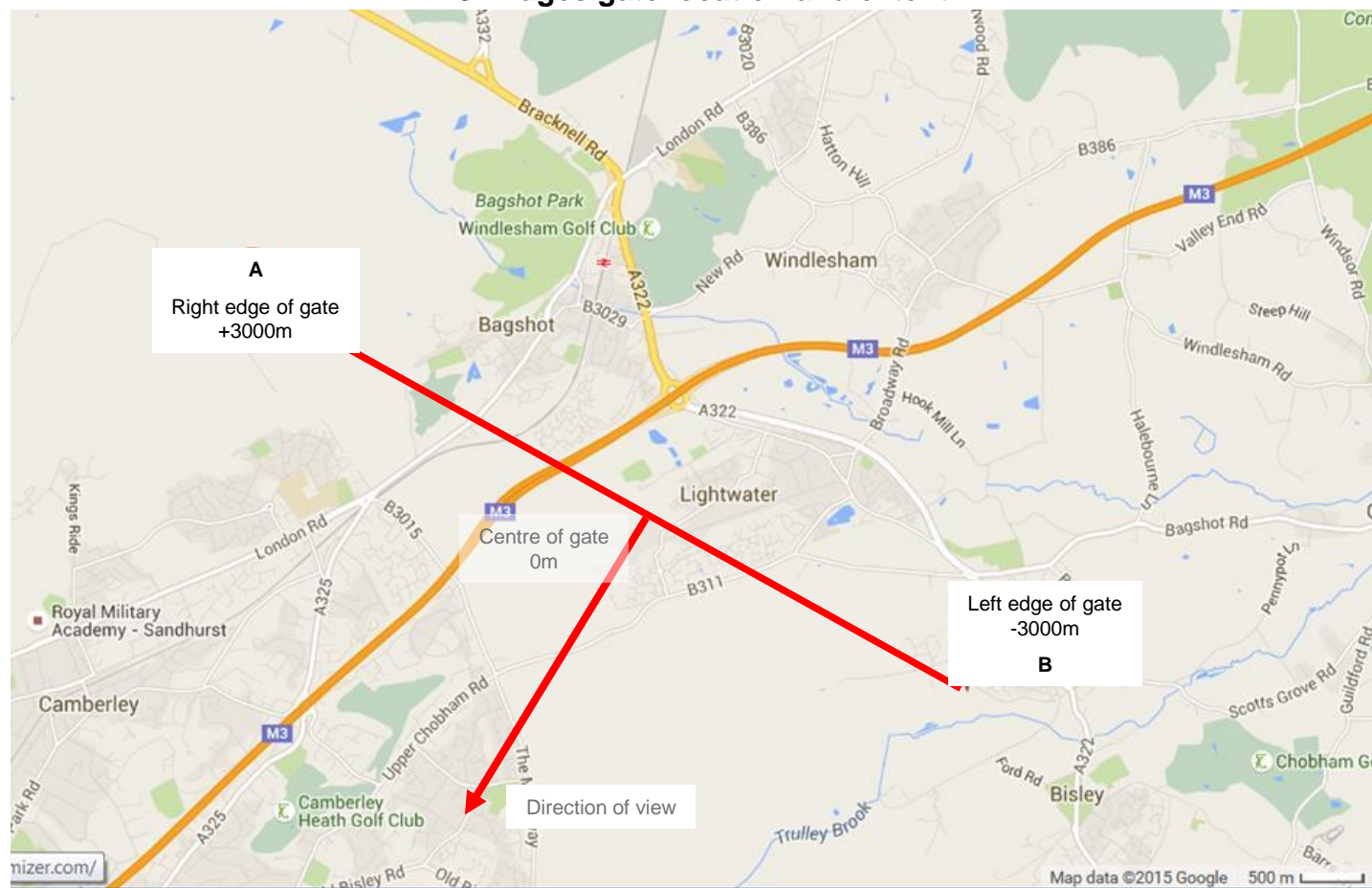
# INTRODUCTION

---

# 2

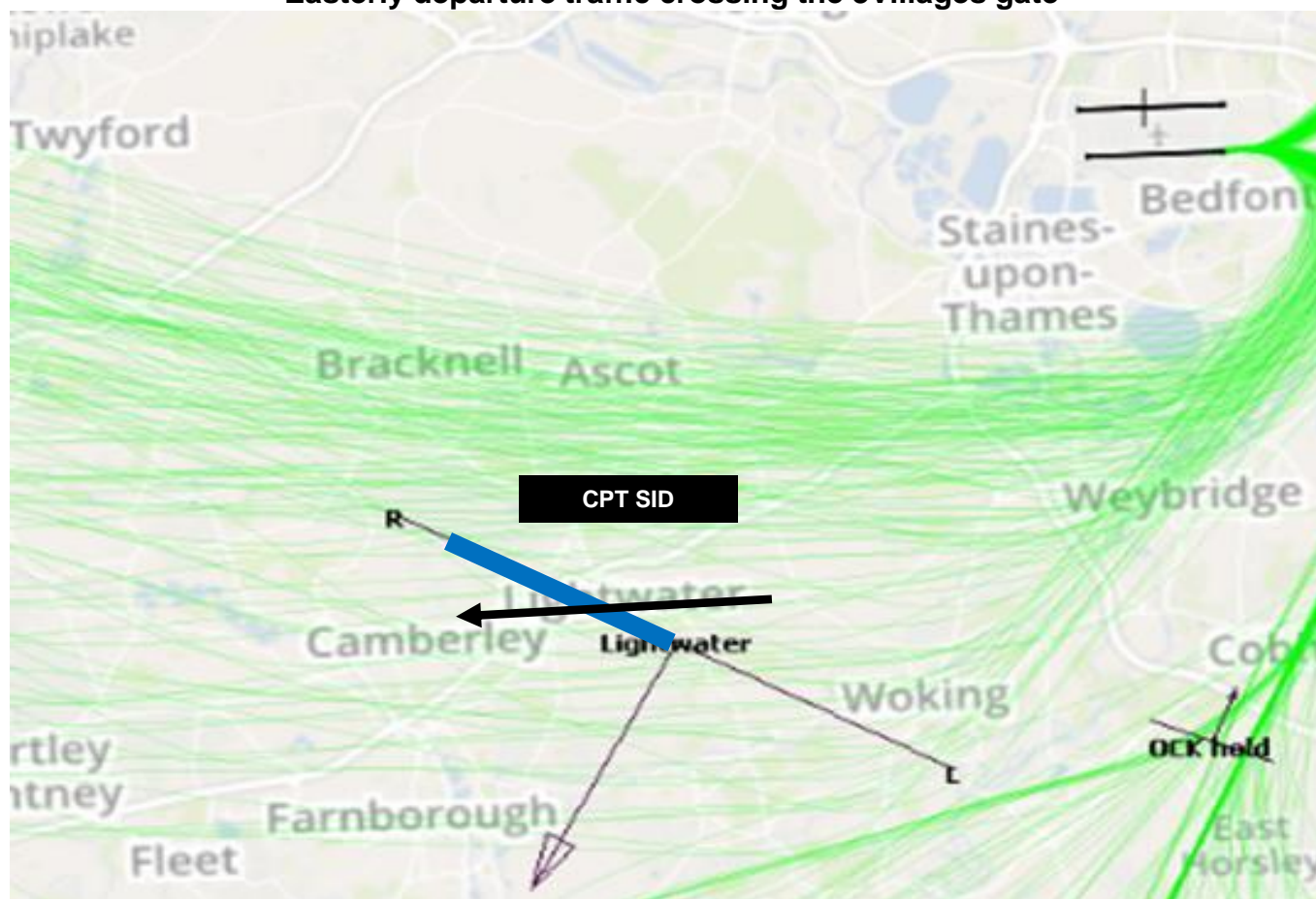
The 3Villages gate runs approximately north west-south east and is approximately 6km long, centred just to the south west of Lightwater

### 3Villages gate location and extent



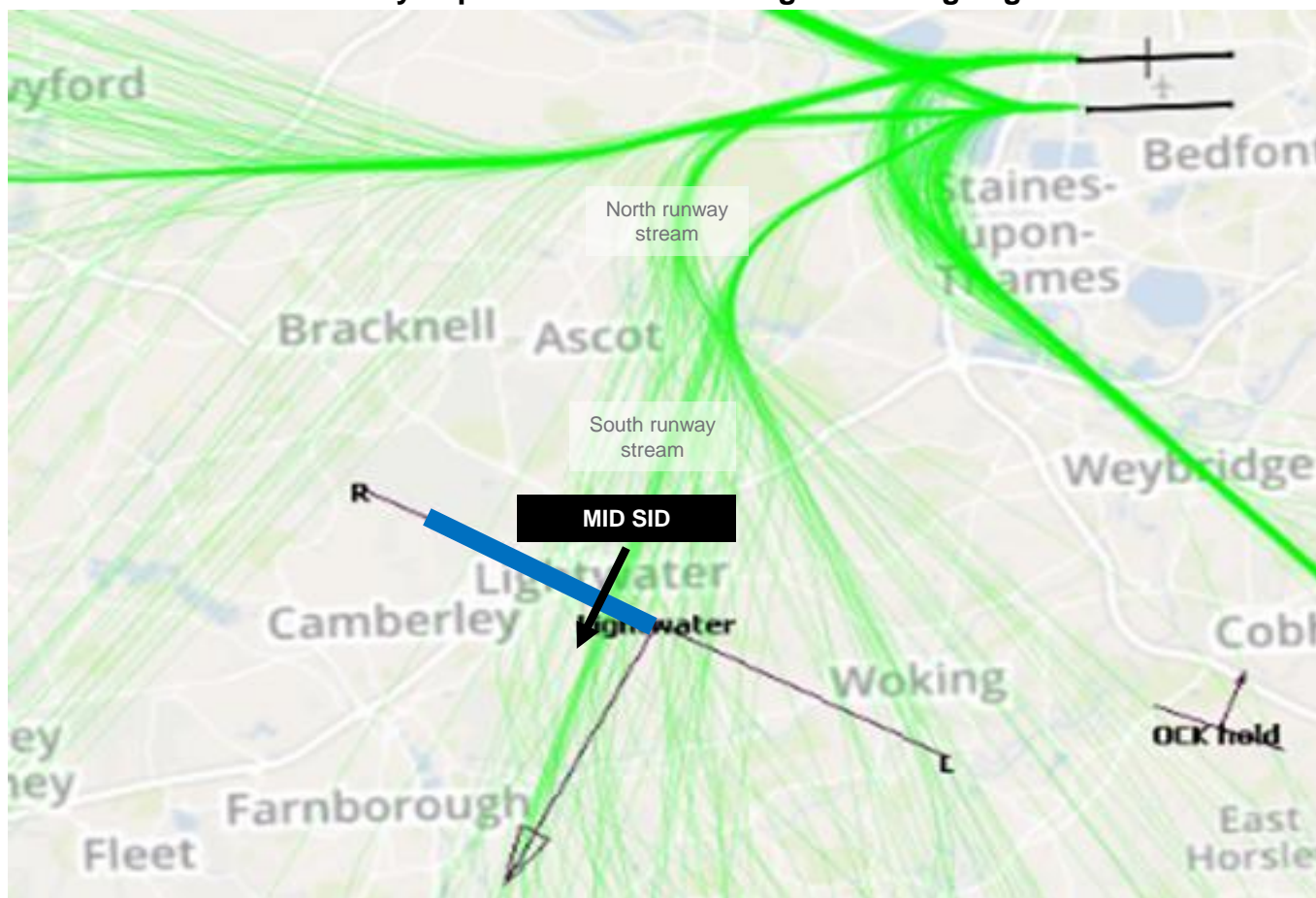
## On easterly departures, dispersed CPT SID traffic crosses the 3Villages gate

Easterly departure traffic crossing the 3Villages gate



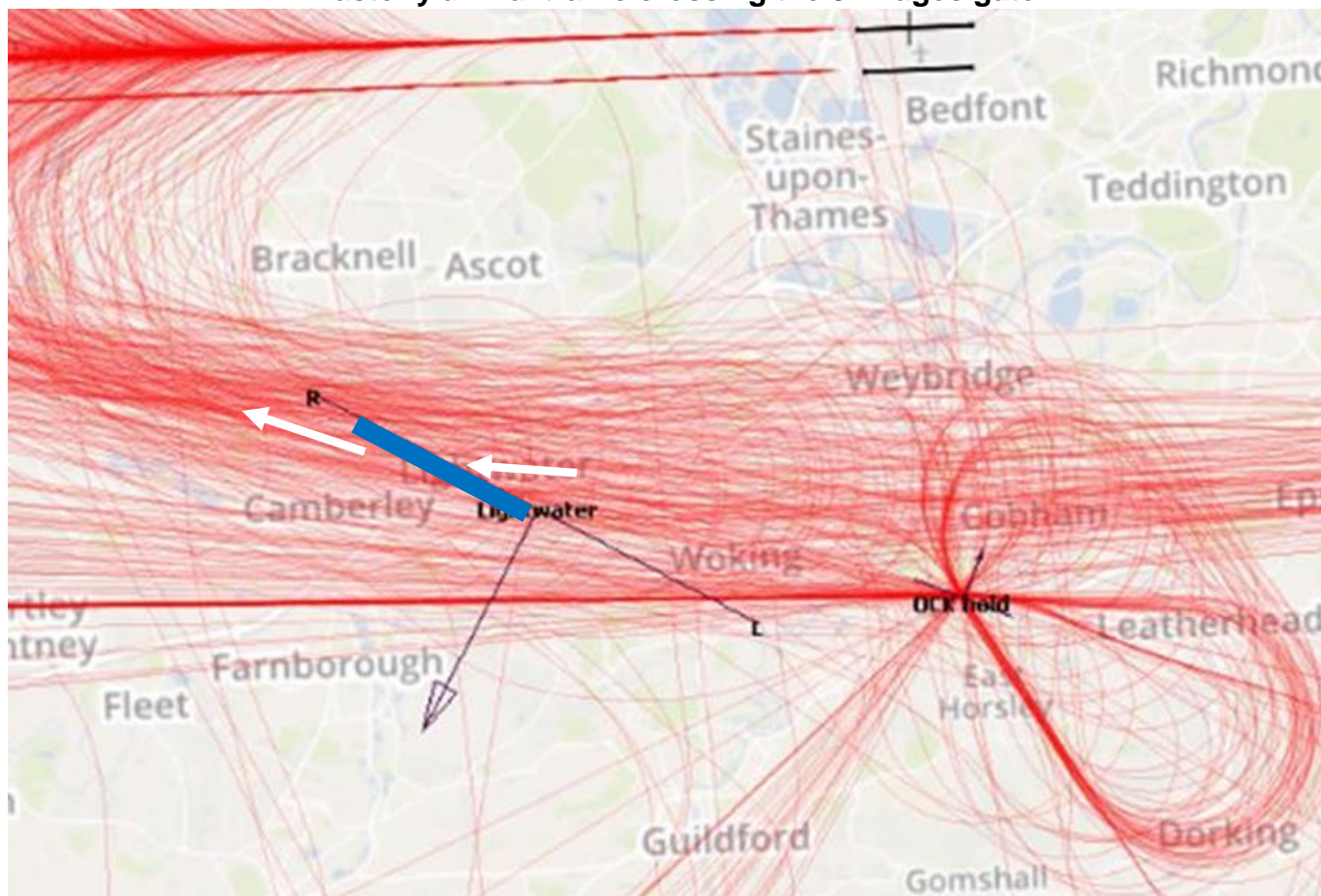
For westerly departures, MID SID traffic originating from the south runway crosses the south eastern half of the 3Villages gate

Westerly departure traffic crossing the 3Villages gate



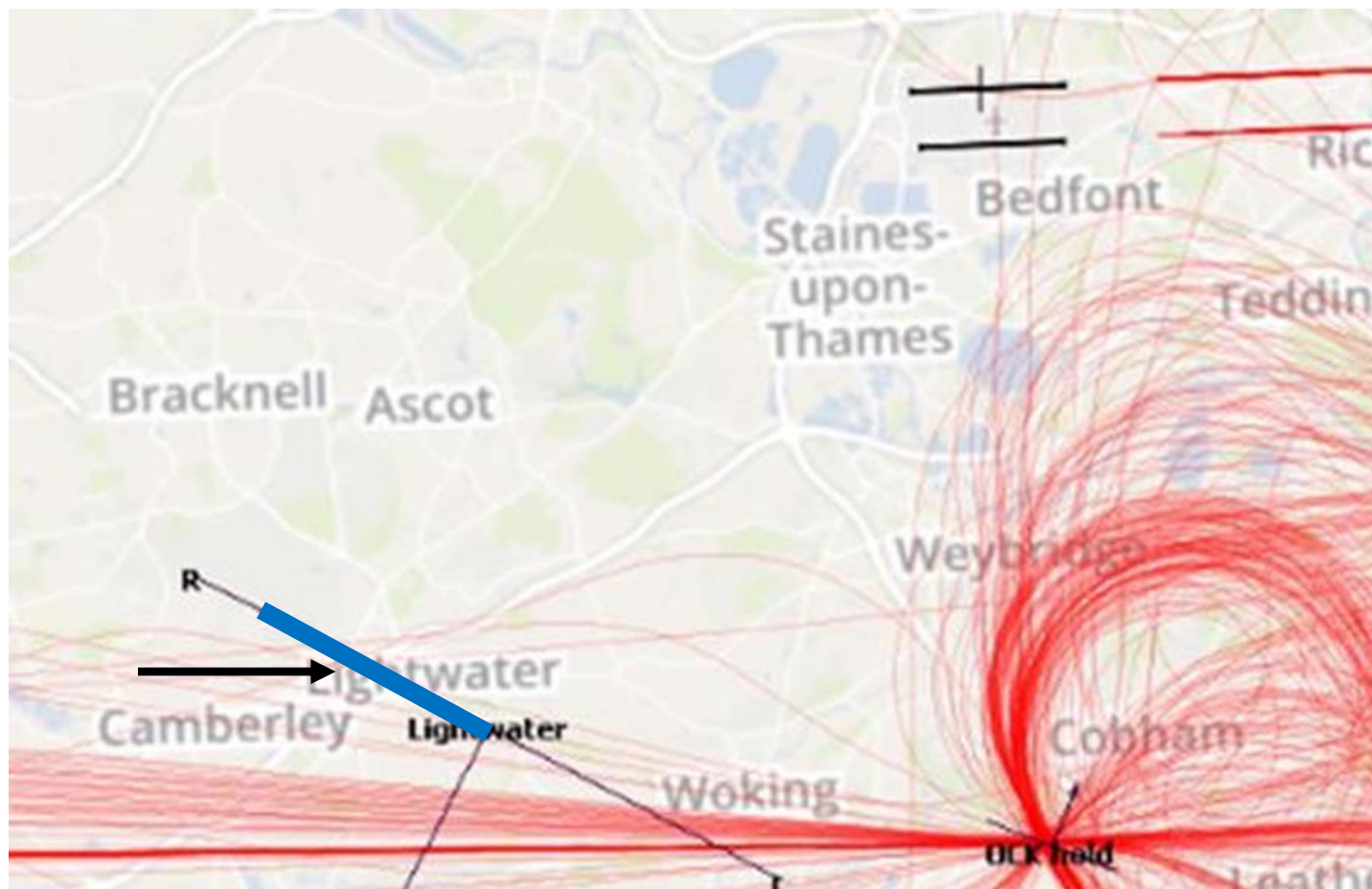
## Easterly arrivals cross the gate flowing west from the Ockham and Biggin stacks to loop round to approach the easterly runways

Easterly arrival traffic crossing the 3Villages gate



## Westerly arrival tracks cross the 3Villages gate flowing east as they approach the Ockham stack from the west

Westerly arrival traffic crossing the 3Villages gate



## The analysis has investigated different characteristics of the departure traffic traversing the gate for the years 2005, and 2010 to 2015 inclusive

---

- The proportion of days per year when the gate has westerly, easterly and mixed operations
  - Traffic volume (number of flights) crossing the gate per day
    - for each day during 2005, and 2010 to 2015 inclusive
    - the average daily traffic for each year
    - the average distribution of traffic across the day in half-hour intervals by aircraft type
  - The lateral and vertical distributions of the traffic crossing the gate for each year, including:
    - The lateral and vertical centres of gravity (average positions) of the traffic swaths
    - The minimum height at which the lowest aircraft crosses the gate each day
    - The number of flights crossing the gate below 1500 feet and between 2000 feet and 2500 feet per day
    - Gate penetration (scatter) plots showing the lateral and vertical position that each flight crosses the gate for each of the years analysed
  - Heat maps showing the concentration or density of the traffic crossing the gate
  - The aircraft fleet mix:
    - the relative proportions of A380, heavy and medium sized aircraft crossing the gate for each year analysed
    - gate penetration (scatter) plots for A380, heavy and medium sized aircraft showing the lateral and vertical position that each flight crosses the gate for each of the years analysed
  - The mix of destinations – short-haul, medium-haul, long-haul and ultra long-haul – for the traffic crossing the gate for each year
  - Changes that occurred on or around the beginning of September 2014
  - The profiles of a set of specific flights departing to African destinations
-



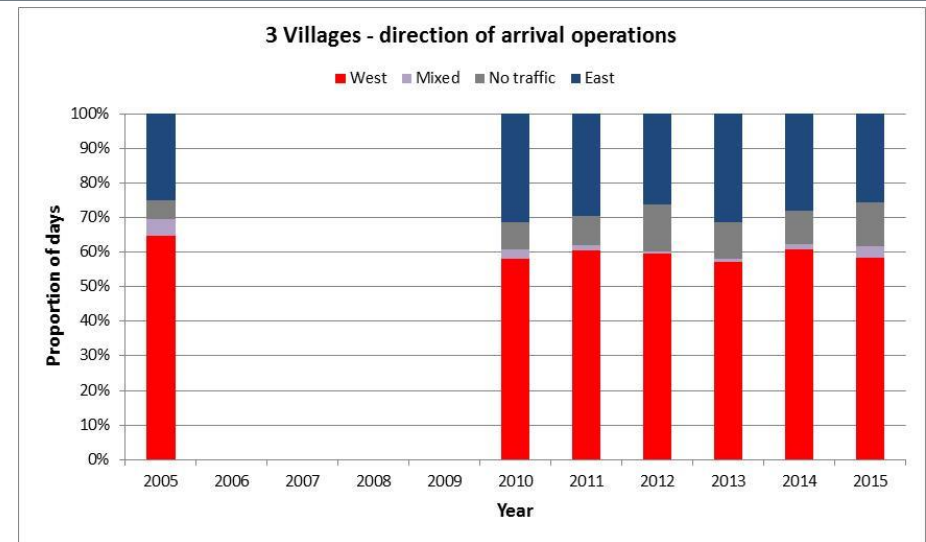
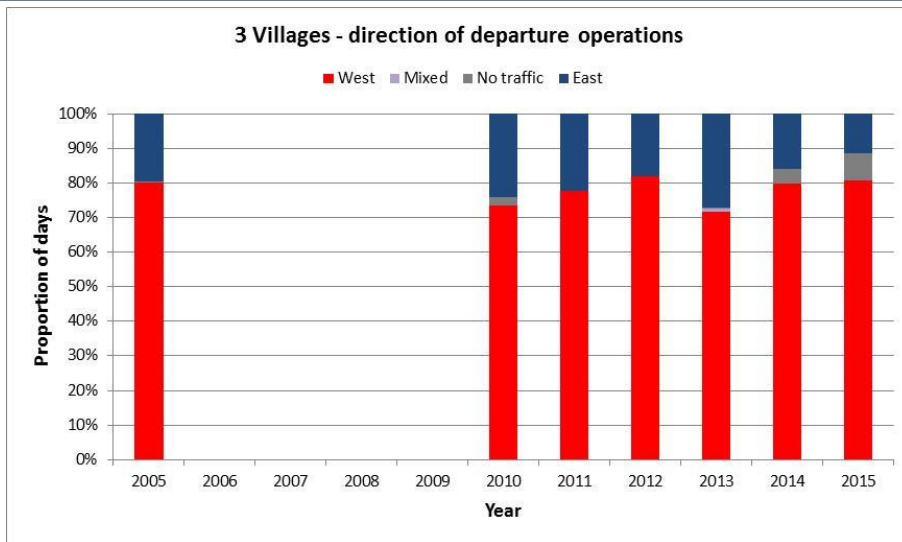
# EVOLUTION OF TRAFFIC FROM 2005 TO 2015

---

# 3



The gate operates on westerlies for between 70% and 80% of days for departures and approximately 60% of days for arrivals

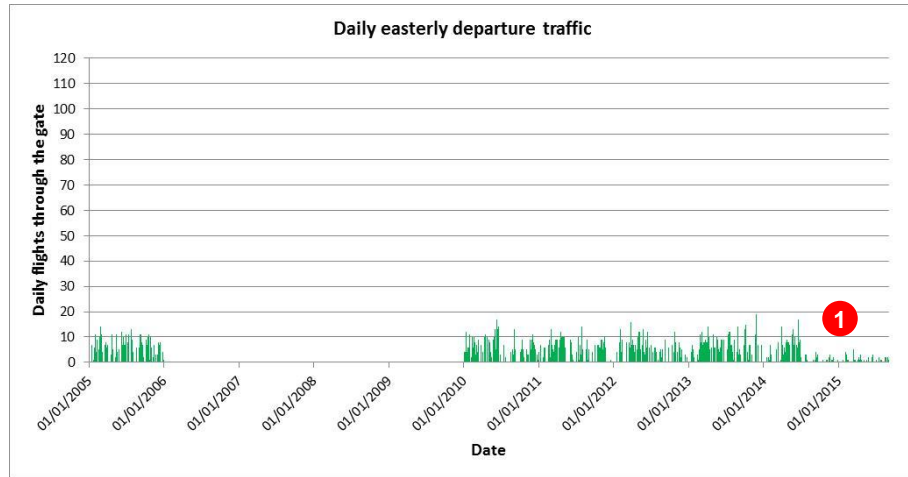


Westerly operations are defined as days when the airport operates solely in the westerly direction; similarly easterly operations are defined as days when the airport operates solely in an easterly direction. Mixed operations are defined as days when there are operations in both directions. No traffic is defined as days when no aircraft cross the gate

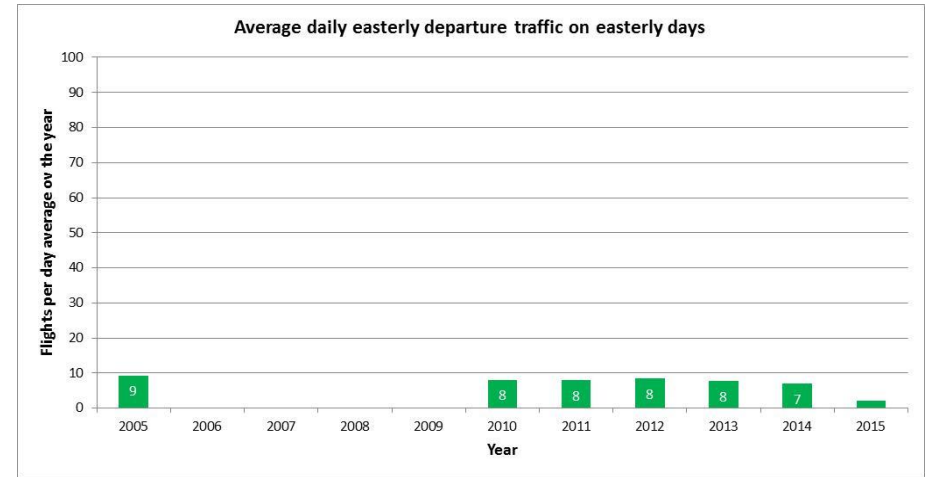
The reason for the difference west:east mix is likely due to a combination of:

- early morning arrivals, following a different alternation pattern to daytime traffic and sometimes have an easterly preference that switches to westerly preference at 06:00 hours. When this switch happens, traffic can arrive on the easterly runways in the early morning and switch to the westerly runways at 06:00 even though wind conditions have not changed
- the higher proportion of no traffic days for arrivals than departures

## The daily volume of easterly departure traffic was at a consistent level from 2010 to 2013 but has largely disappeared but to a realignment of the Compton route



From 2005 to 2014 inclusive, the daily easterly departure traffic crossing the gate fluctuated around ten flights per day with no systematic pattern. In 2015, the number of departures crossing the gate per day on easterly days has reduced, see (1) on the chart above

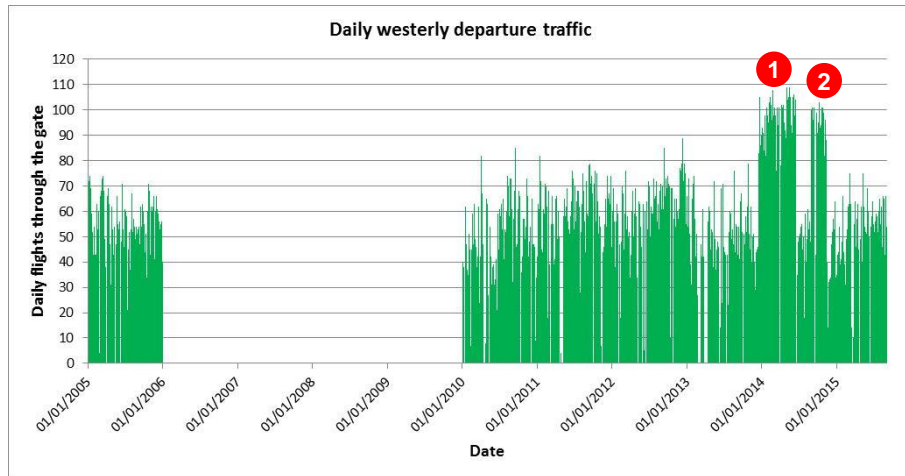


The overall traffic through the gate remained constant at approximately eight flights per easterly day until 2014, when it reduced to seven and subsequently reduced to two per easterly day on average in 2015 .

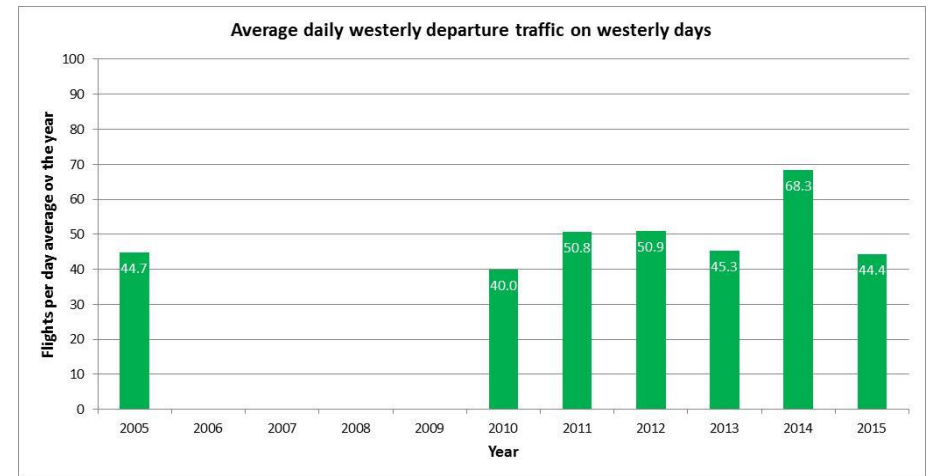
This reduction is due to the re-aligning of the CPT SID

Note: easterly daily averages are derived from days when the airport is operating in the easterly direction only, e.g. the annual daily average is the total easterly traffic crossing the gate per year divided by the number of easterly days for that year

## Westerly departure traffic shows large peaks in 2014, associated with the departure trials



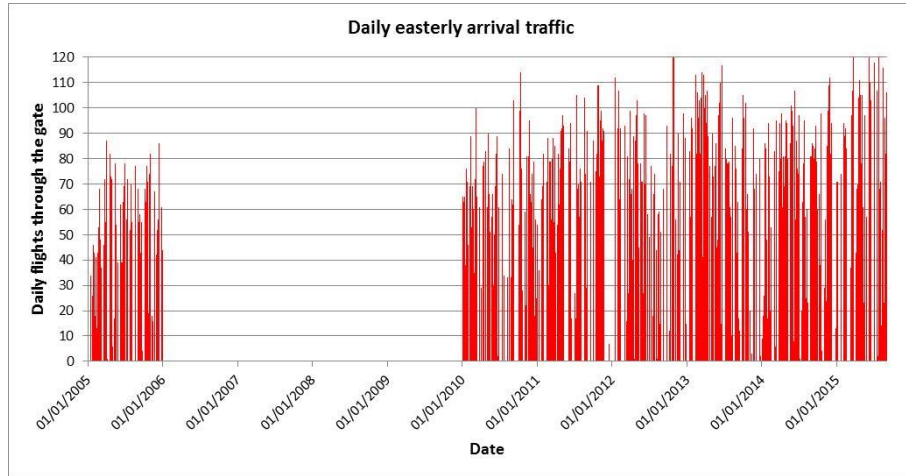
Daily westerly departure traffic shows two large increases in 2014, (1) and (2) above. These increases are associated with the first and second westerly departure trials, which took place from December 2013 to July 2014 and August to November 2014 respectively. Outside of the trial period, the daily traffic levels are similar in 2013 and 2015, both of which are slightly lower than 2011 and 2012.



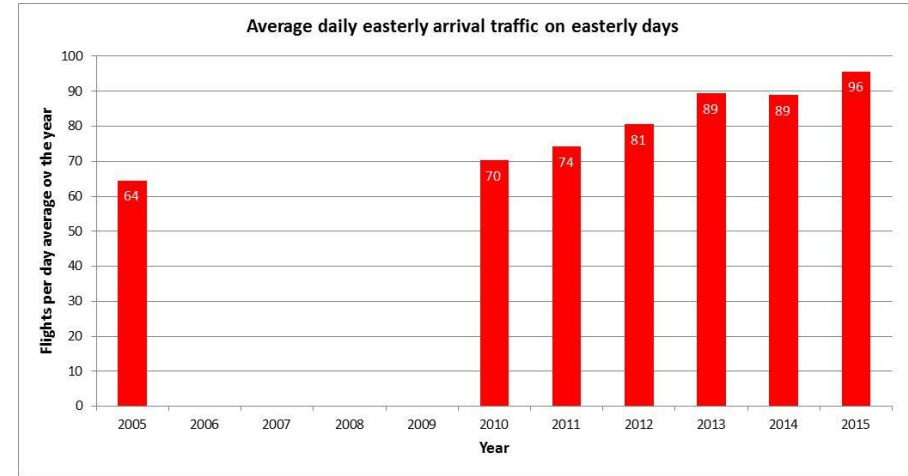
The average daily departure traffic through the gate on westerly days is approximately 44 flights per day, similar to the 2005 and 2013 levels but reduced from approximately 50 flights per westerly day in 2011 and 2012. There is a peak of approximately 68 flights per day in 2014 associated with the departure trials.

Note: westerly daily averages are derived from days when the airport is operating in the westerly direction only, e.g. the annual daily average is the total westerly traffic crossing the gate per year divided by the number of westerly days for that year

## The daily volume of easterly arrival traffic crossing the gate shows a general upward trend, with a plateau in 2014, but then increasing again in 2015



The daily arrivals traffic crossing the gate on easterly days shows an underlying increasing trend (see right hand chart for annual averages). However, there is considerable day-to-day variation above and below the average. There is also a wave pattern modulating the underlying increase. However, this wave pattern does not appear to follow the cyclical summer:winter pattern observed in other gates and in, for example, height characteristics of the traffic

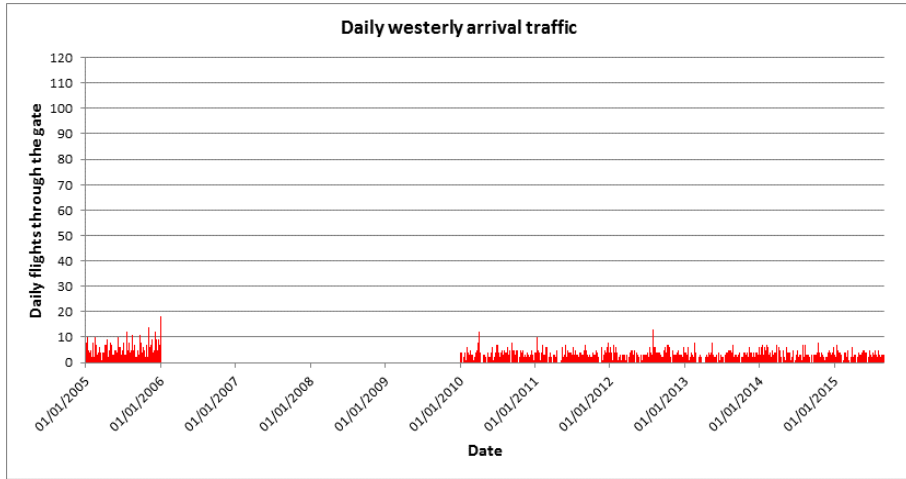


The overall traffic through the gate has increased from 2010 at 64 flights per easterly day to 96 flights per easterly day in 2015.

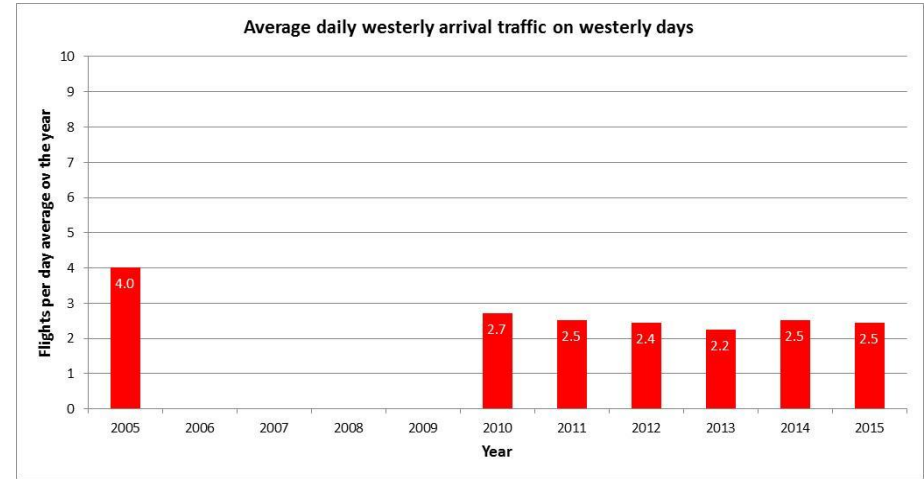
This increase has been continuous except for a plateau in 2014

Note: easterly daily averages are derived from days when the airport is operating in the easterly direction only, e.g. the annual daily average is the total easterly traffic crossing the gate per year divided by the number of easterly days for that year

## The volume of westerly arrivals traffic crossing the gate shows a slight downward trend



Daily westerly traffic has been at a constant level since 2010, reduced from higher levels in 2005

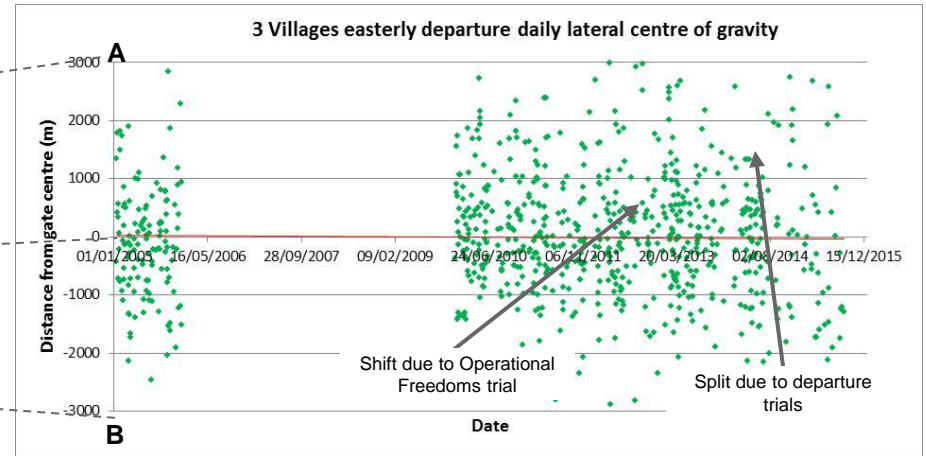
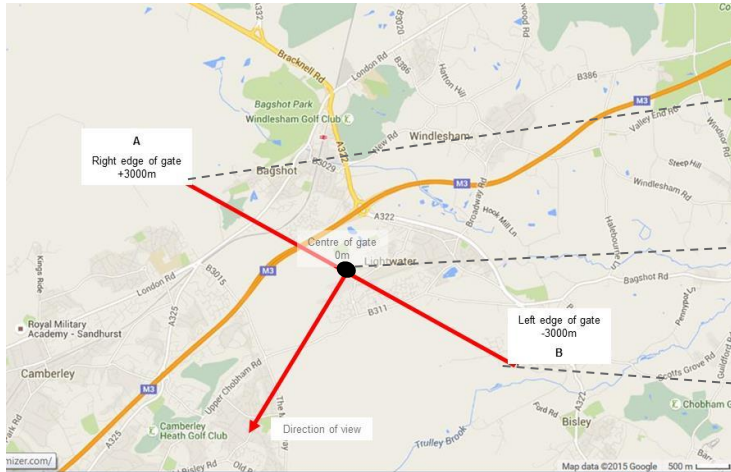


The average daily arrival traffic through the gate on westerly days reduced from approximately four per westerly day in 2005 to approximately 2.5 per day in 2015. The overall underlying trend is downwards

Note: westerly daily averages are derived from days when the airport is operating in the westerly direction only, e.g. the annual daily average is the total westerly traffic crossing the gate per year divided by the number of westerly days for that year

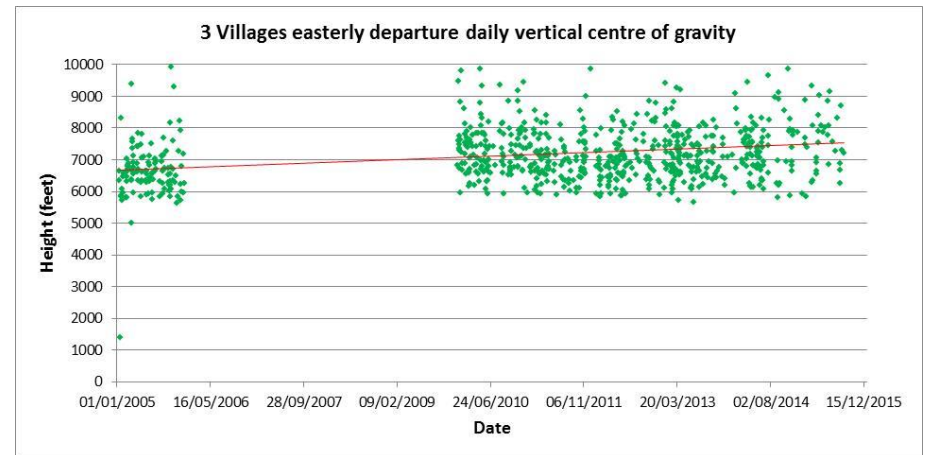
# Easterly departure traffic is randomly distributed across the gate but with an underlying upwards trend in height albeit with large day-to-day variation

## Approximate centre of gravity and extent of easterly departures



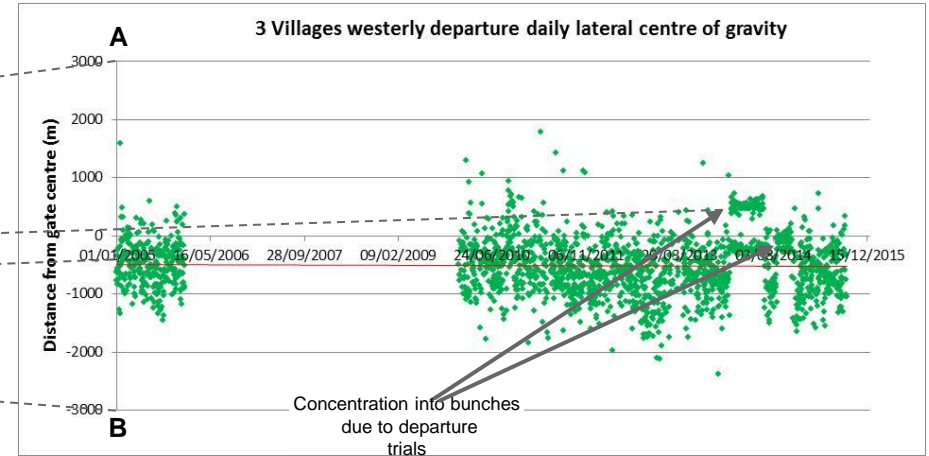
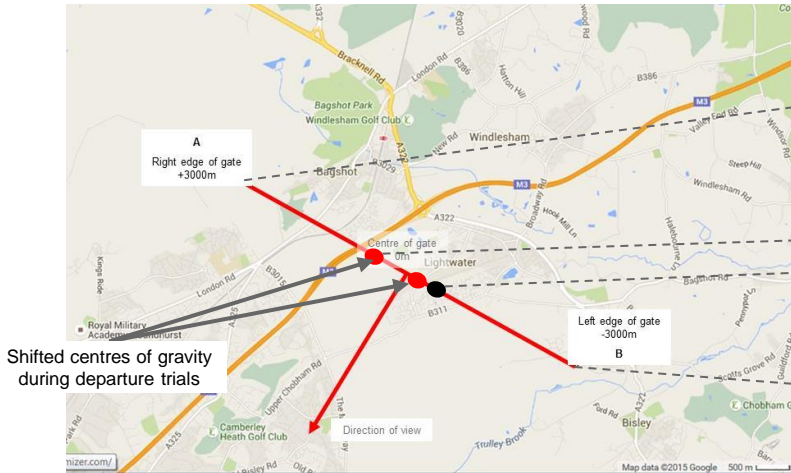
The average lateral centre of gravity (CoG) of the easterly departure traffic is near to the centre of the gate, over Lightwater. The position of the lateral CoG has remained consistent from 2005 to 2015. However, there is considerable scatter from day-to-day indicating that easterly departures are randomly distributed across the gate

There is upward trend on the vertical CoG of the easterly departure traffic from approximately 6400 feet in 2005 to approximately 7200 in 2015. There is, however, considerable day-to-day variation on this height, from circa 5000 feet to approximately 10000 feet



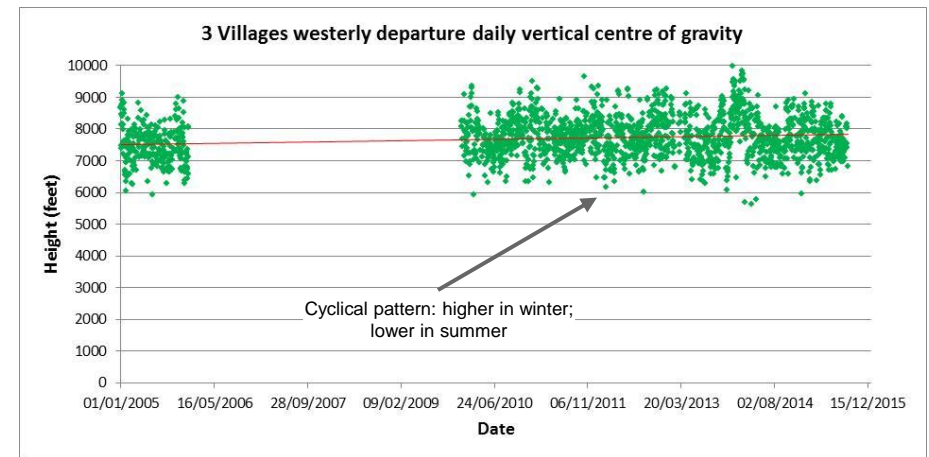
# Westerly departures were shifted during the trials but have reverted since: there is an underlying upwards trend in height but with summer:winter cyclical variation

## Approximate centre of gravity and extent of westerly departures



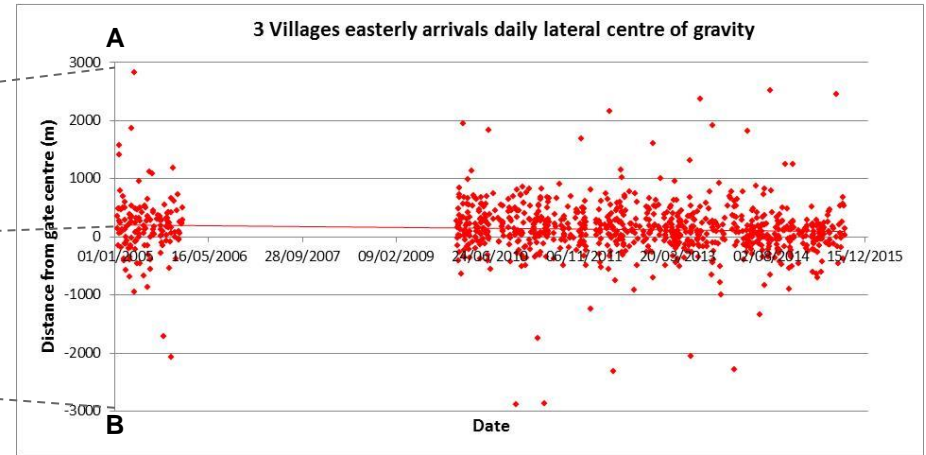
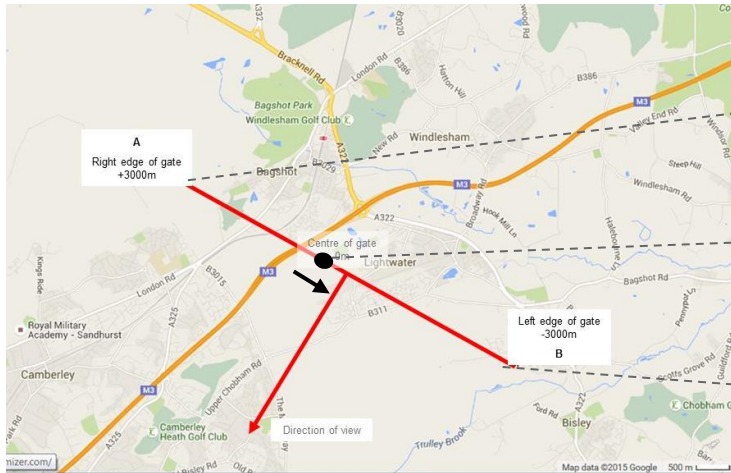
Other than during the trials, the average lateral centre of gravity (CoG) for westerly departures is approximately 400m to the left of the gate centre in direction of traffic flow. The trials created two additional centres of gravity close to the gate centre, over Lightwater and further to the north west. There is considerable day-to-day variation in the lateral CoG

There is a slight upward trend on the vertical CoG from approximately 7400 feet in 2005 to approximately 7900 in 2015 with wide daily variation. There is a cyclical pattern in the vertical CoG indicating westerly departures are generally lower in summer than in winter



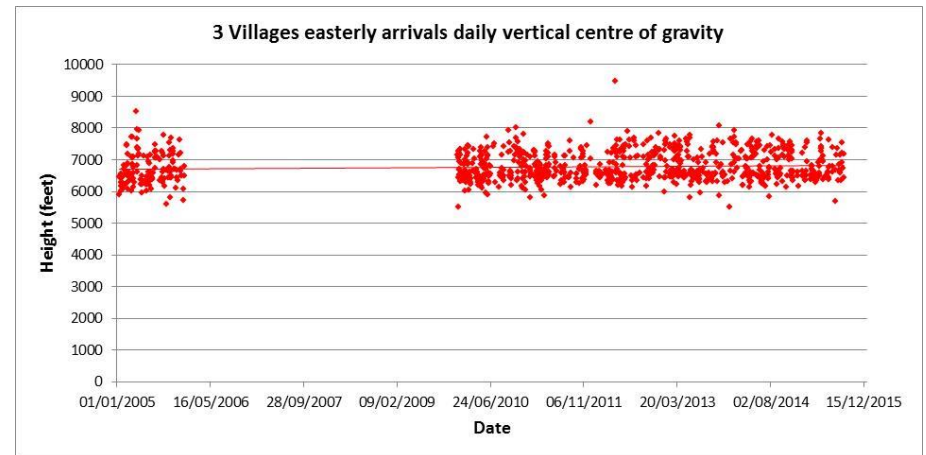
# There has been slight shift of the centre of gravity of easterly arrivals from the north west towards the centre of the gate

## Approximate centre of gravity and extent of easterly arrivals



The average lateral centre of gravity (CoG) for easterly arrivals is just to the right of the centre of the gate but with large day-to-day fluctuations. There is a trend for this to shift towards the centre of the gate, towards the centre of Lightwater

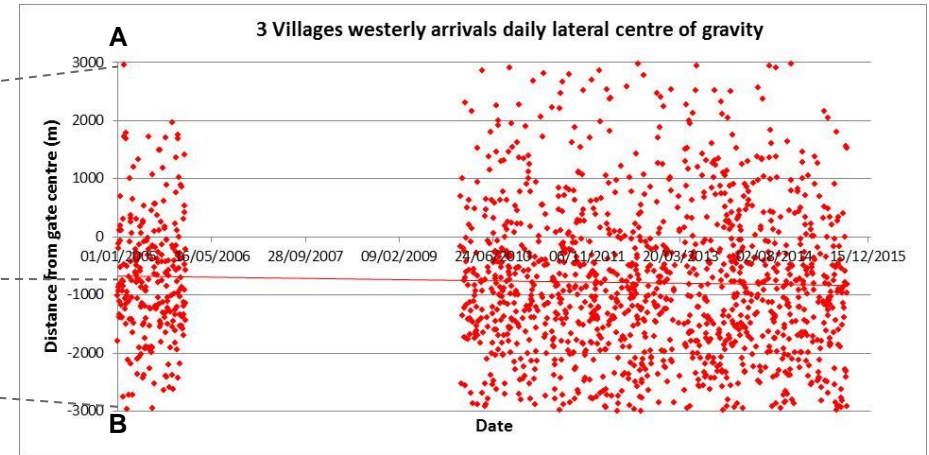
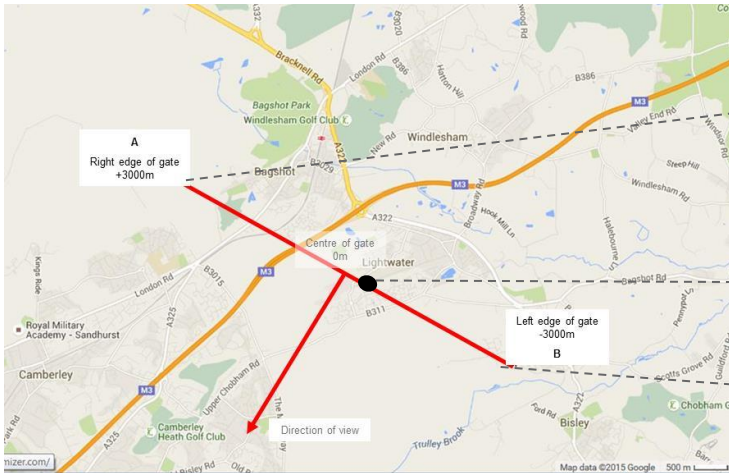
There is no immediately apparent trend on the vertical CoG for easterly arrivals, which has remained constant at approximately 6600 feet. There is again large day-to-day variation in the vertical CoG from around 5500 feet to above 9000 feet





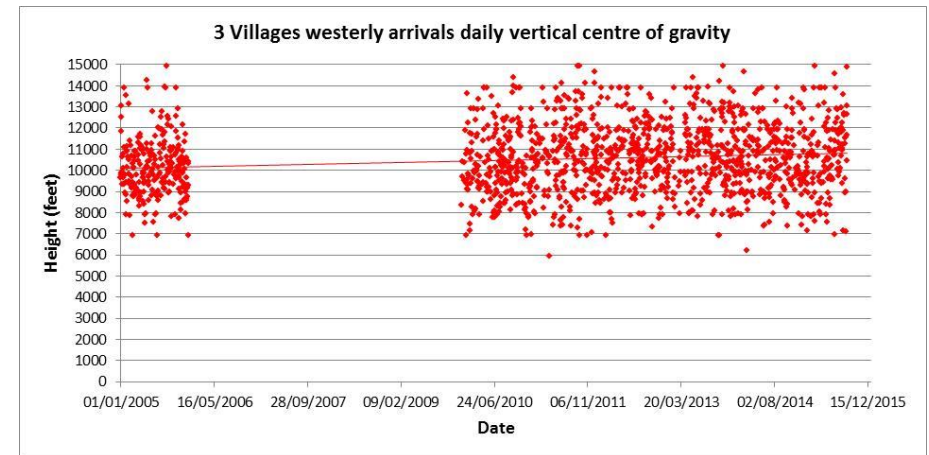
# There is considerable scatter on the lateral and vertical positions of westerly arrivals

## Approximate centre of gravity and extent of westerly arrivals

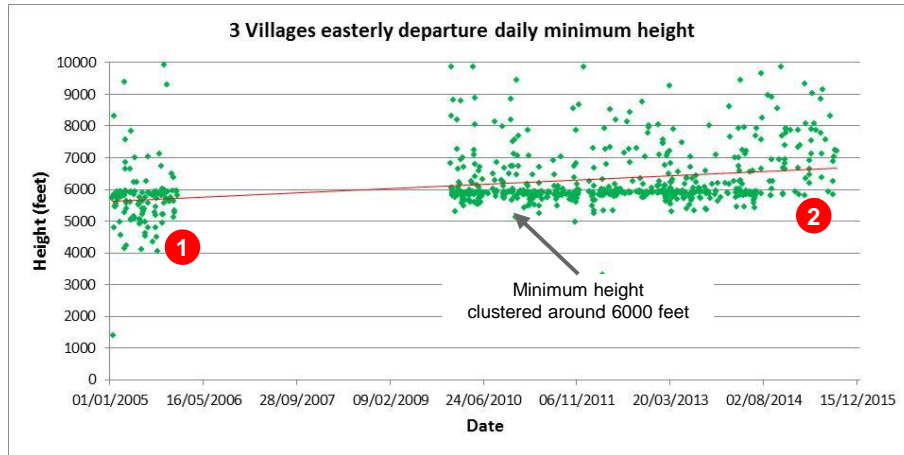


The daily lateral centres of gravity (CoG) for westerly arrivals are randomly distributed across the gate with an average centre of gravity approximately 500m to the south east of gate centre

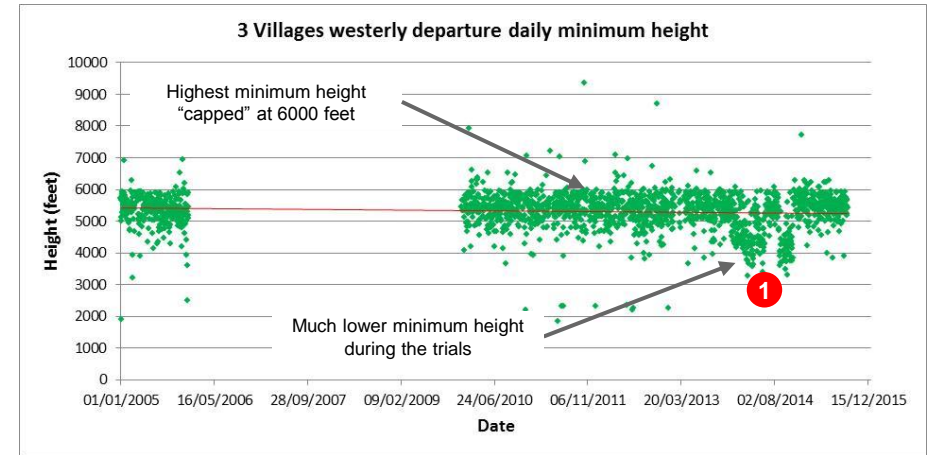
Similarly, the daily vertical centres of gravity for westerly arrivals are randomly distributed in height from approximately 7000 feet and occasionally lower to above 14000 feet



## The trend on the minimum height for easterly departures is upwards whereas that for westerly departures is downwards



The minimum height for easterly departures shows an upwards trend from 2005 to 2015 from 5500 feet to 6700 feet. The underlying drivers of this trend are: (i) the removal of the low departures shown at (1) in the above figure; and (ii) the disappearance at (2) of the cluster of departures at around 6000 feet, corresponding to the re-alignment of the CPT SID



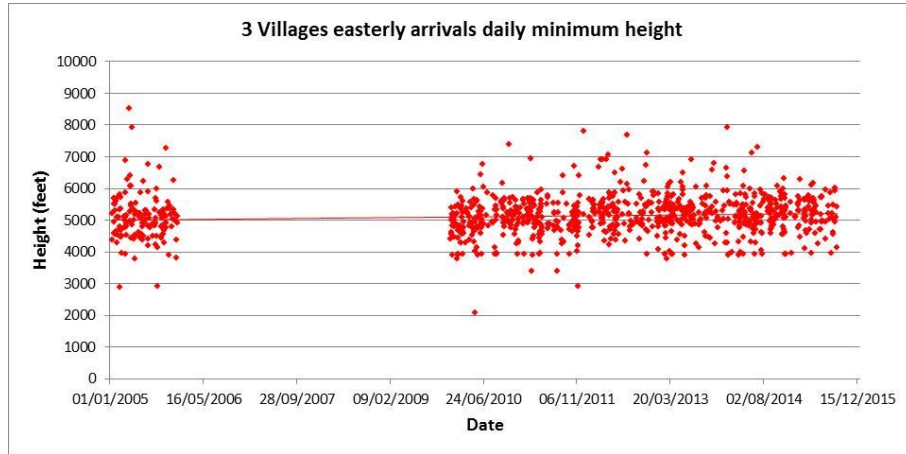
The minimum height for westerly departures shows a slight downward trend for 2005 to 2015 from 5600 feet to 5200 feet.

During the trial periods, the minimum height (1) was reduced considerably from an average of approximately 5300 feet to a minimum of approximately 3700 feet.

The chart shows the cap on minimum height of 6000 feet as departing aircraft are held down by air traffic control to avoid conflicts with arrivals traffic.

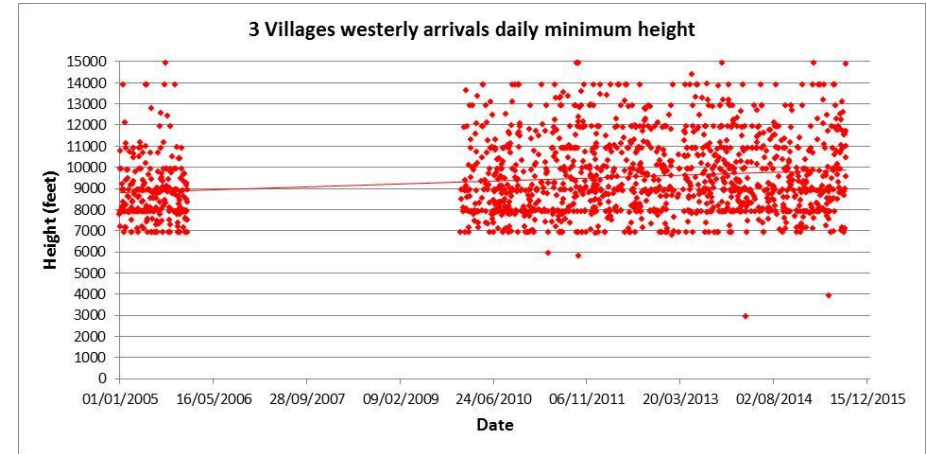
The flights at heights of order 2000 feet to 3000 feet are generally business jets

## Both easterly and westerly arrivals show a slight upward trend in minimum daily height



The average minimum height for easterly arrivals is approximately 5000 feet ranging from 4000 feet and sometimes below to 6000 feet and sometimes above.

The flights below 3000 feet are generally technical flights used to calibrate the airport's landing systems



The observed minimum heights for westerly arrivals traffic are generally ordered at the flight levels used in the stacks, starting at 7000 feet and increasing in 1000 foot intervals

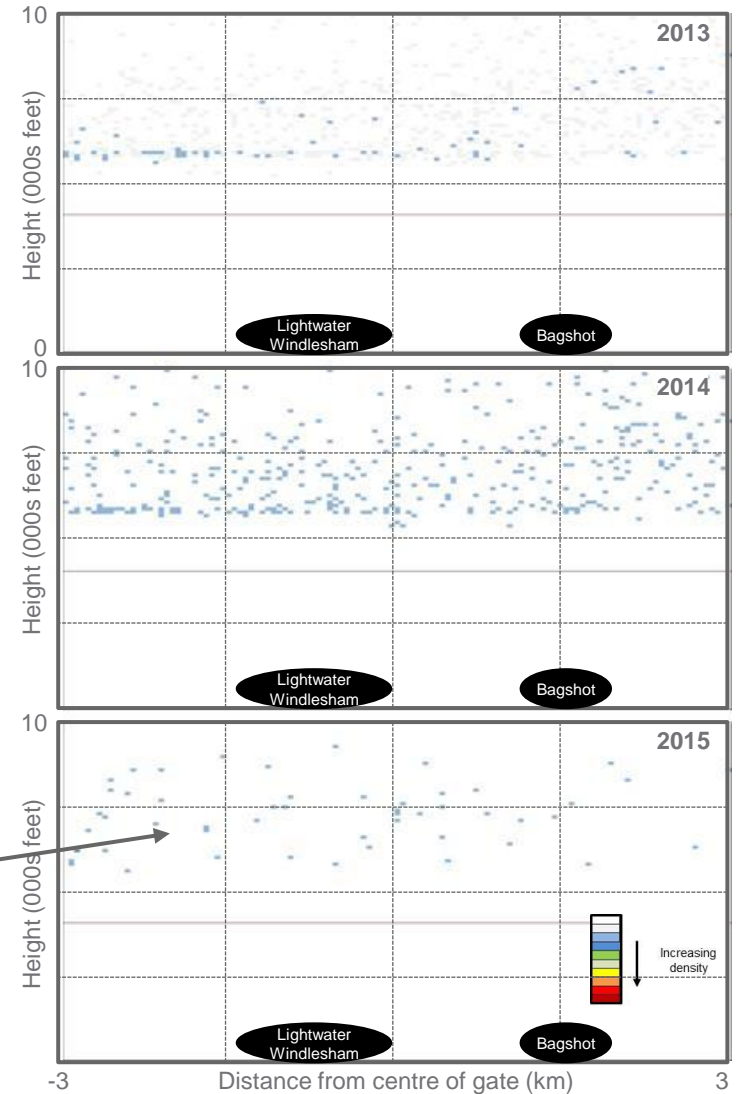
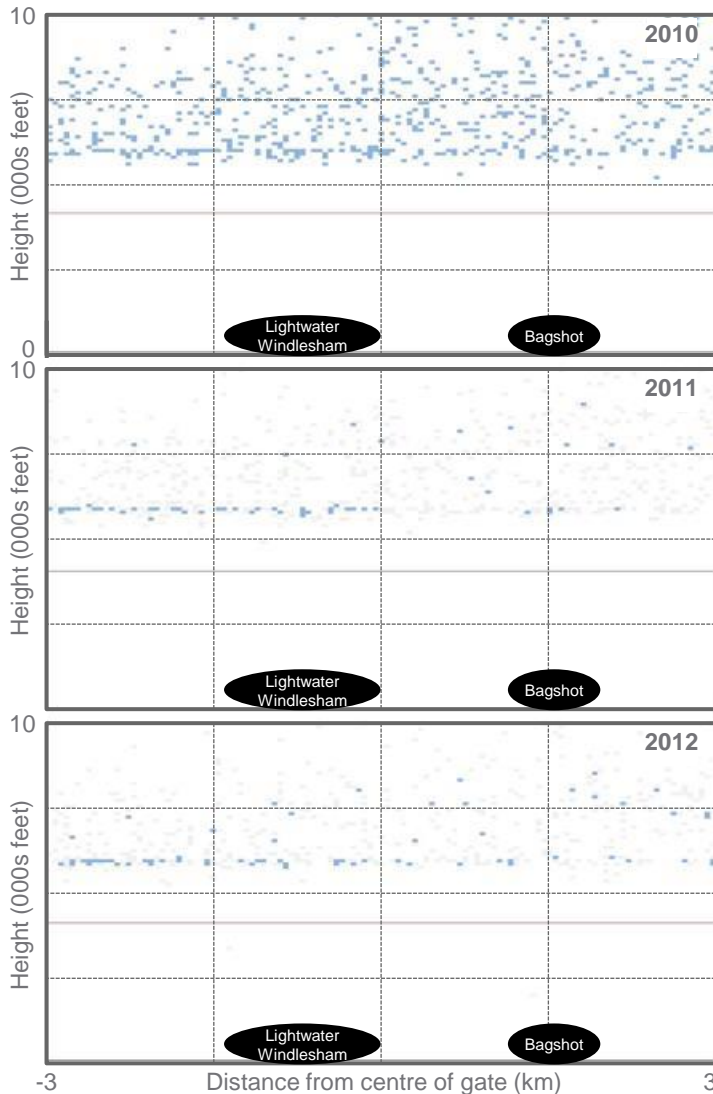


# EASTERLY DEPARTURES

---

# 4

# Easterly departure heat maps show the random distribution of flights across the gate, generally at 6000 feet and above: density is much reduced in 2015

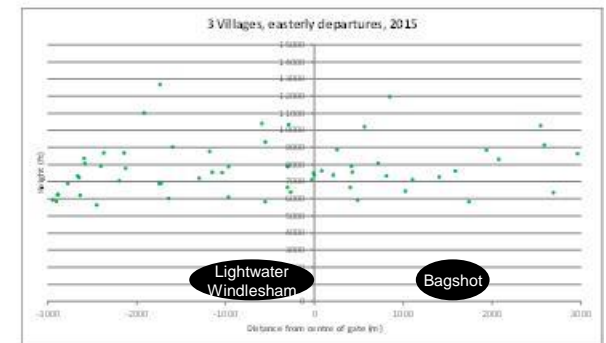
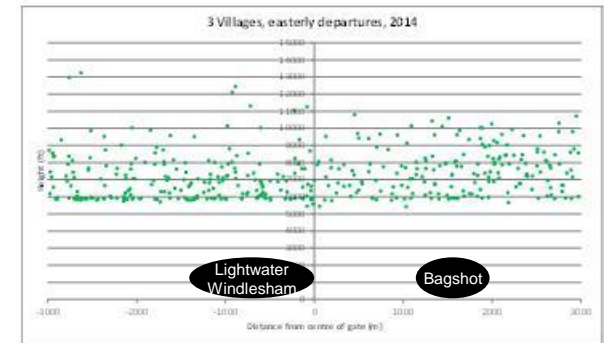
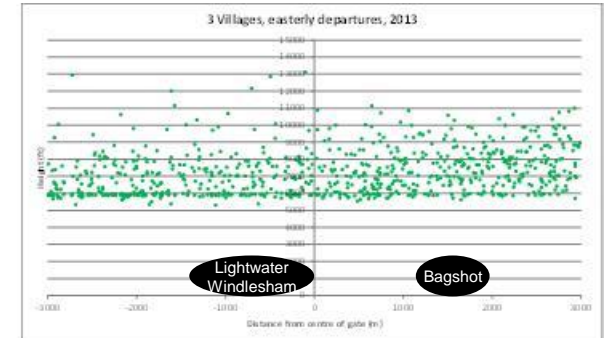
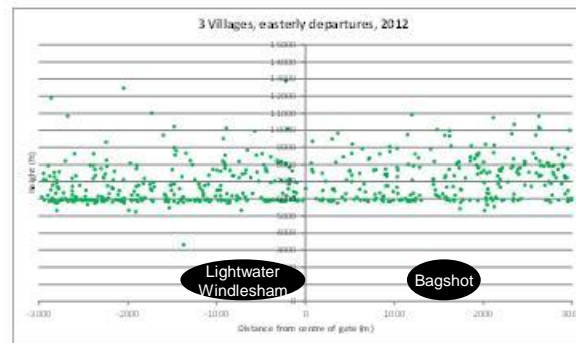
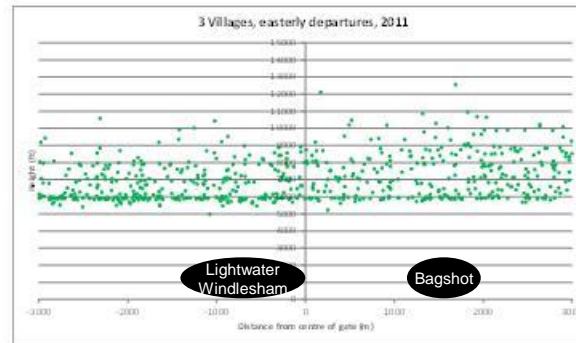
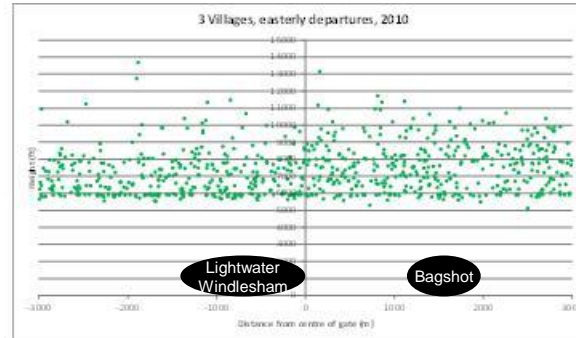
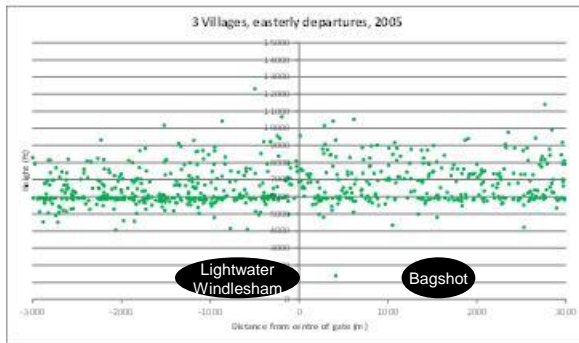


Density reduced corresponding to the re-alignment of the CPT SID

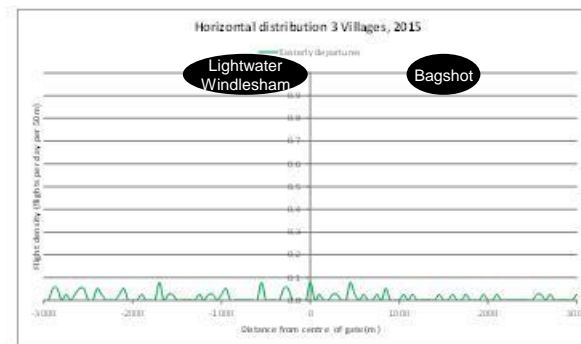
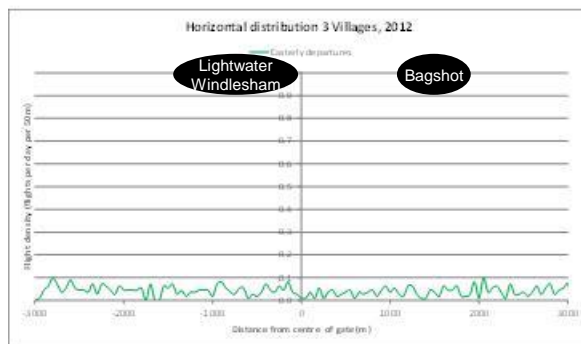
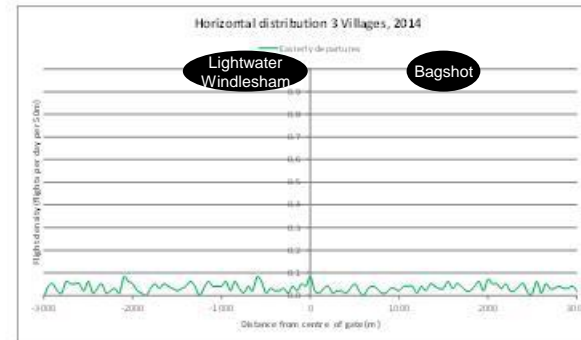
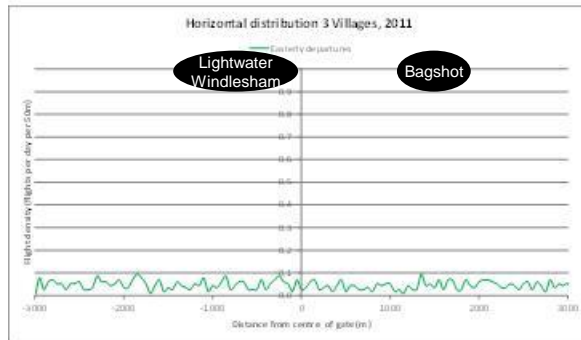
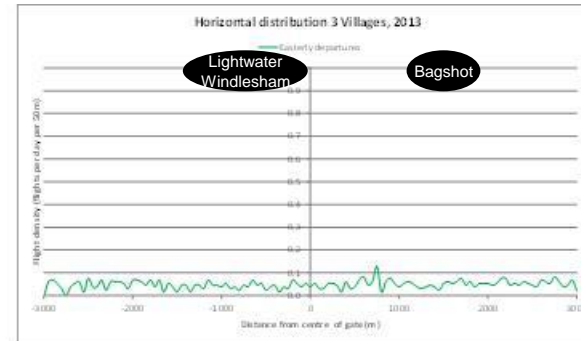
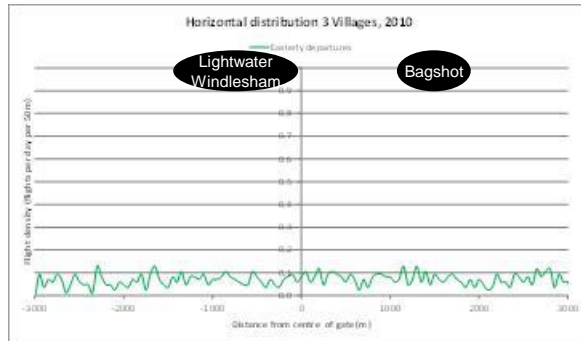


# Scatter plots for easterly departures show the random distribution of flights and their reduction in 2015

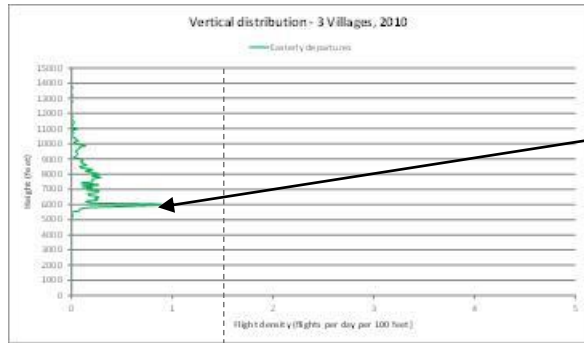
Easterly departure traffic is randomly distributed across the gate with a floor at approximately 6000 feet



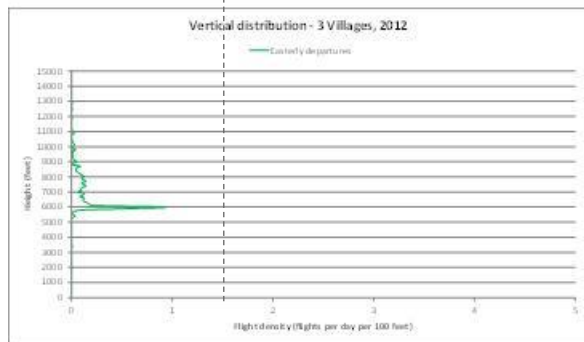
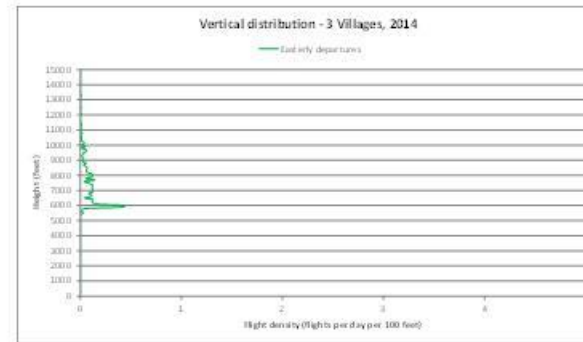
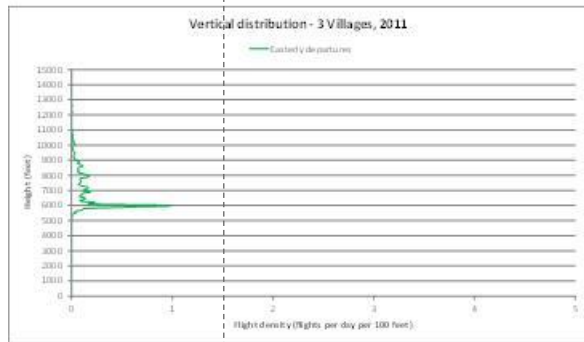
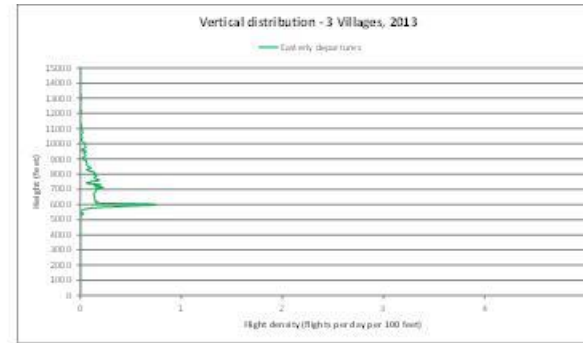
# The horizontal traffic distributions confirm the low volume and random nature of easterly departure traffic crossing the gate



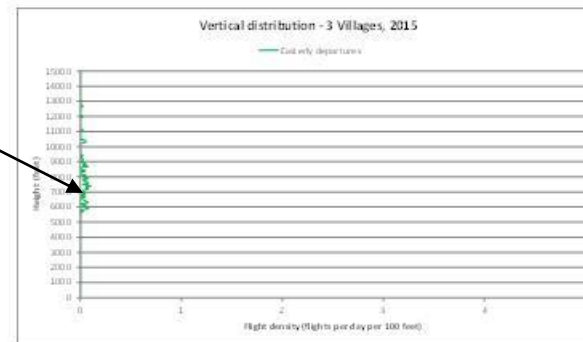
# Vertical distributions show pre-2015 the most likely departure height was 6000 feet: this has now become random with the removal of most traffic from the gate



Bulk of traffic crossing the gate at 6000 feet

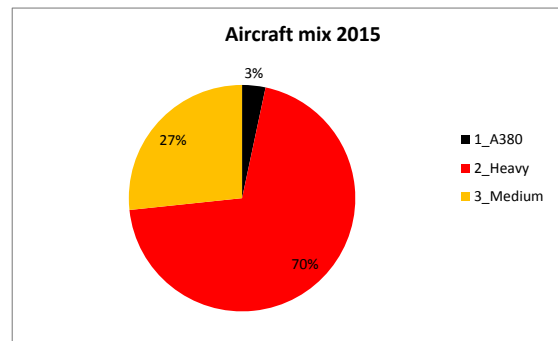
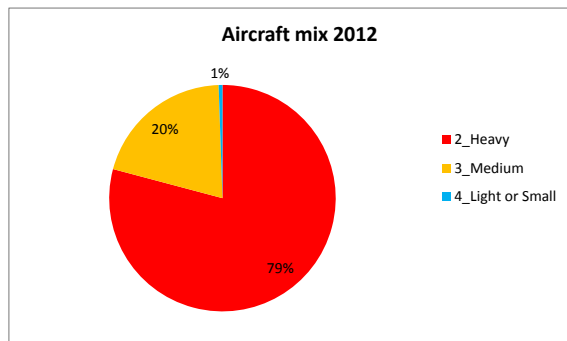
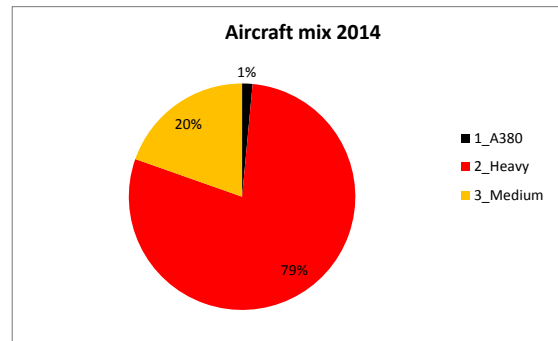
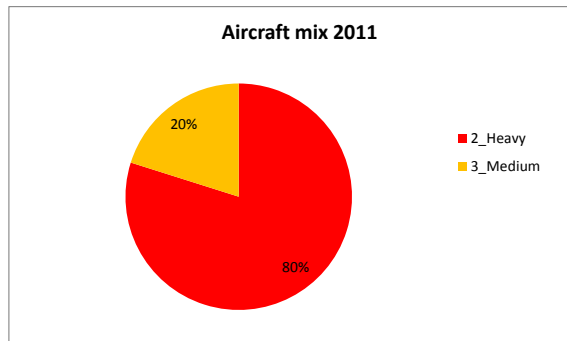
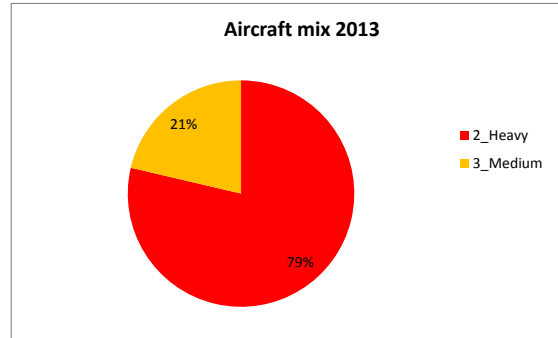
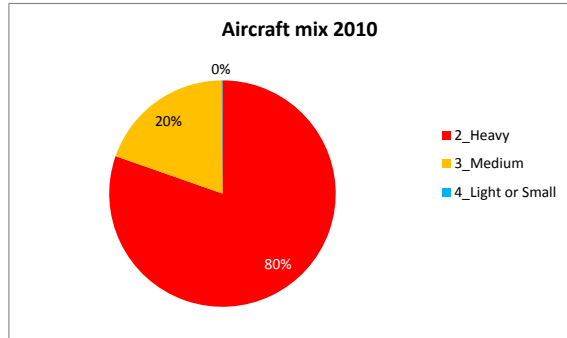


Majority of traffic and peak at 6000 feet has disappeared

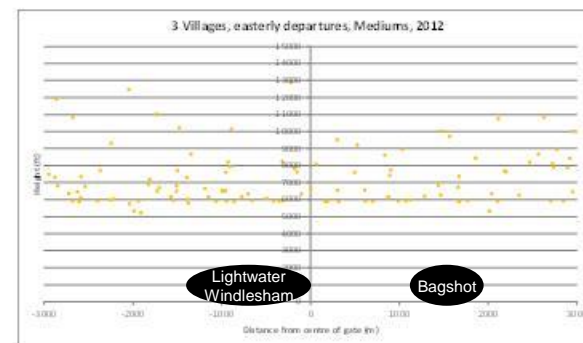
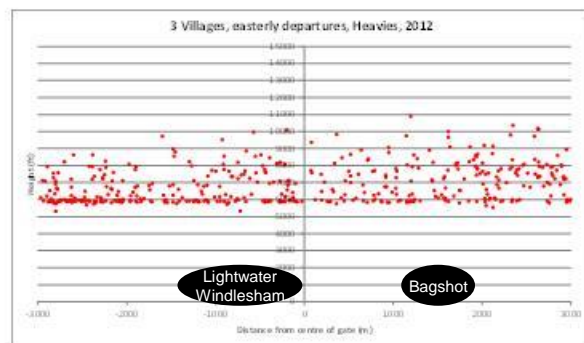
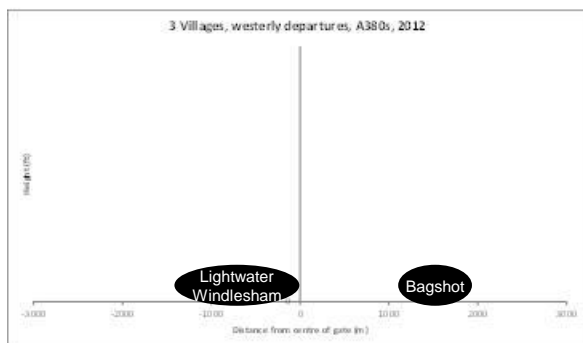
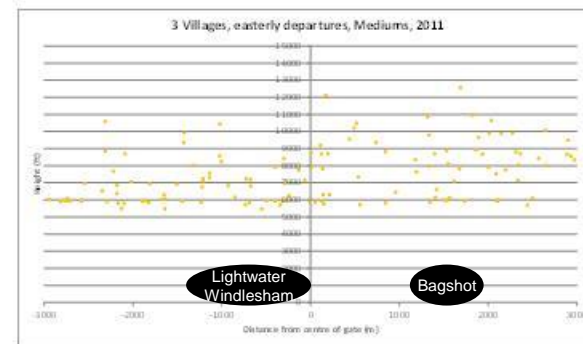
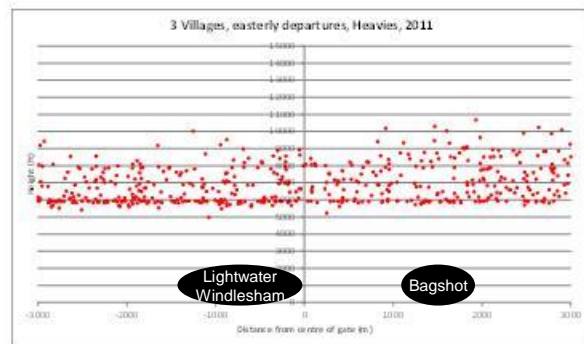
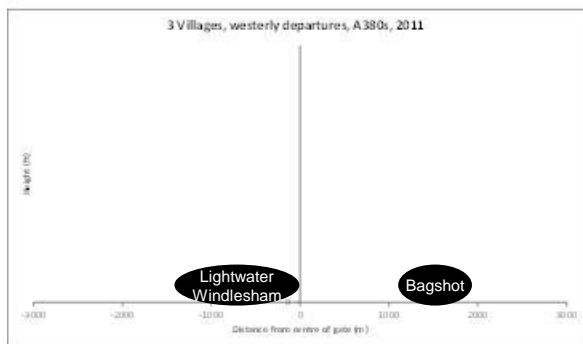
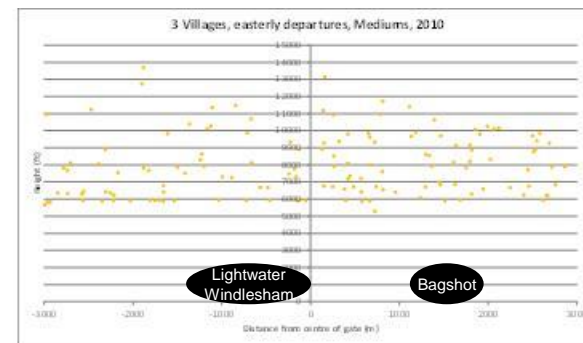
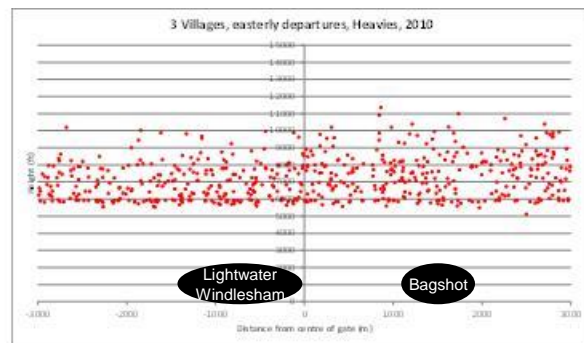
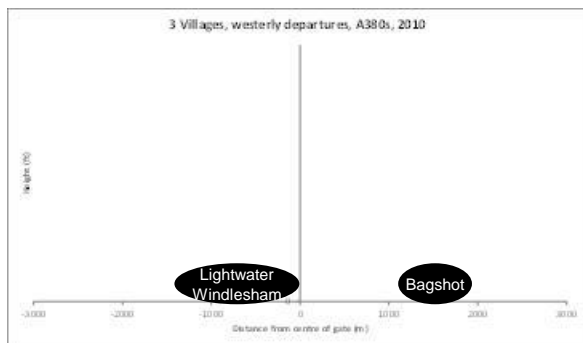




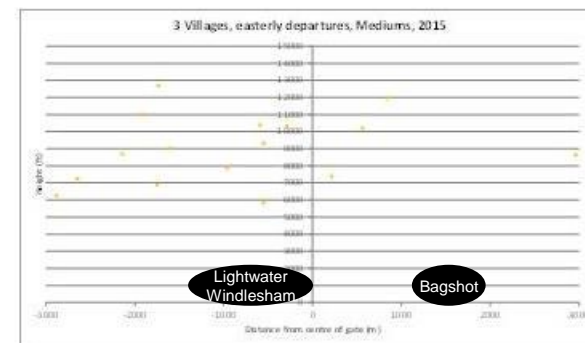
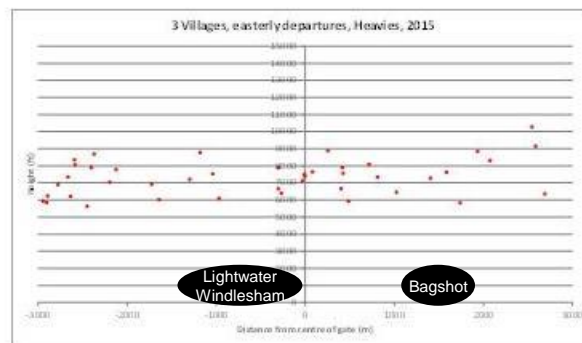
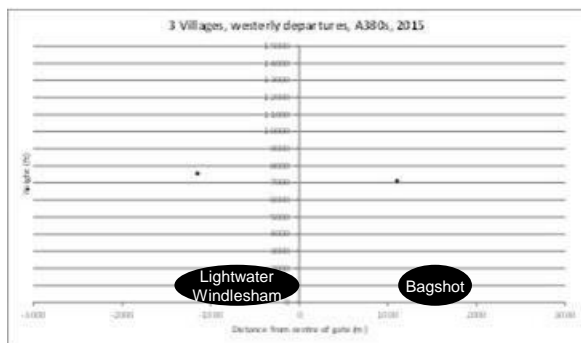
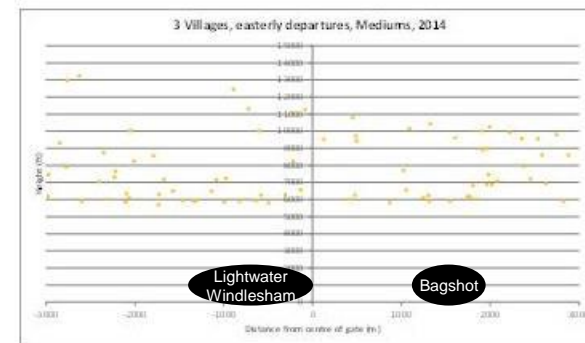
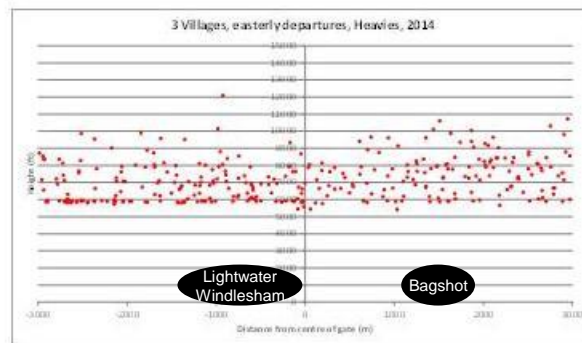
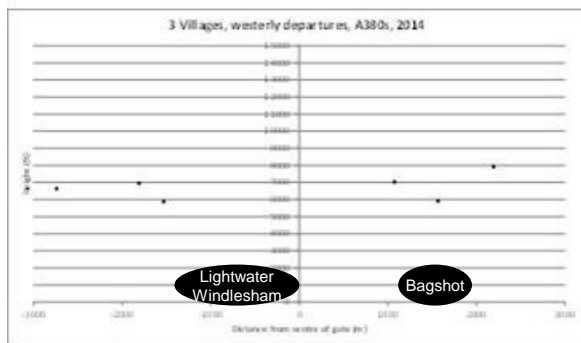
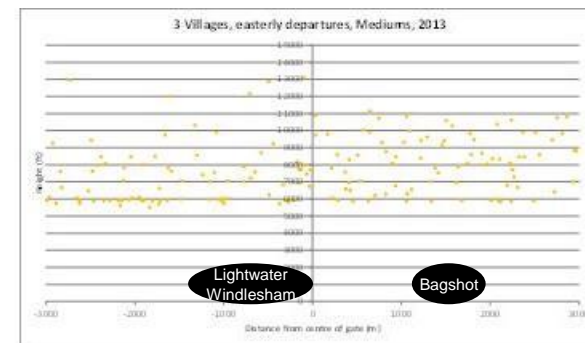
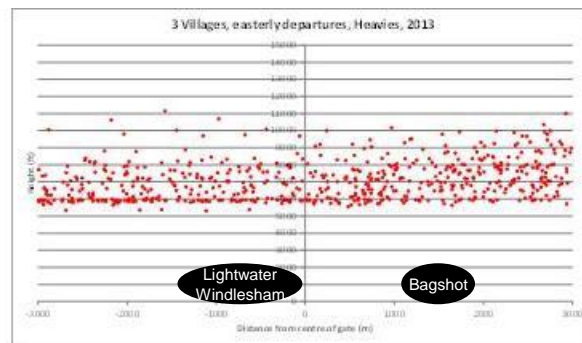
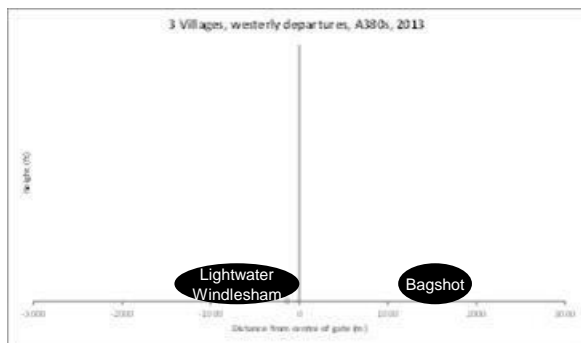
# The proportion of large aircraft in the easterly departure mix is approximately 75% with A380s making up 3% in 2015



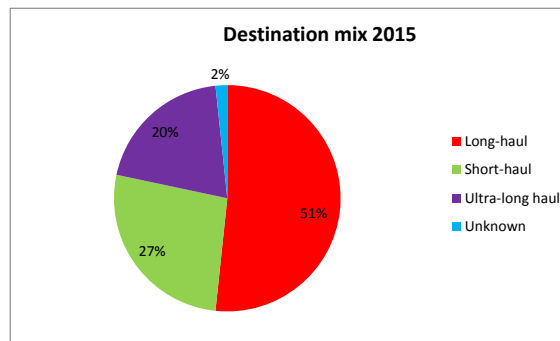
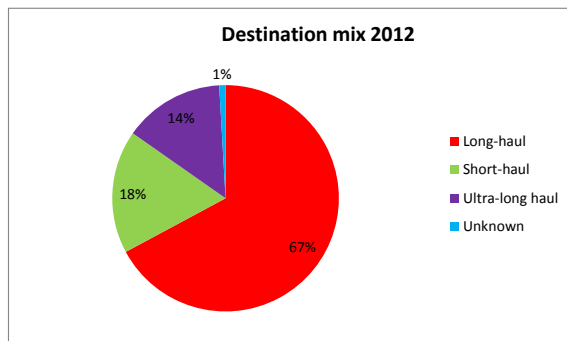
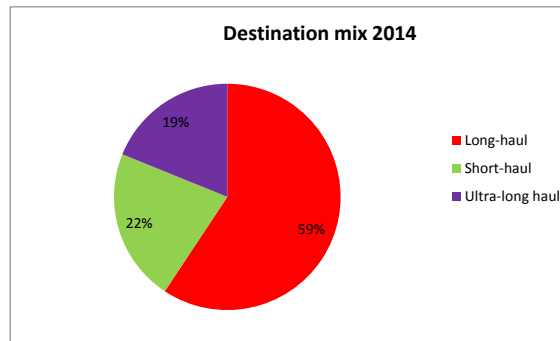
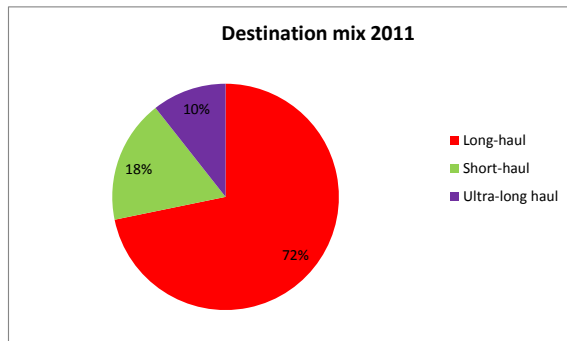
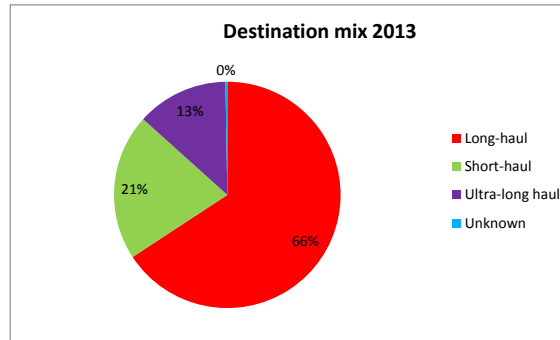
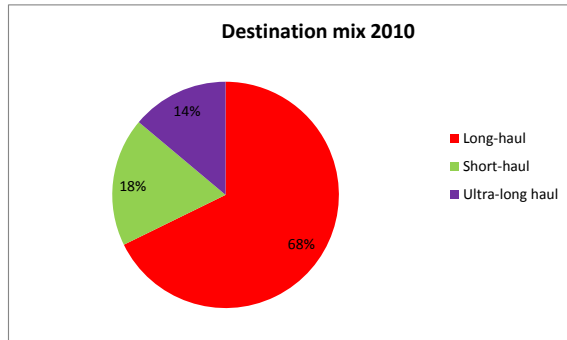
# There does not appear to be any bunching by size of aircraft from 2010 to 2012



# There also does not appear to be any bunching by aircraft size from 2013 to 2015



# The proportion of ultra long and long-haul destinations served by easterly departure traffic is consistent with the proportion of large aircraft in the mix, greater than 75%



Short-haul destinations typically have flights times shorter than three hours

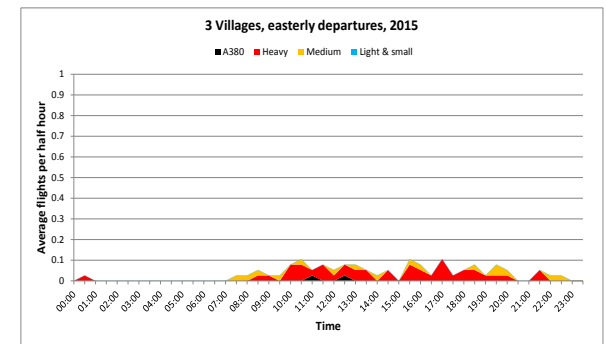
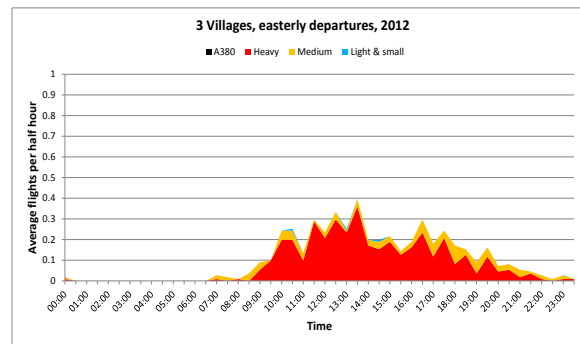
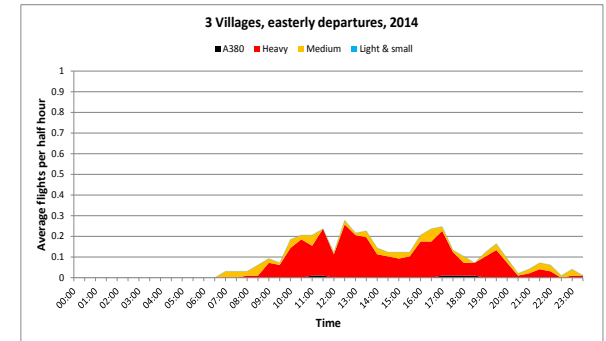
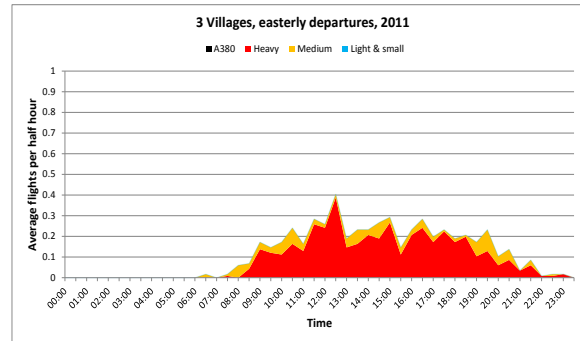
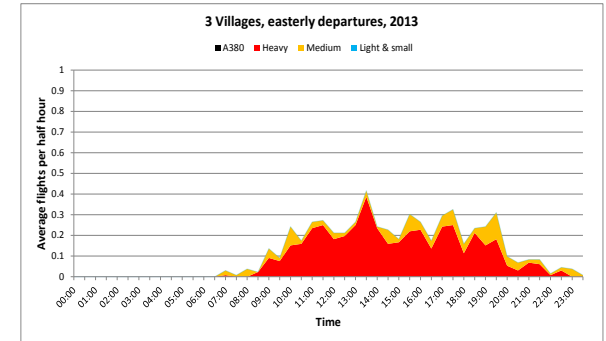
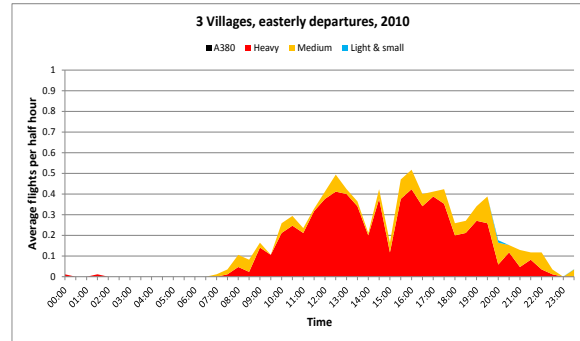
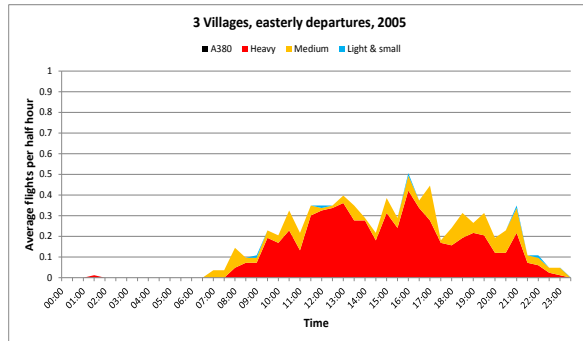
Medium-haul destinations typically have flight times between three and six hours

Long-haul destinations typically have flight times between six nine hours

Ultra long-haul destinations typically have flight times greater than nine hours

Destinations marked as “unknown” do not have a recognised airport code associated with the flight in the data used for analysis

# The peak in the traffic occurs between 10:00 hours and 20:00 hours: traffic has reduced considerably in 2015



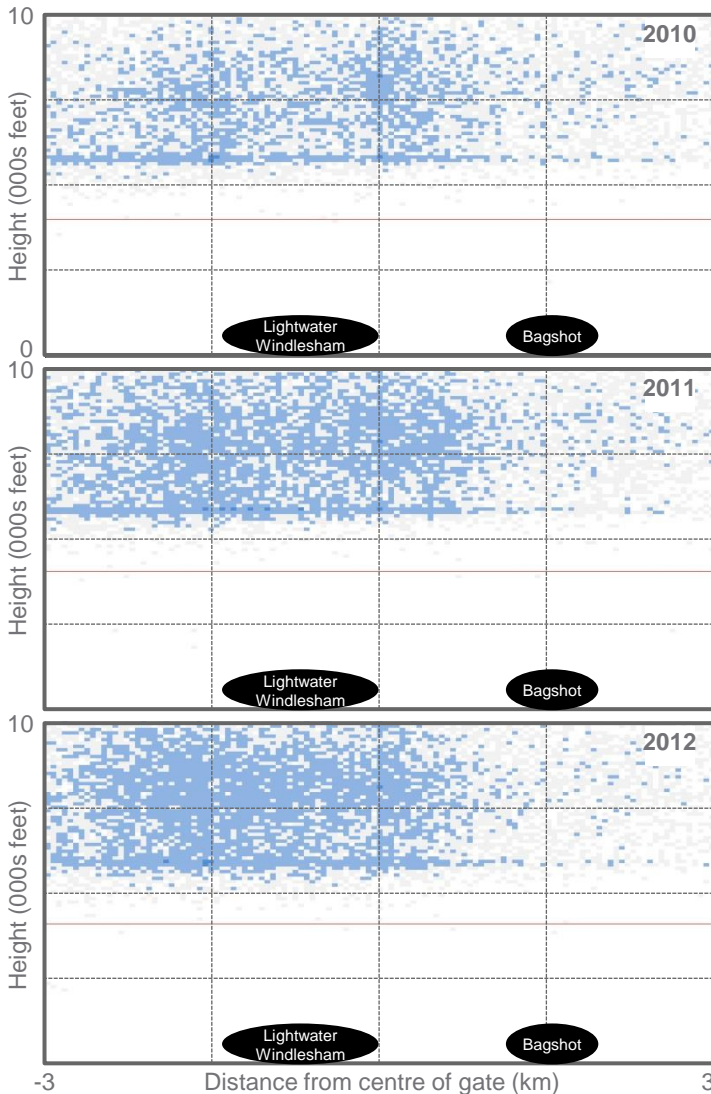


# WESTERLY DEPARTURES

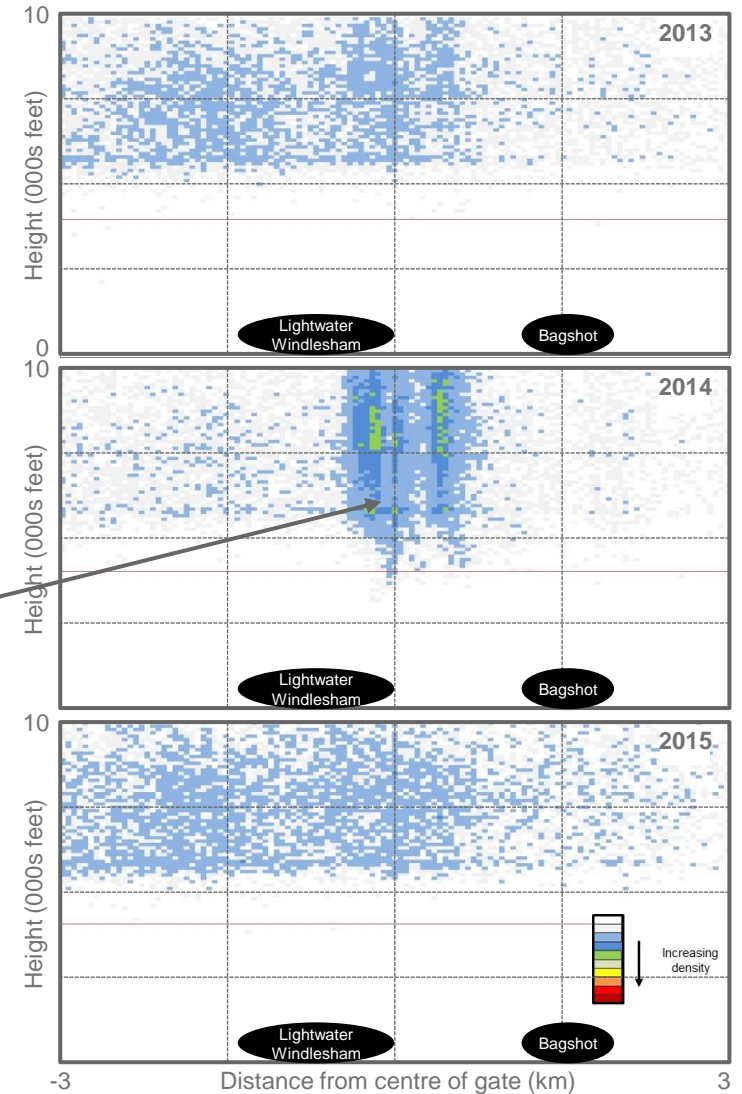
---

# 5

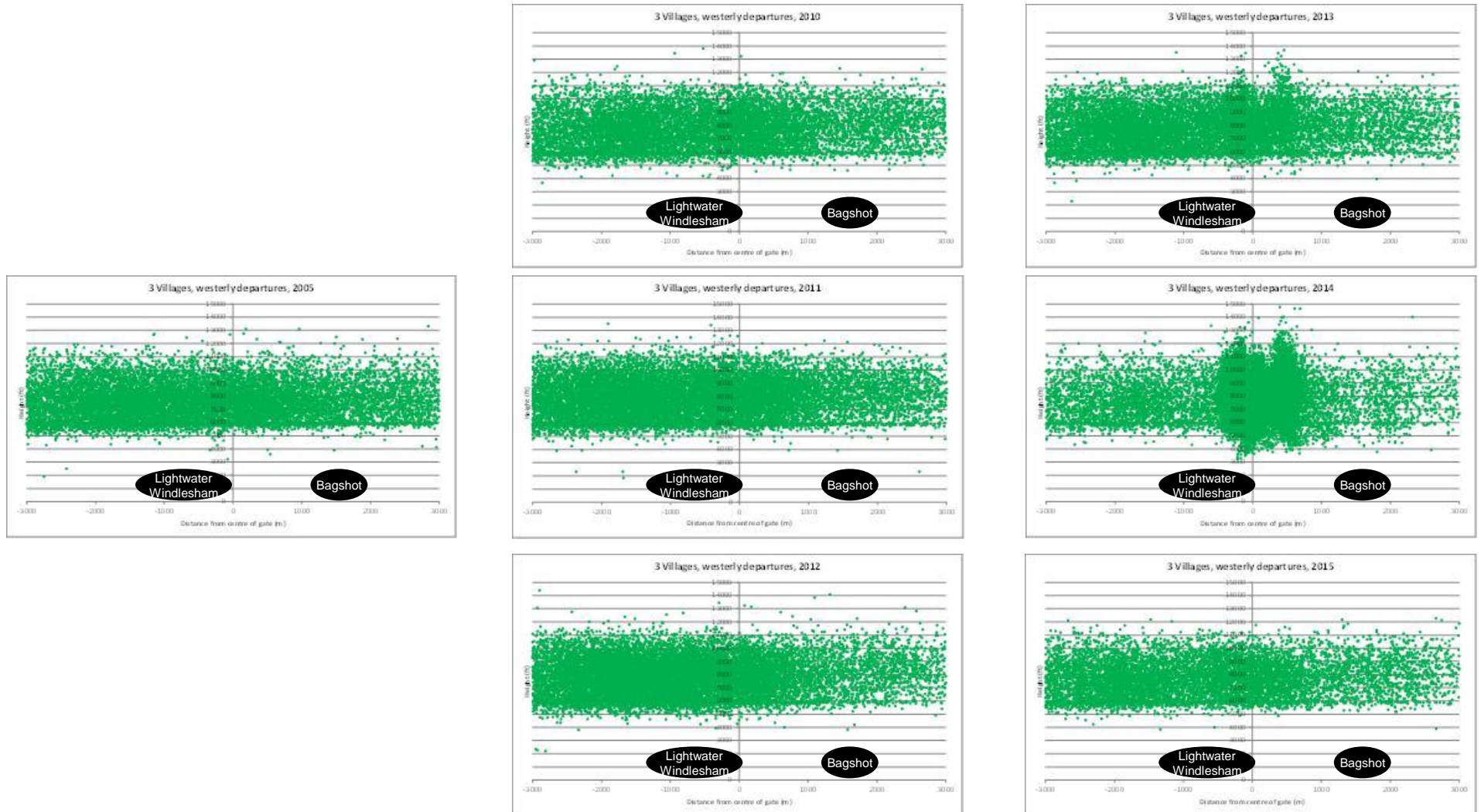
Other than during the trials, the westerly departure heat maps show a broad swath of traffic across the south eastern three quarters of the gate



High density swaths associated with concentration of flights during the trials

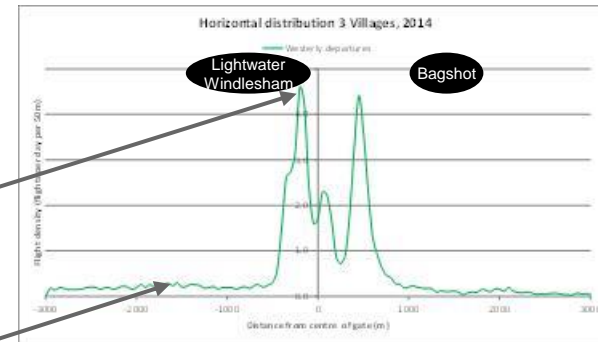
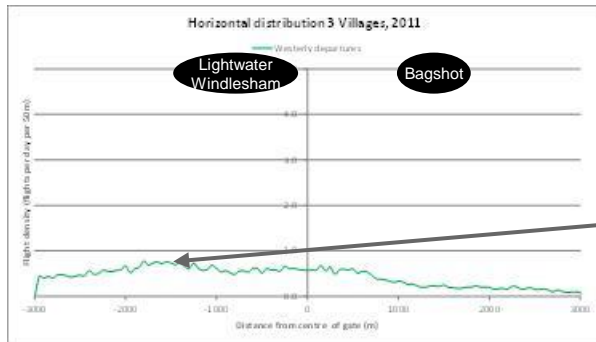
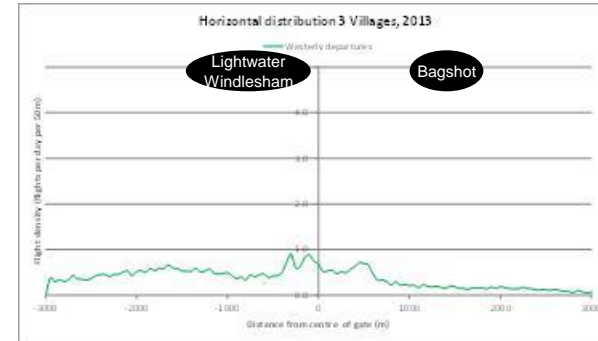
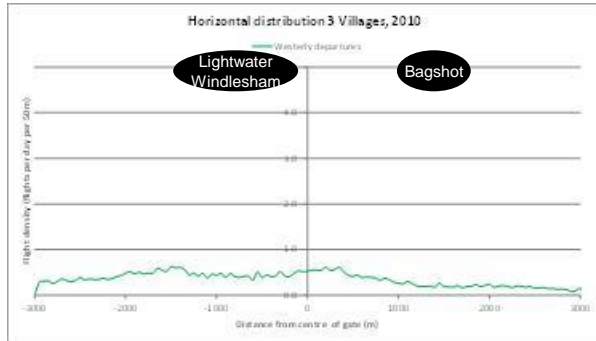


# Westerly departure scatter plots show the trials SID structure but are broadly distributed across the gate at other times



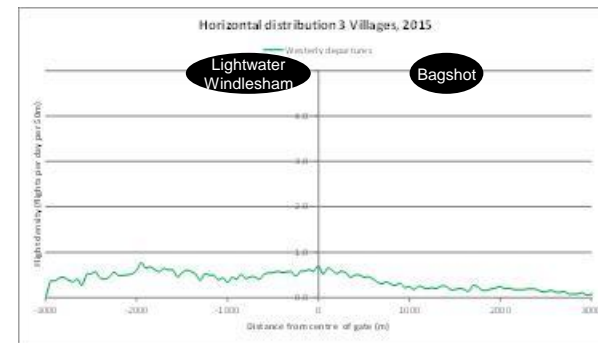
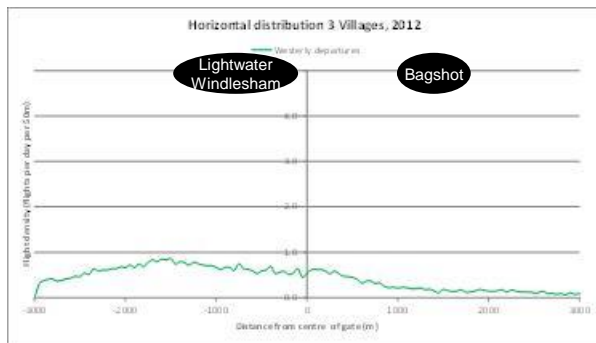


# Lateral distributions for westerly departures show the degree of concentration reached during the trials compared to the normal distribution

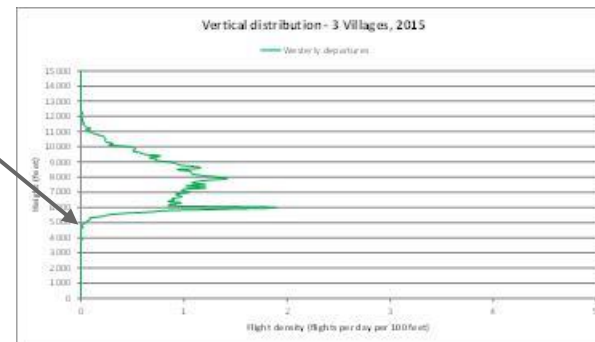
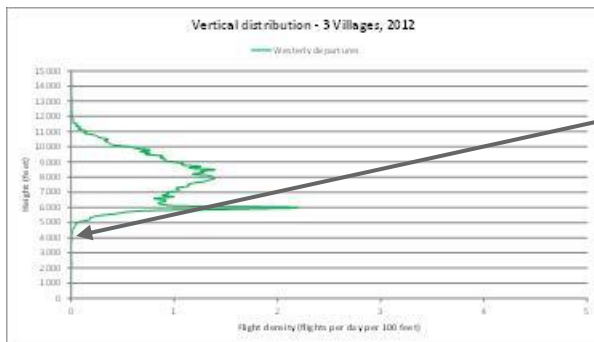
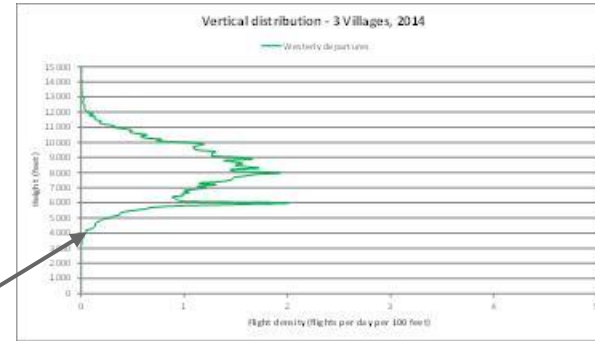
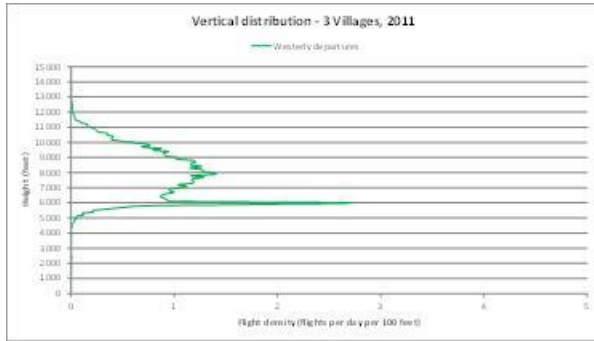
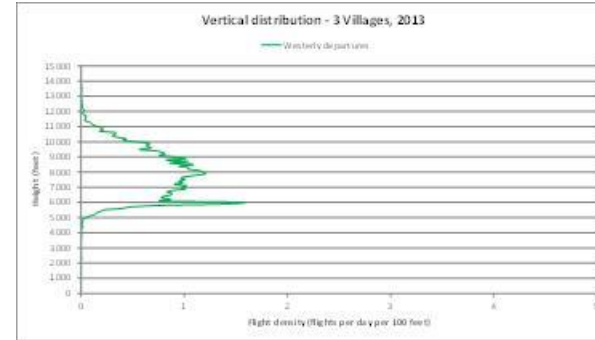
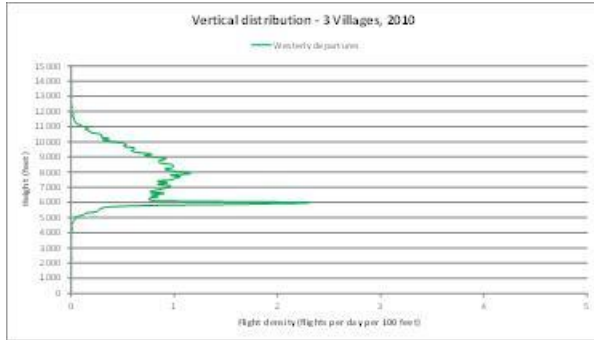


Trial peak of order six times higher than normal traffic levels

"Background" levels during trial reduced by around a factor of four compared to normal levels

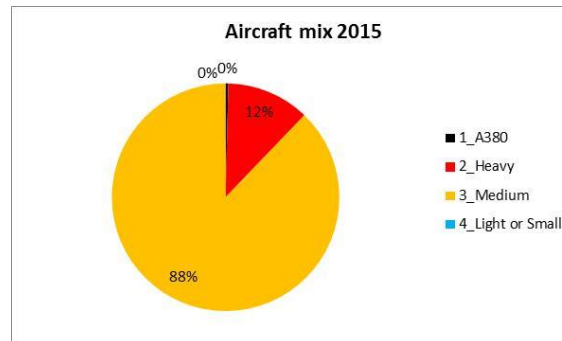
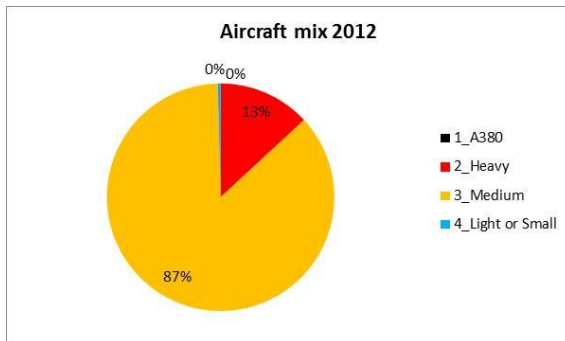
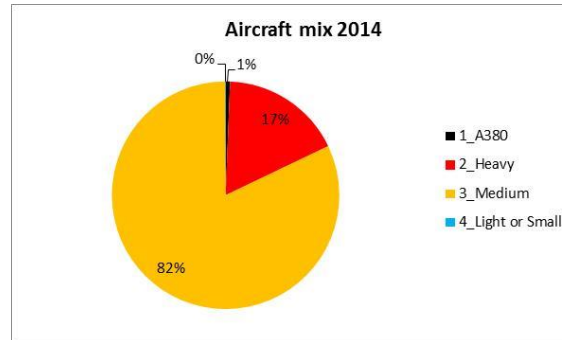
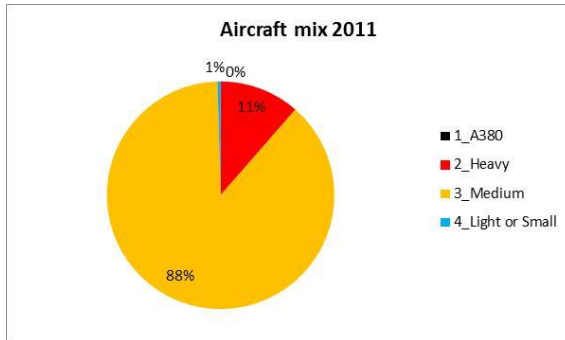
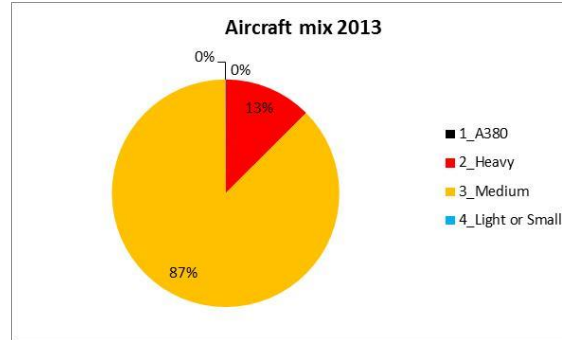
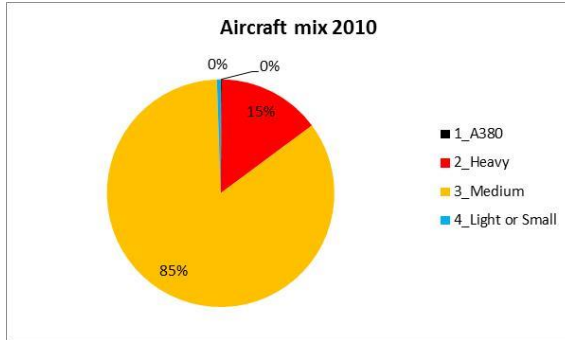


# Vertical distributions show traffic was lower during the trials but otherwise are consistent across the years investigated



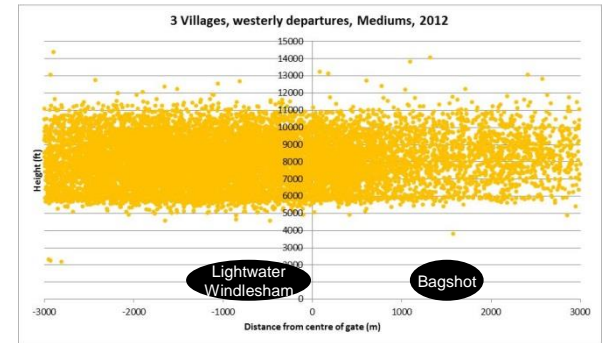
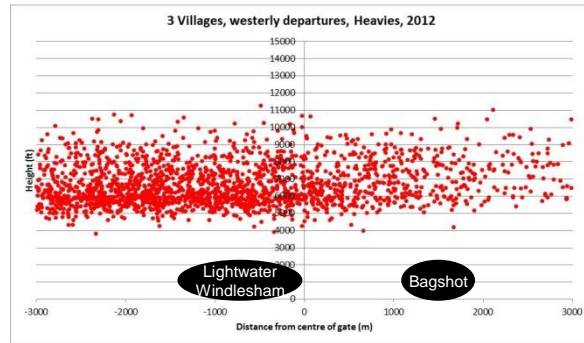
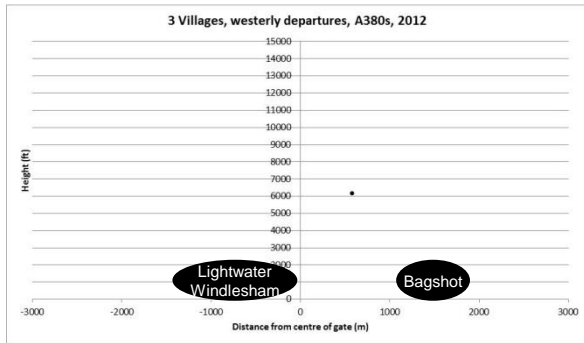
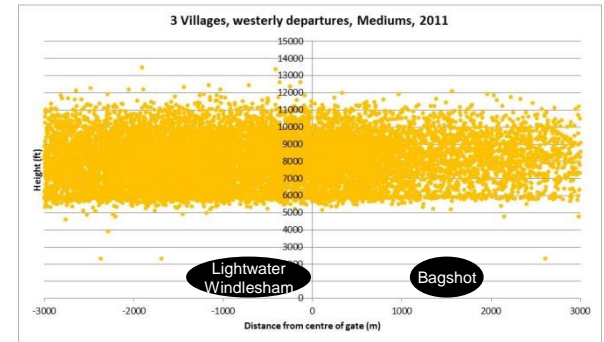
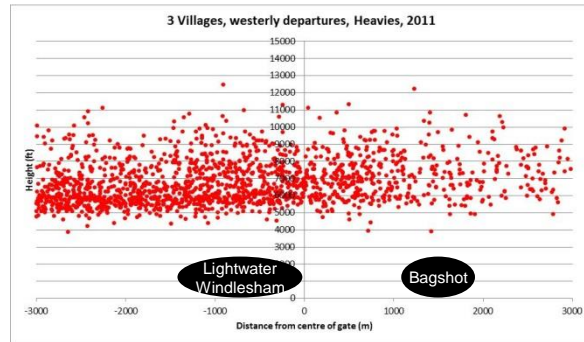
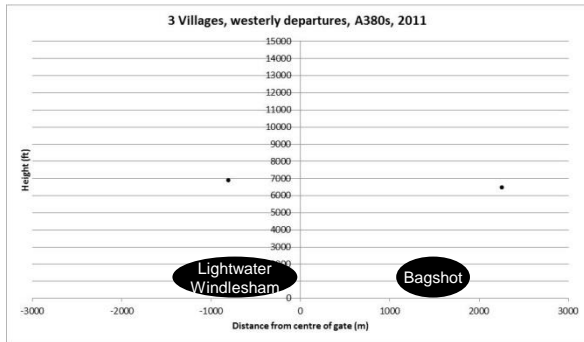
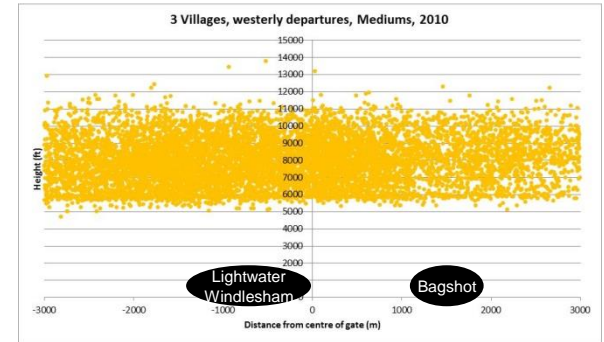
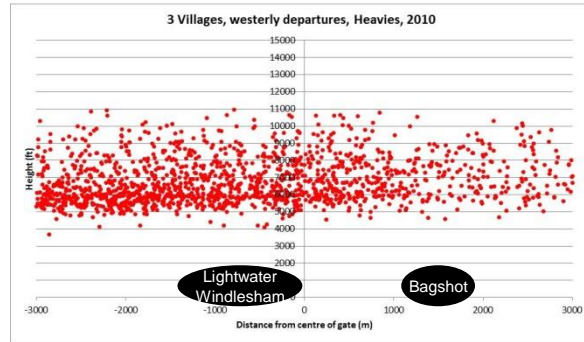
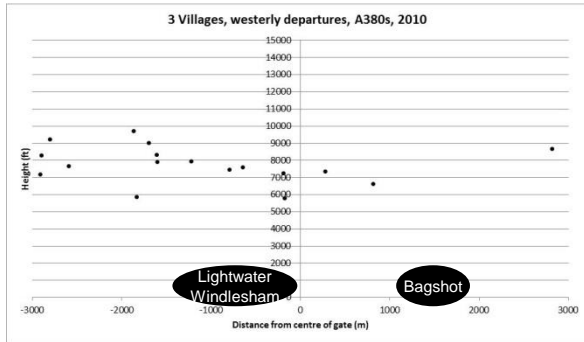
Higher levels of traffic below 5000 feet during trial period than before and afterwards

The underlying traffic mix is nearly 90% medium aircraft and 10% large aircraft, a few of which (<1%) are A380s: this proportion increased during the trials

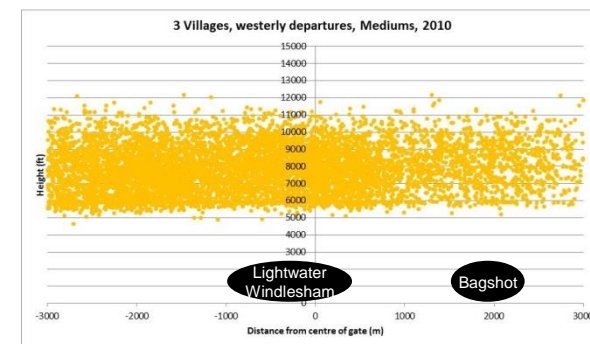
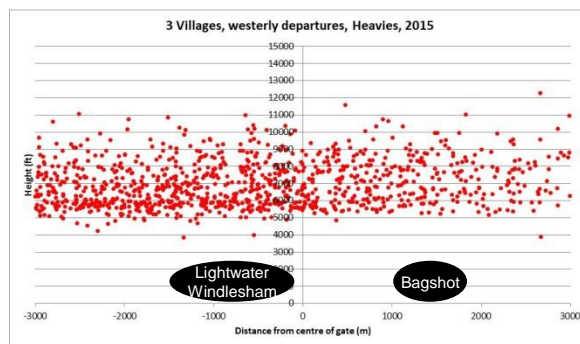
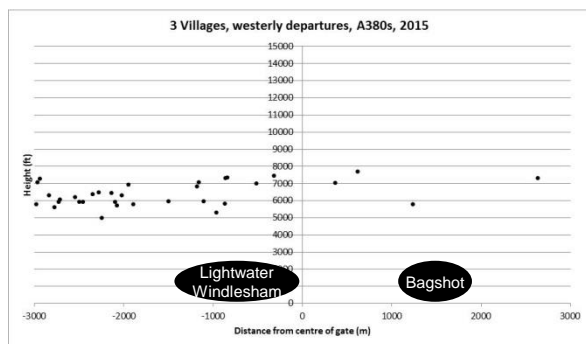
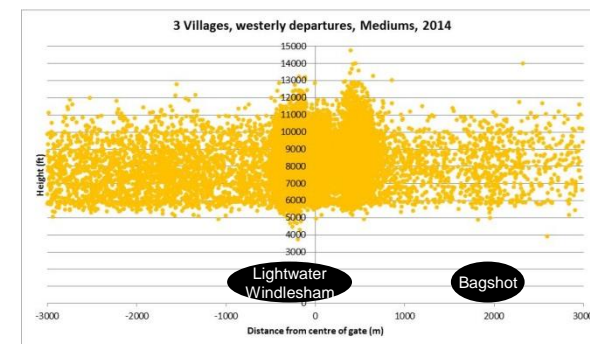
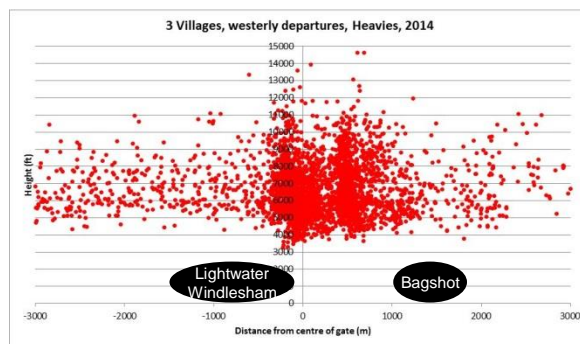
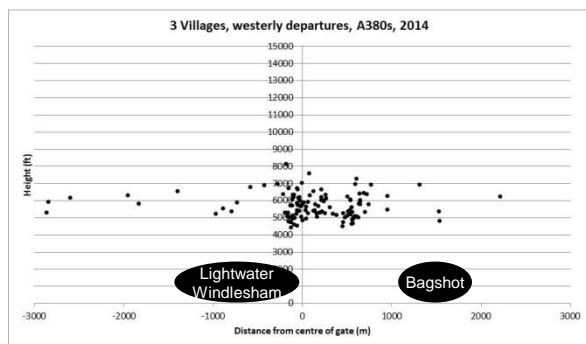
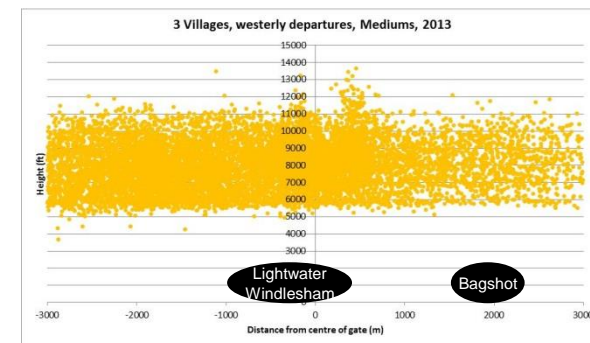
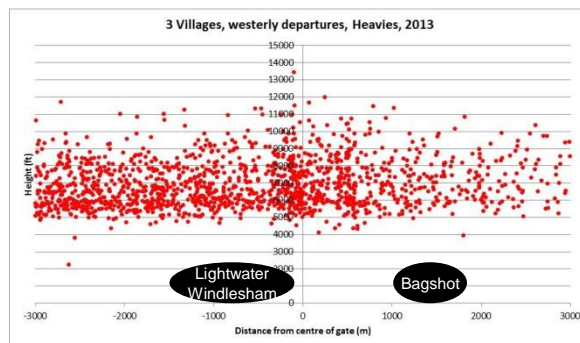
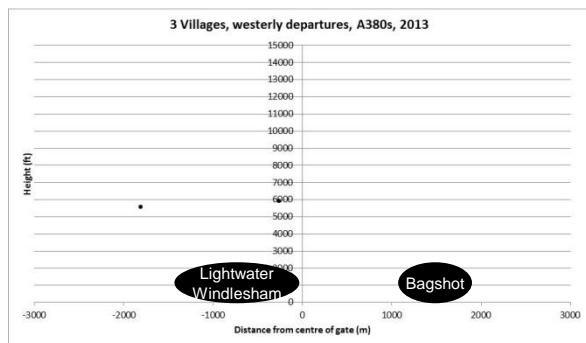


The proportion of medium aircraft in the mix has stayed approximately the same of the analysis period except during the trial period in 2014 when the proportion of medium aircraft decreased slightly to be replaced by heavy aircraft

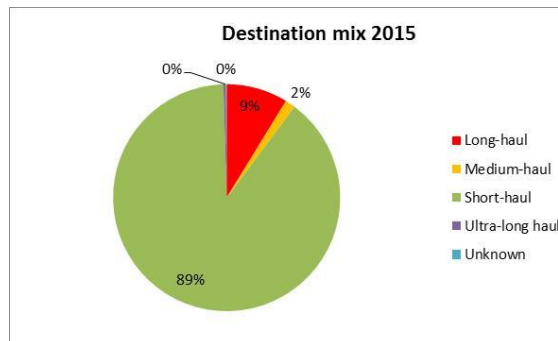
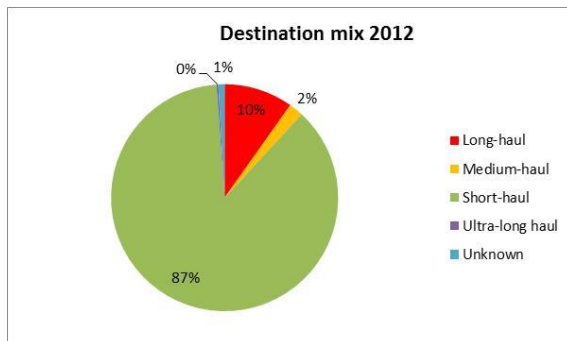
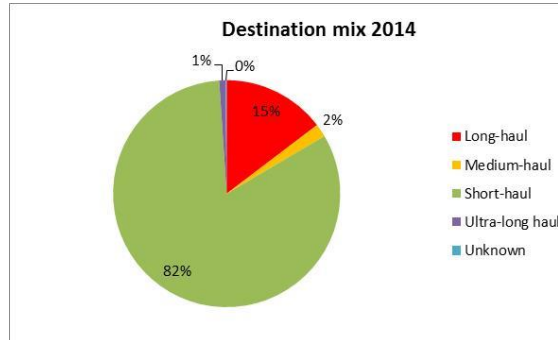
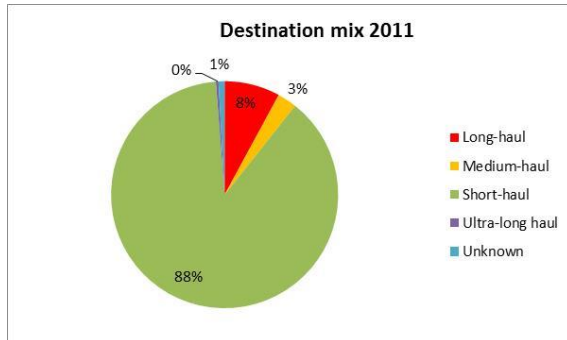
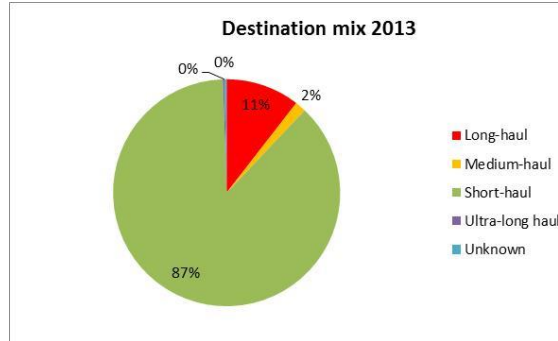
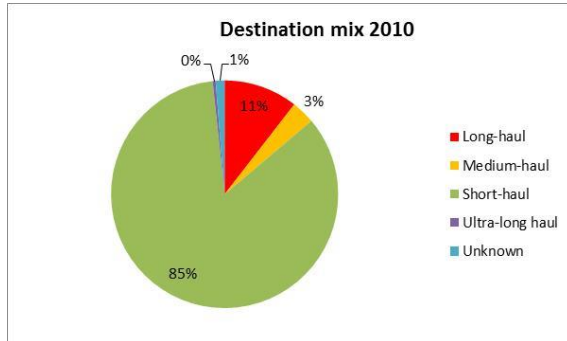
During the period 2010 to 2012, there does not appear to be any bunching of aircraft types



During the trials in 2014, all categories of aircraft are bunched in the trial SIDs at the centre of the gate: afterwards they are more evenly distributed



During the trial period, the proportion of long-haul traffic in the mix increased from its background level of ~11% at other times to 15% and then reverted



Short-haul destinations typically have flights times shorter than three hours

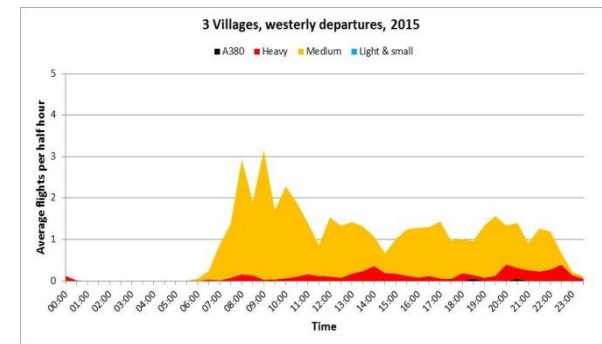
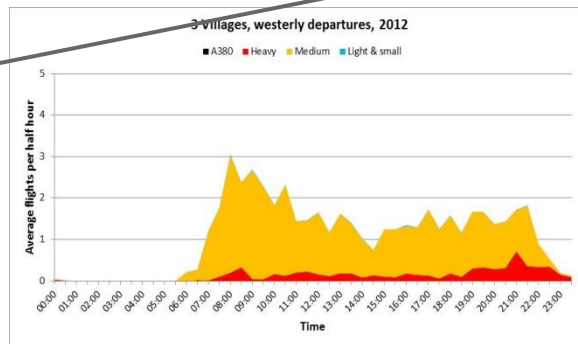
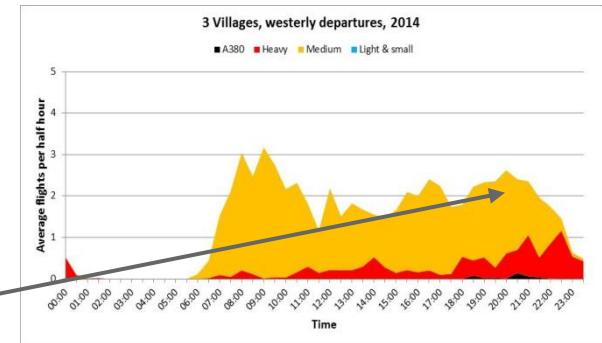
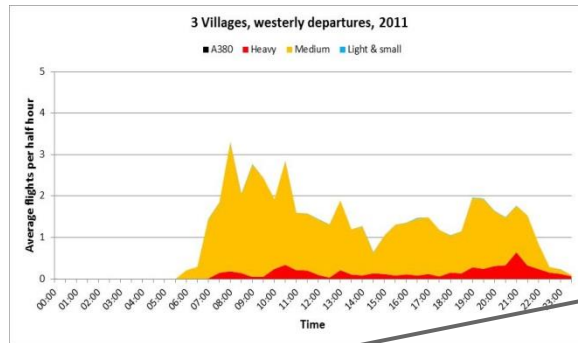
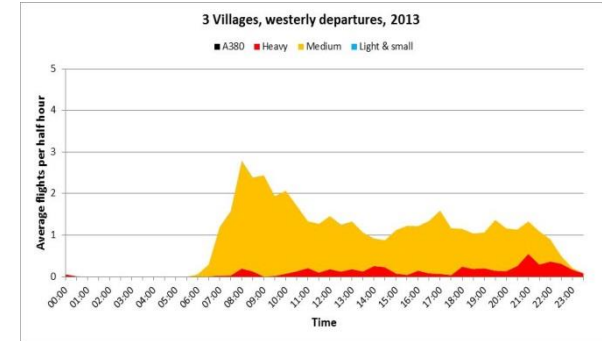
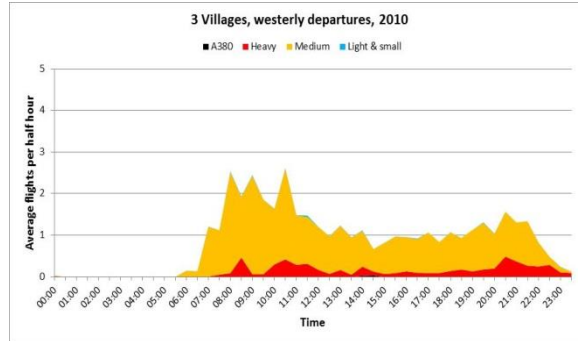
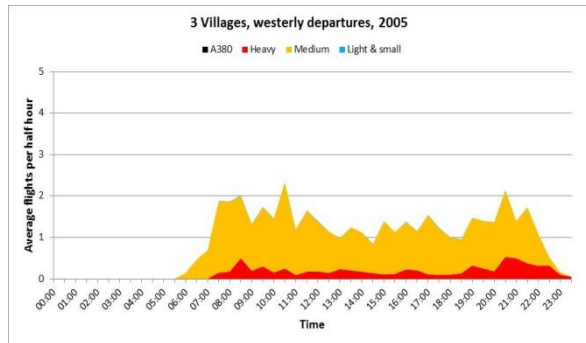
Medium-haul destinations typically have flight times between three and six hours

Long-haul destinations typically have flight times between six nine hours

Ultra long-haul destinations typically have flight times greater than nine hours

Destinations marked as “unknown” do not have a recognised airport code associated with the flight in the data used for analysis

# The main traffic peak for departures is in the morning but during the trials the evening peak increased along with the proportion of heavy aircraft



Increased evening traffic peak compared to most other years, with higher proportion of heavy aircraft



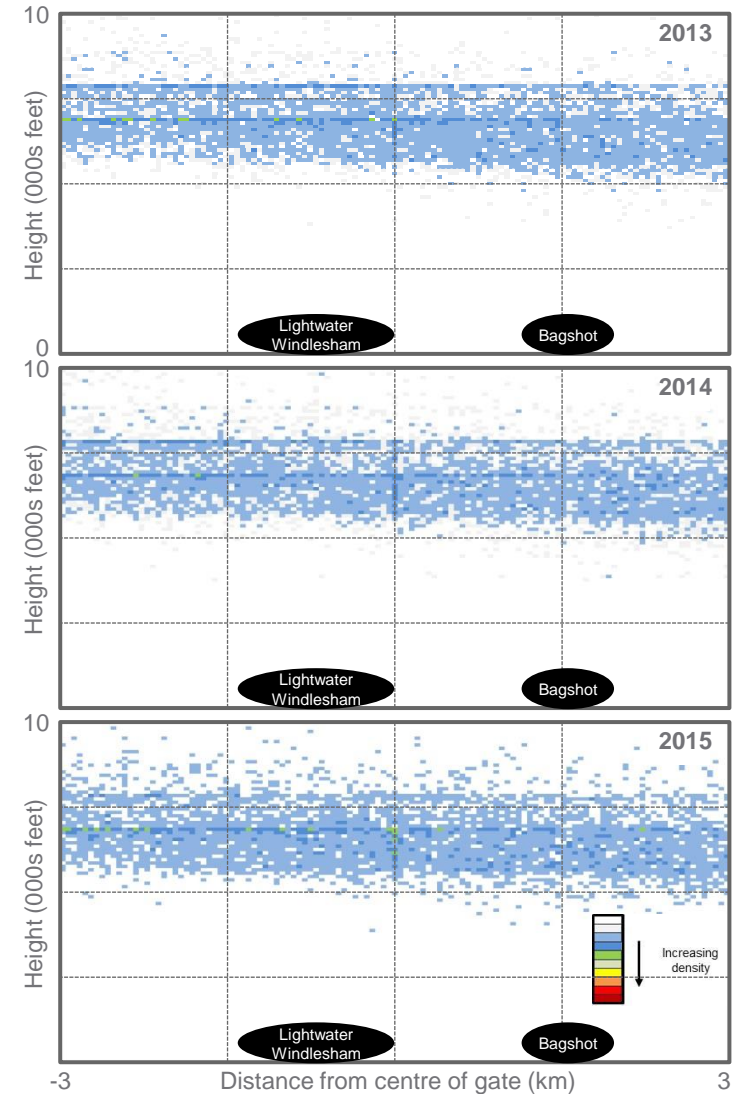
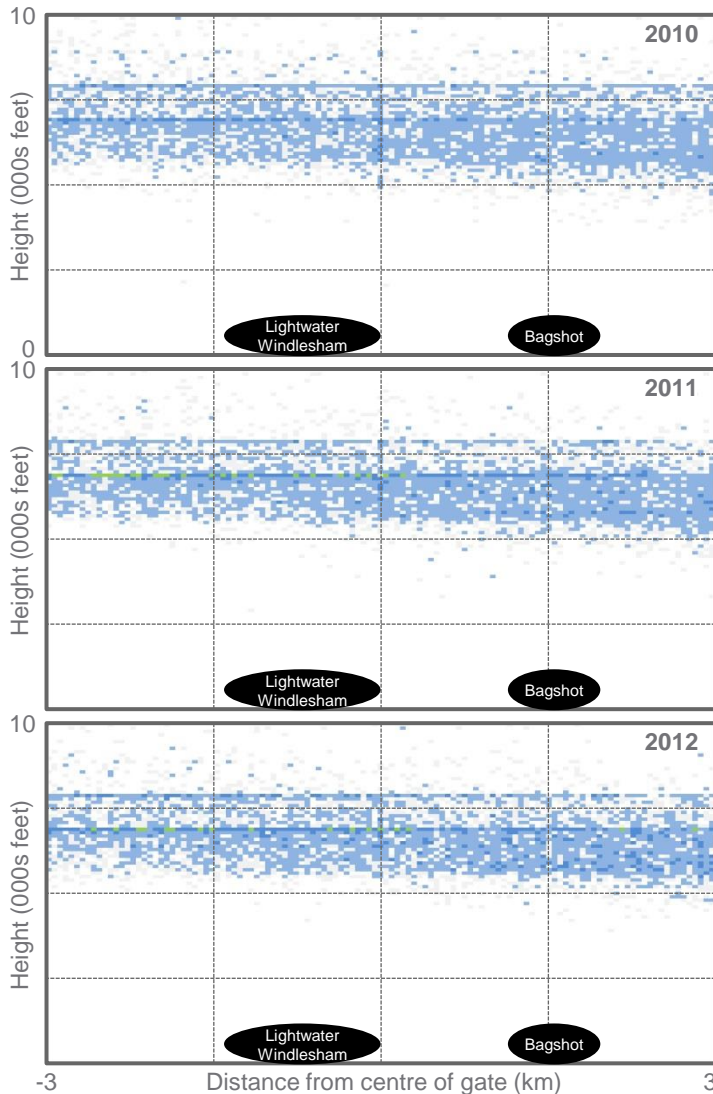
# EASTERLY ARRIVALS

---

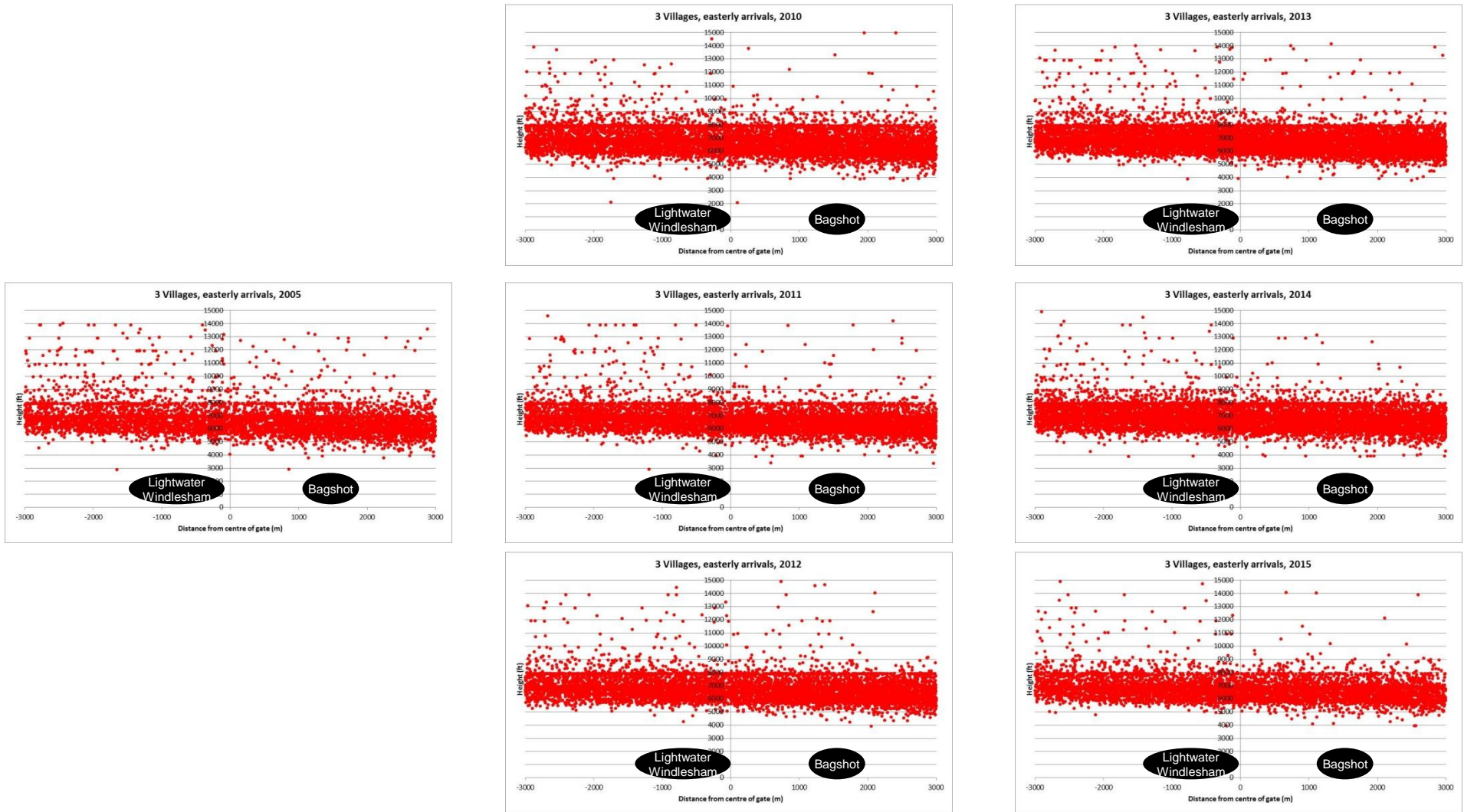
# 6



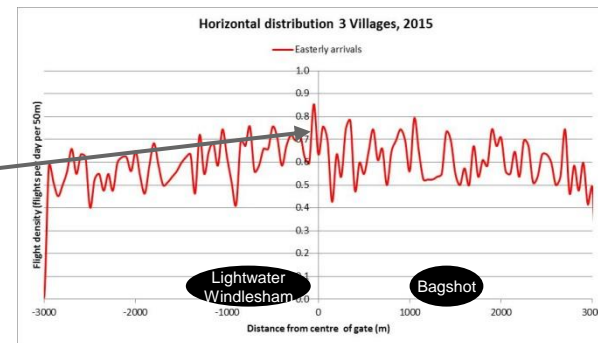
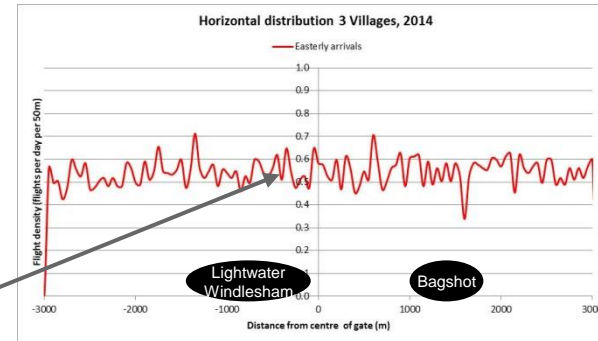
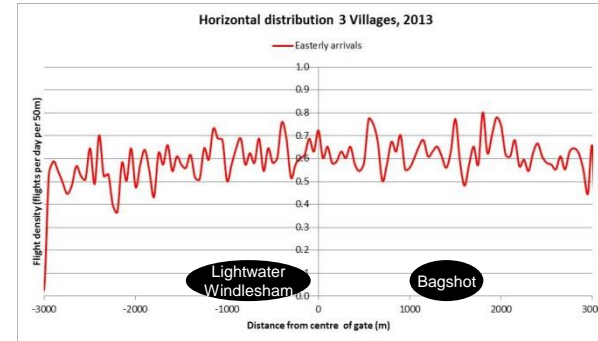
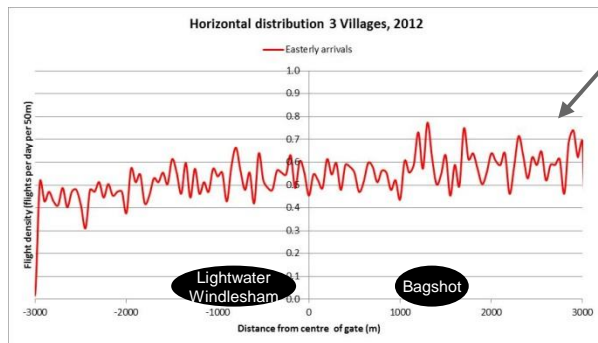
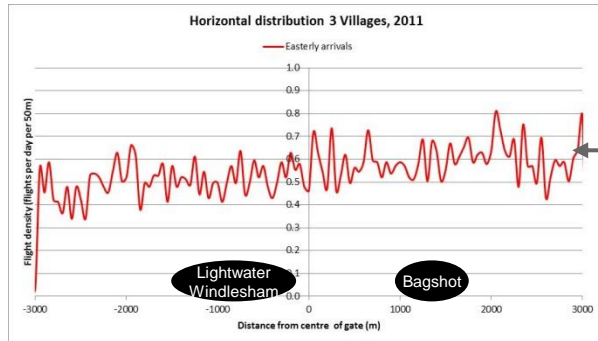
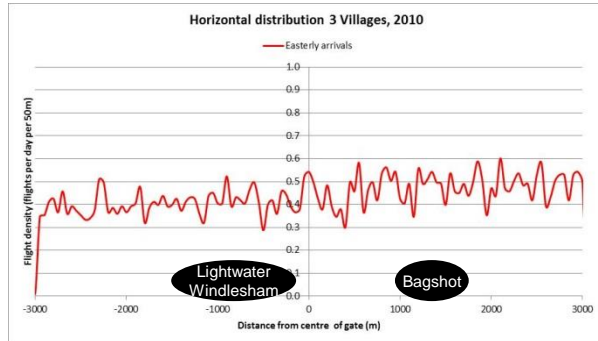
The intensity of easterly arrivals are broadly distributed across the gate but at lower heights towards the north western end (right hand side)



# Scatter plots for easterly arrivals crossing the gate show little variation across the years



# Horizontal traffic distributions for 2010 to 2012 show slightly increasing intensity to the right hand side whereas the 2015 distribution peaks slightly in the centre

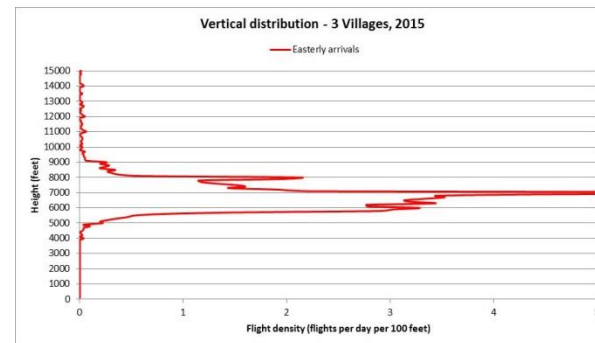
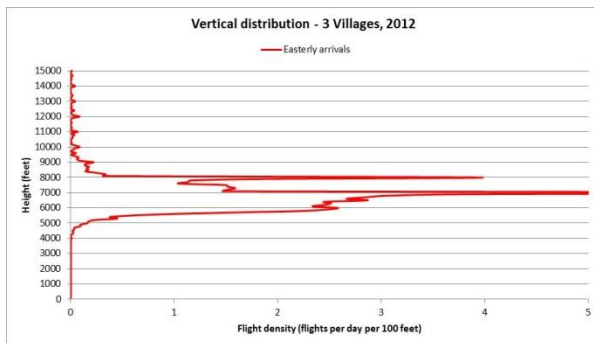
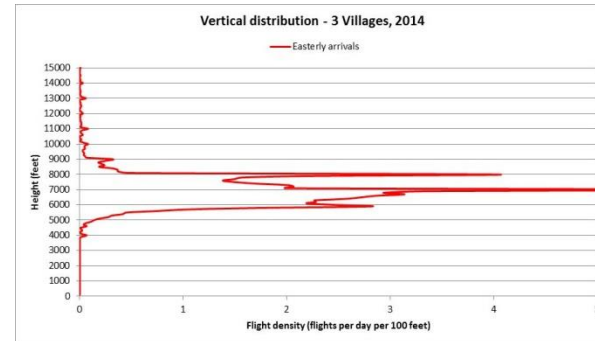
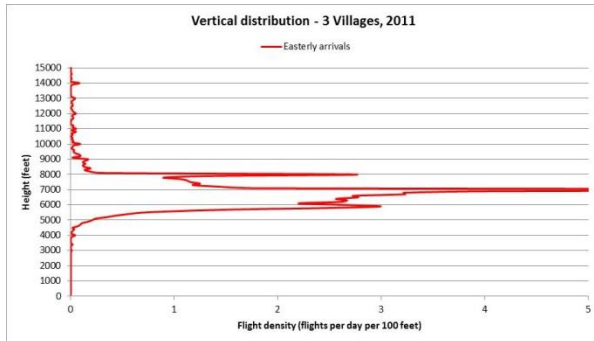
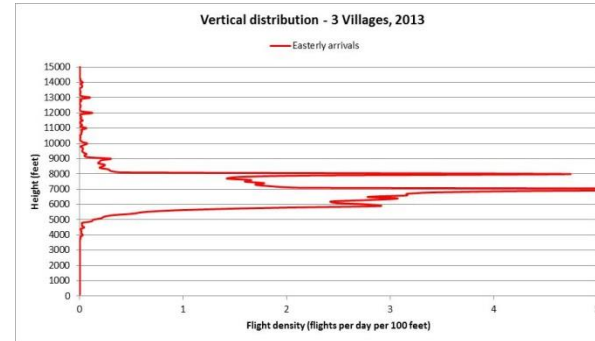
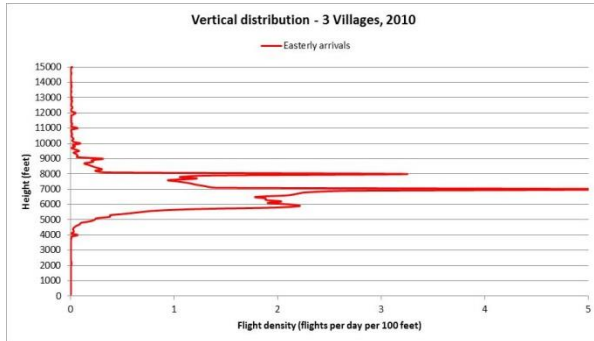


Upward slop to the right hand side for 2010 to 2012

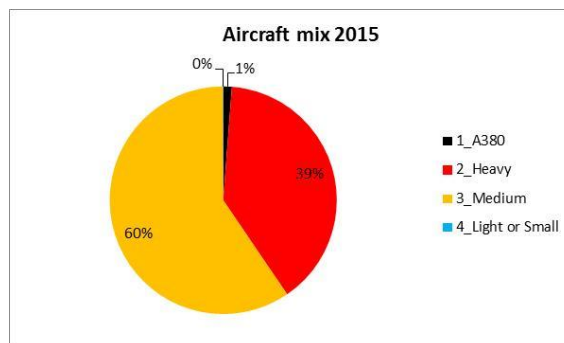
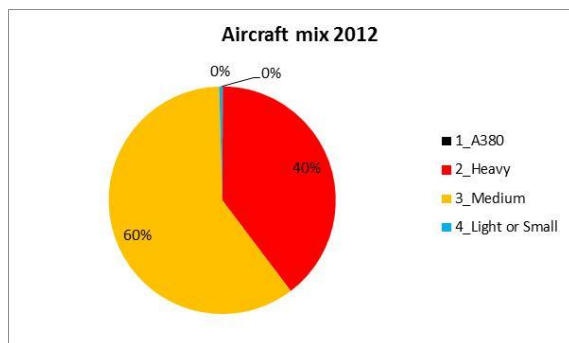
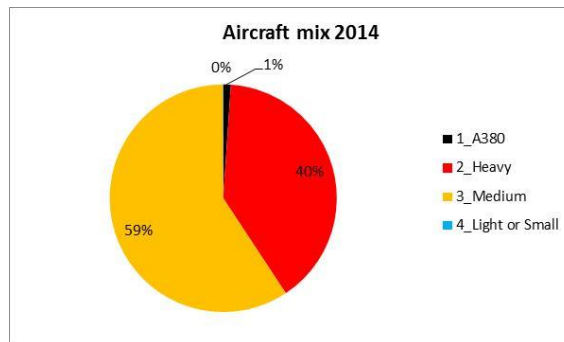
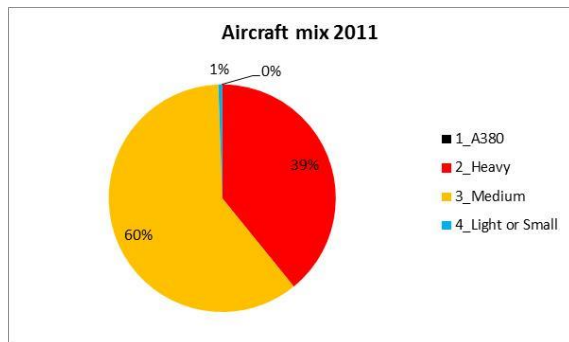
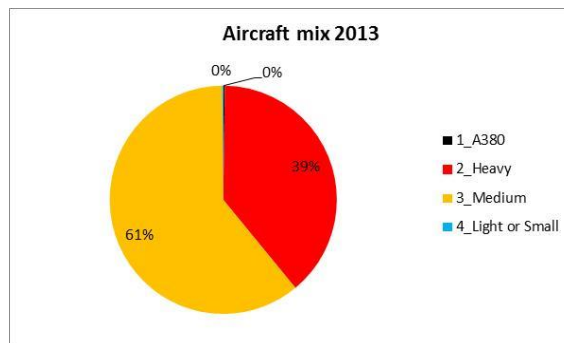
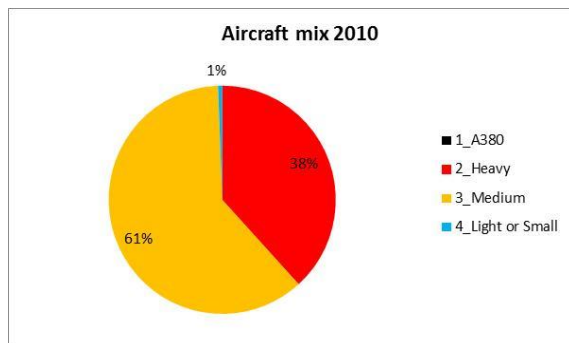
Flatter distribution for 2014

Slight peak in the centre in 2015

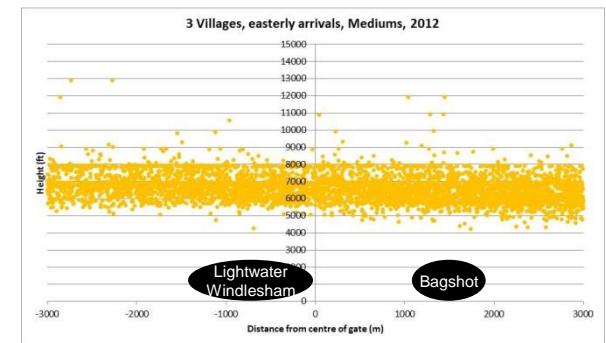
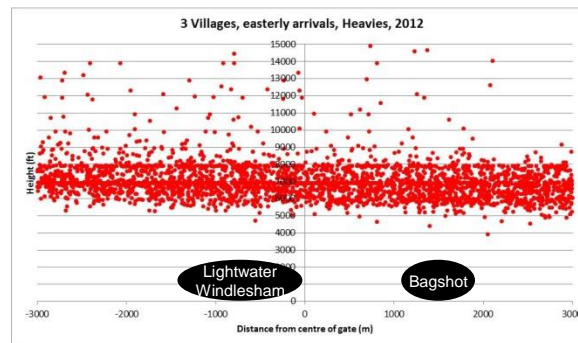
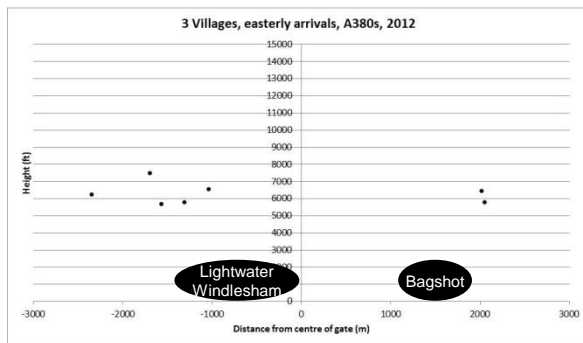
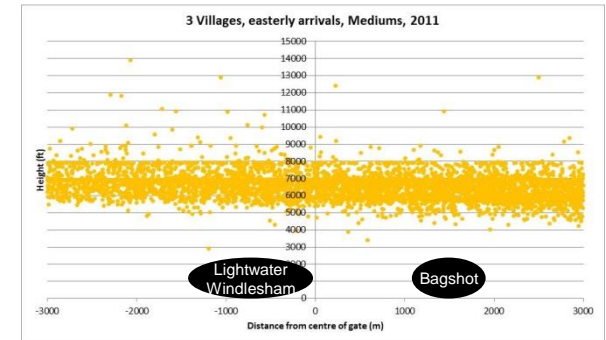
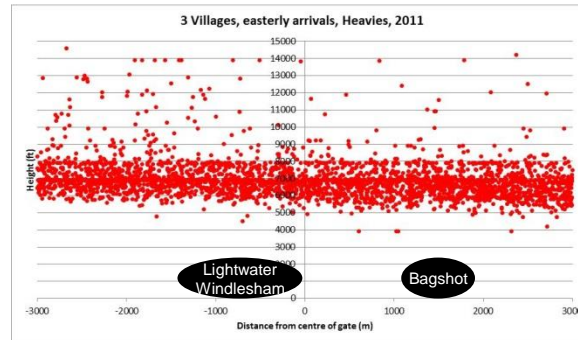
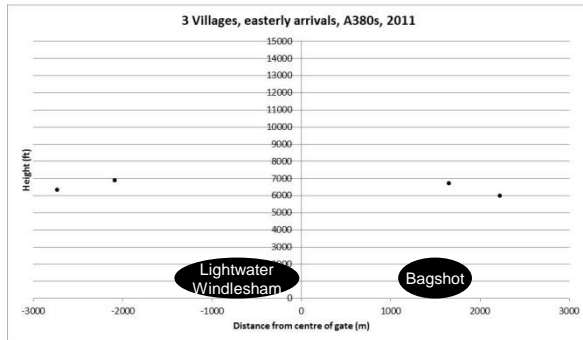
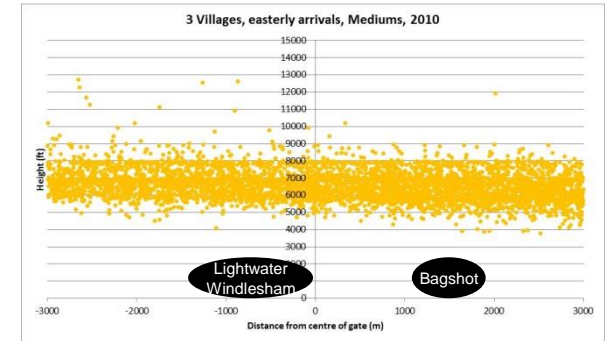
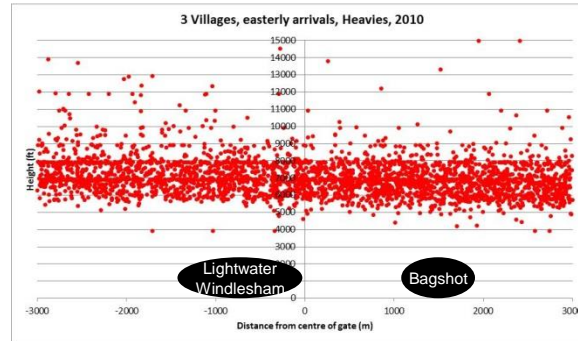
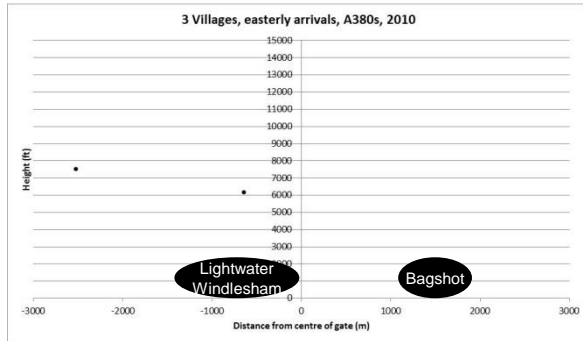
# There is little variation in the vertical distributions for easterly arrival traffic



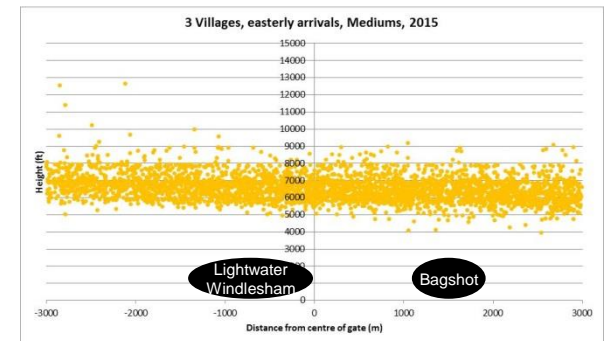
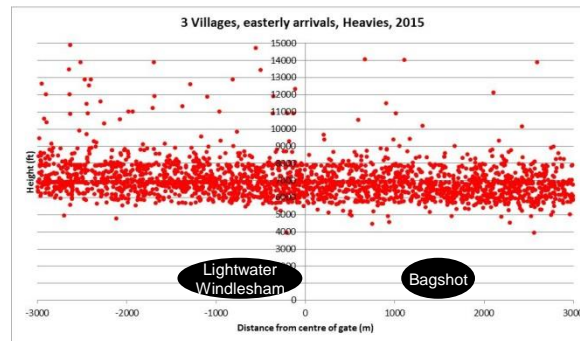
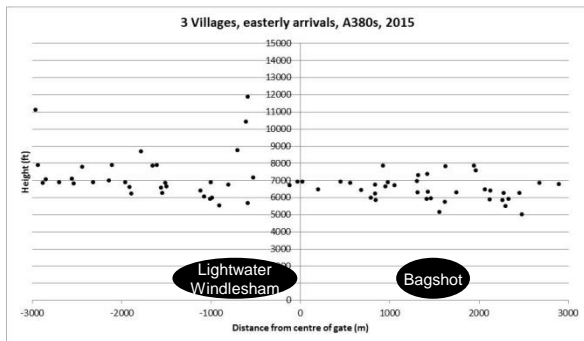
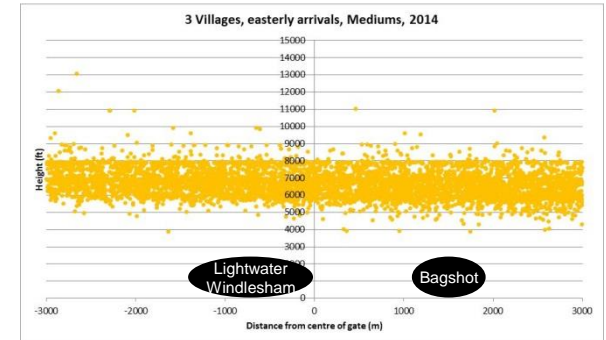
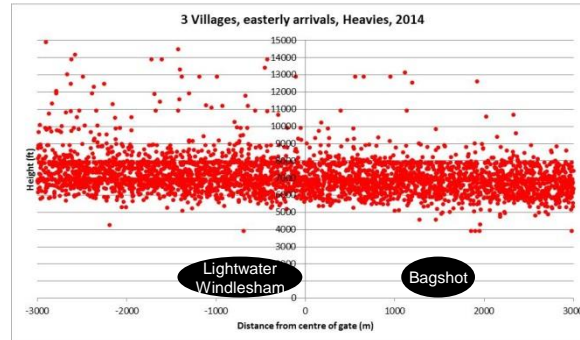
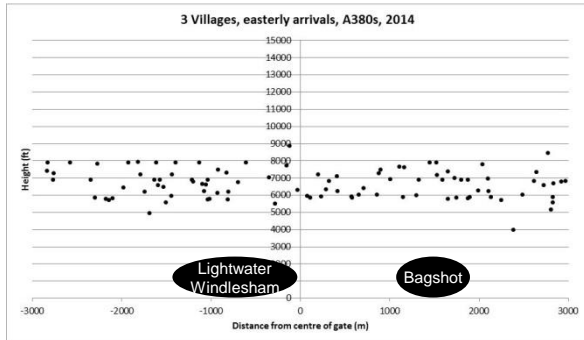
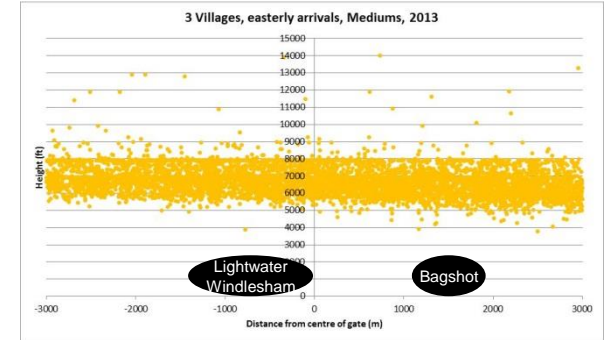
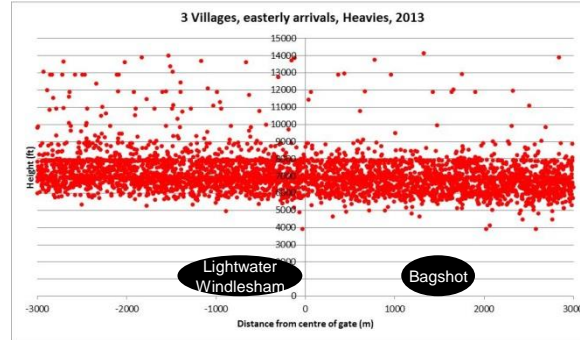
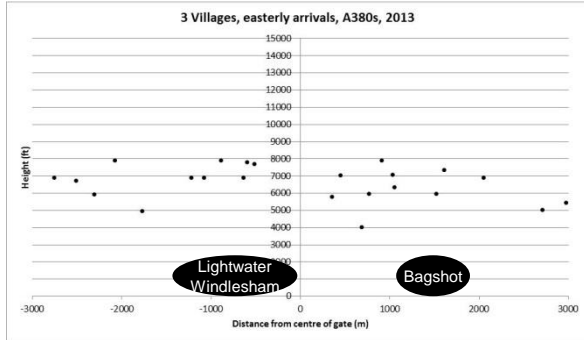
The proportion of large aircraft in the easterly arrival fleet has remained consistent at approximately 40%, with A380s making up 1% and the remainder being medium



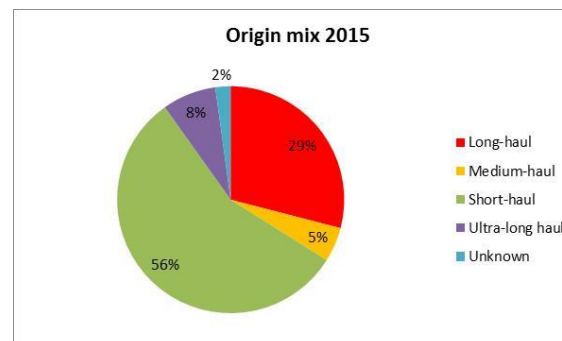
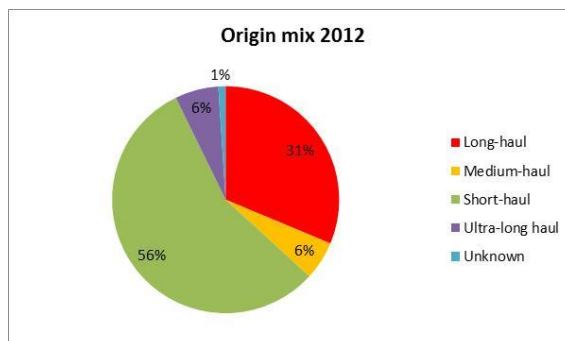
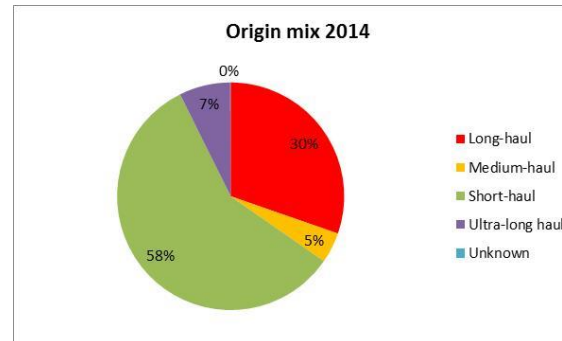
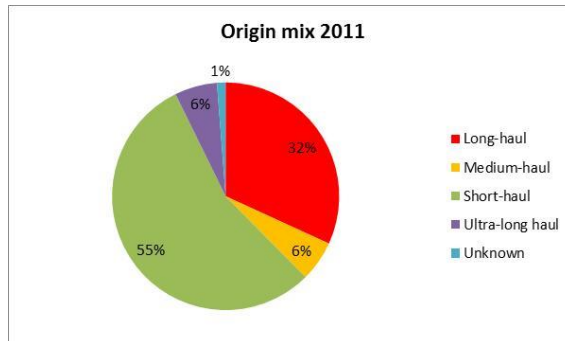
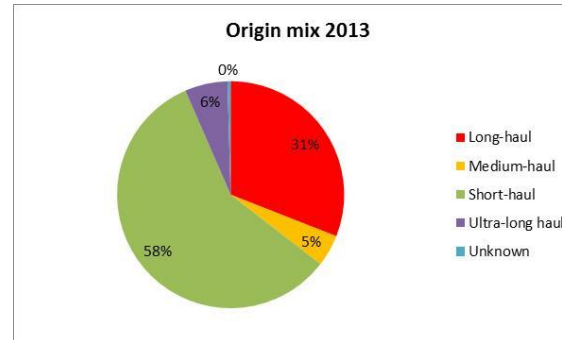
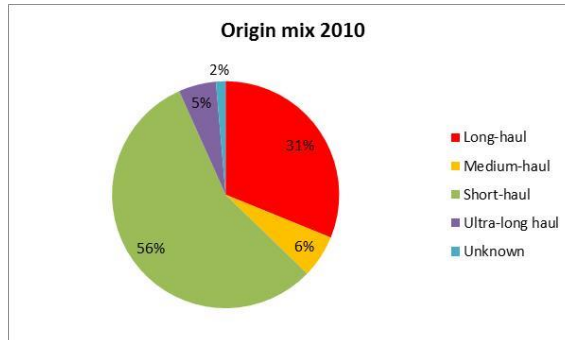
# Easterly arrivals do not appear to be bunched by size of aircraft from 2010 to 2012



# There also does not appear to be any bunching by aircraft size from 2013 to 2015



## The proportion of ultra long- and long-haul origins for easterly arrival traffic has remained consistent at approximately 38% of the total



Short-haul origins typically have flight times shorter than three hours

Medium-haul origins typically have flight times between three and six hours

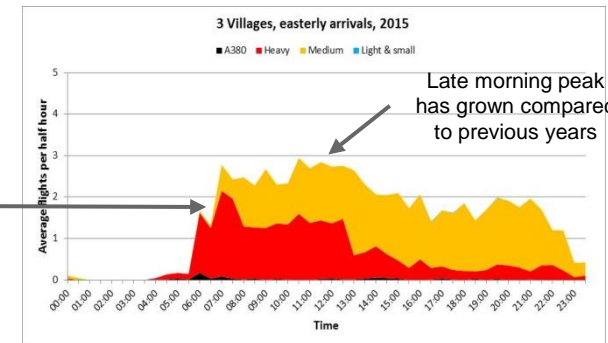
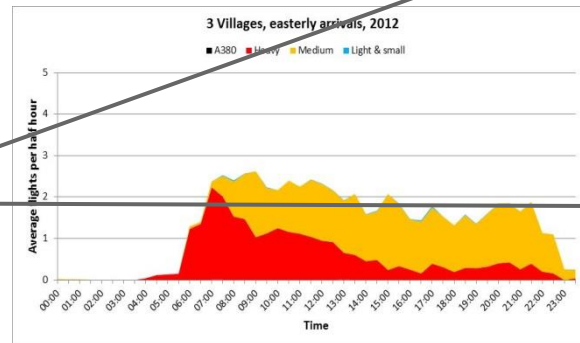
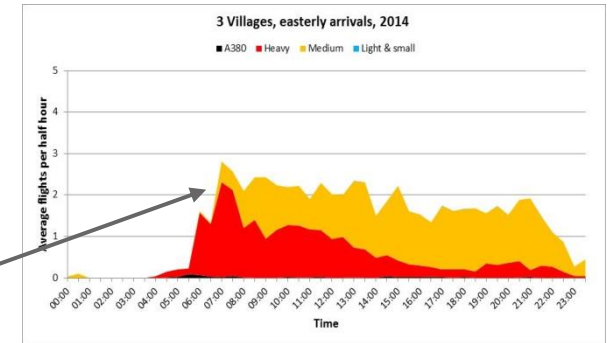
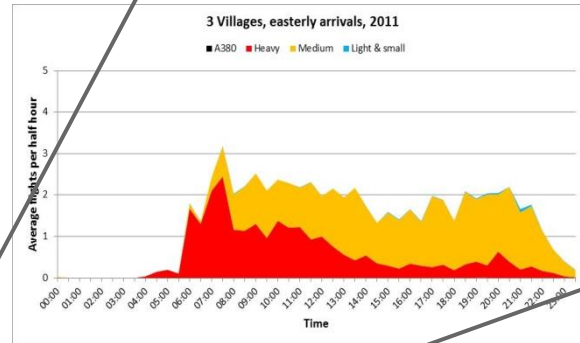
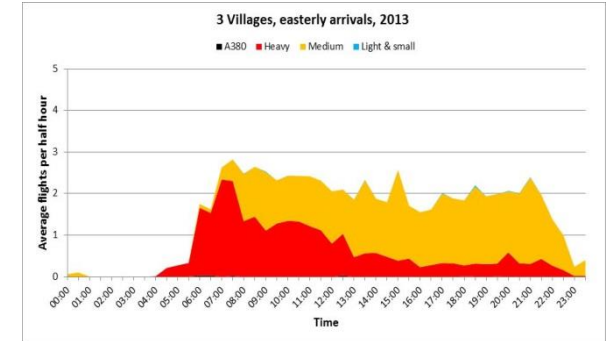
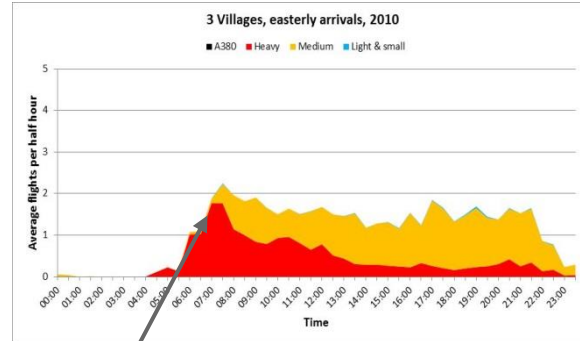
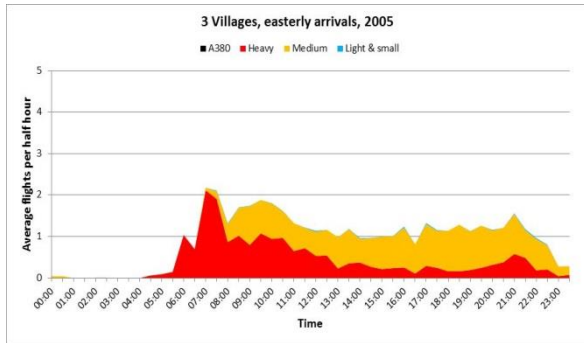
Long-haul origins typically have flight times between six and nine hours

Ultra long-haul origins typically have flight times greater than nine hours

Origins marked as “unknown” do not have a recognised airport code associated with the flight in the data used for analysis



# Arrival traffic is spread across the day with a morning peak of heavy aircraft between 06:00 and 08:00. The mid-day peak has grown in 2015



Early morning peak has a consistently high proportion of heavy aircraft

Late morning peak has grown compared to previous years

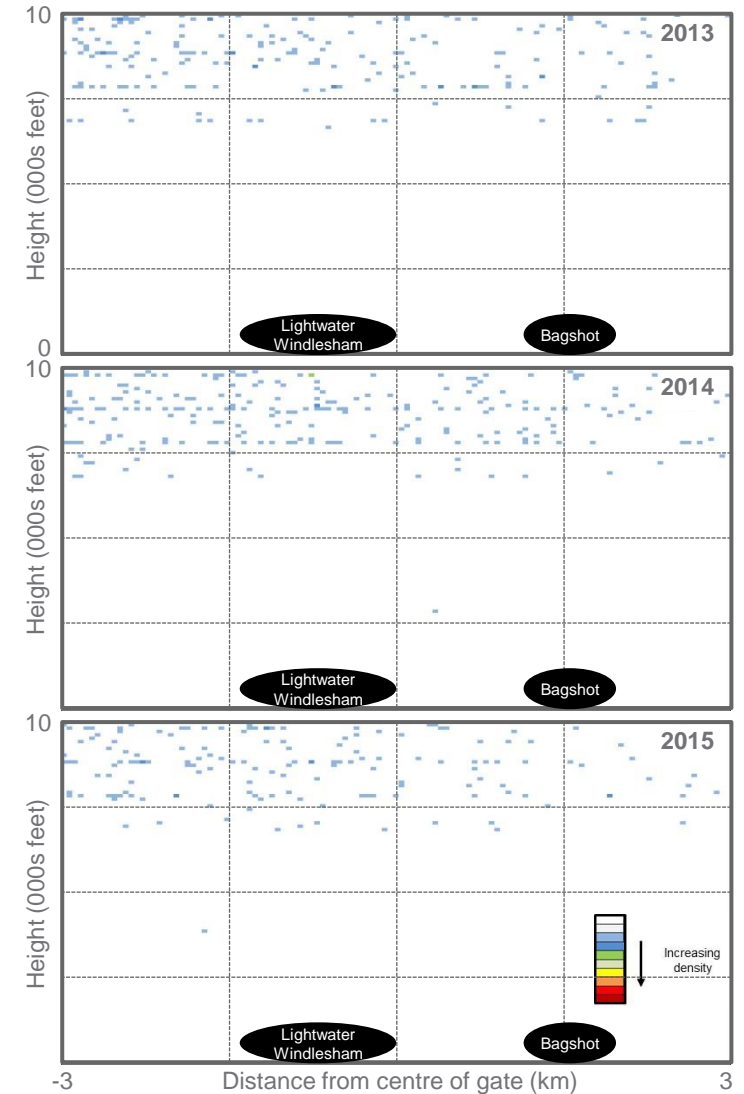
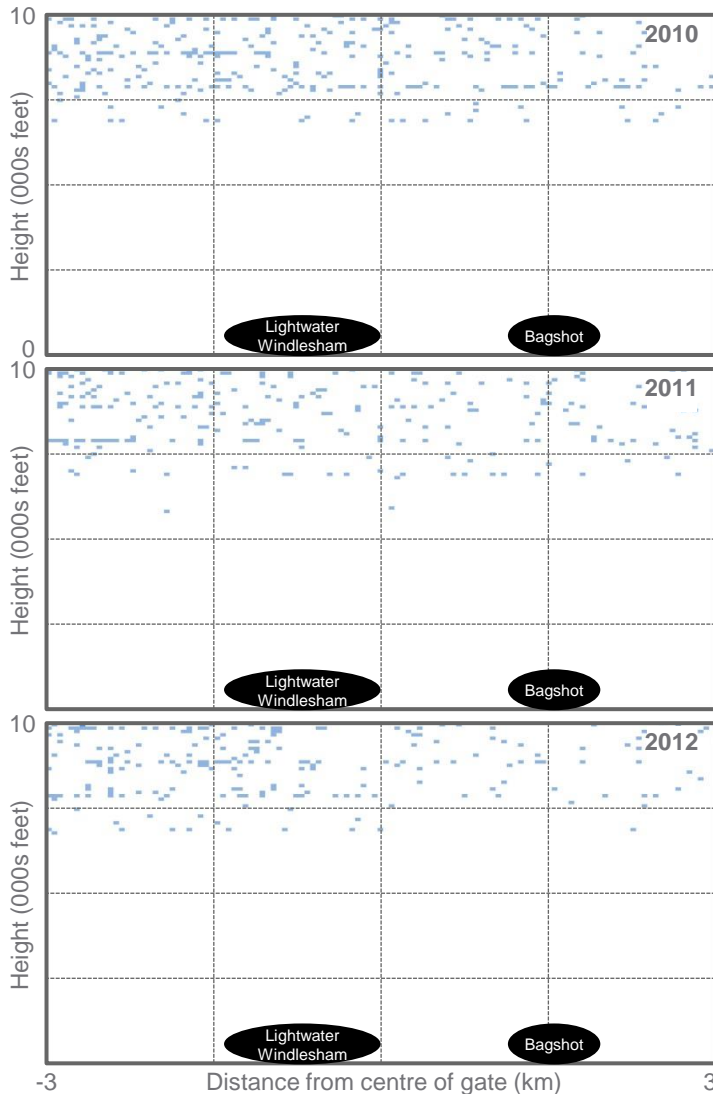


# WESTERLY ARRIVALS

---

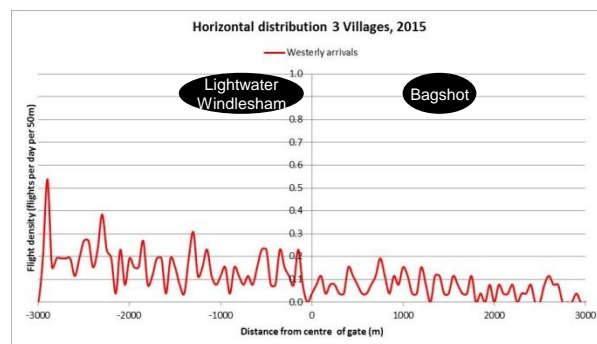
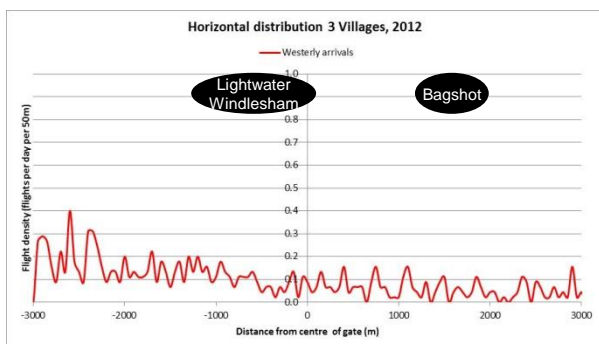
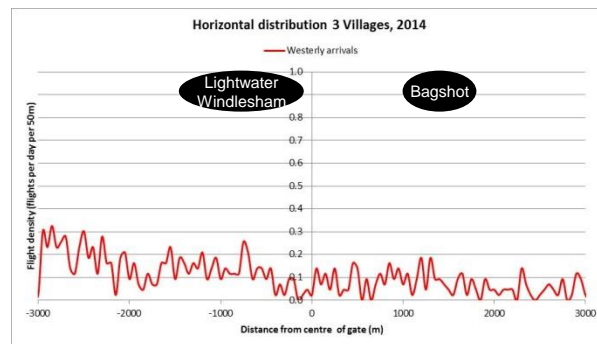
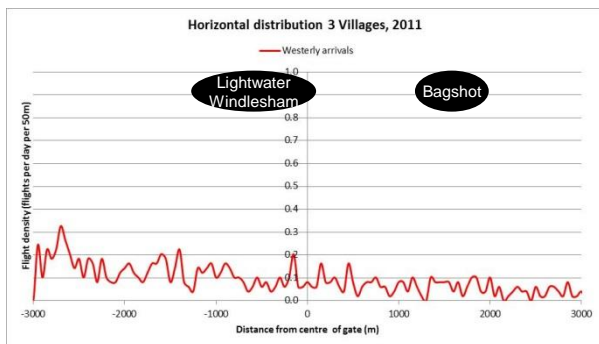
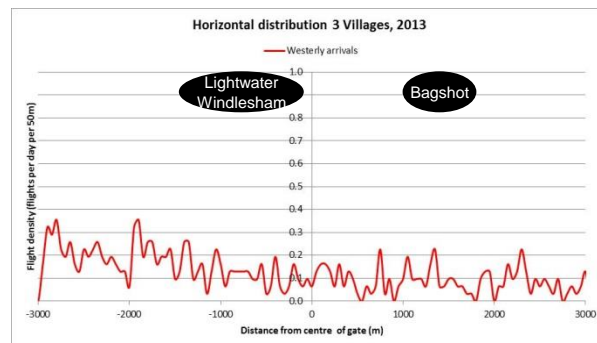
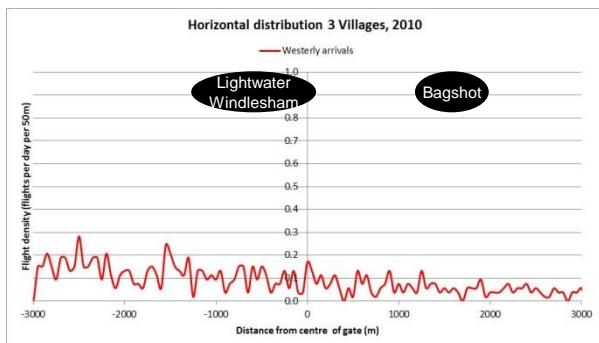
# 7

# Westerly arrival patterns are of low intensity and randomly distributed across the gate

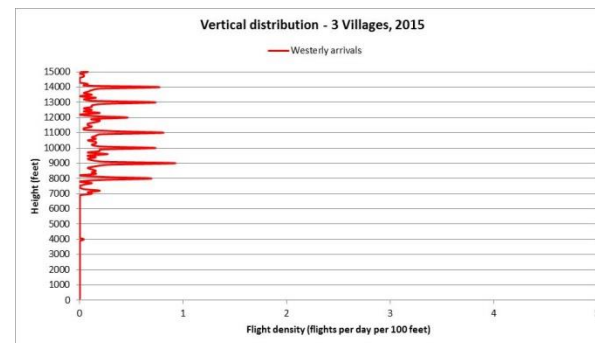
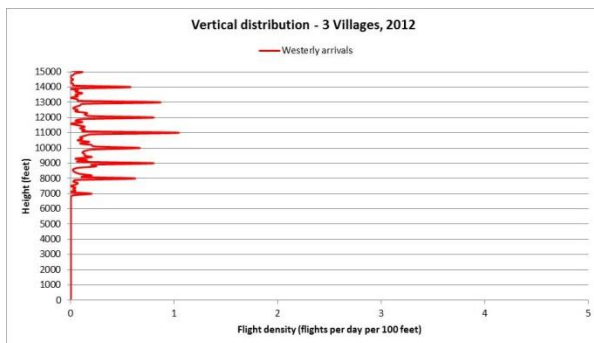
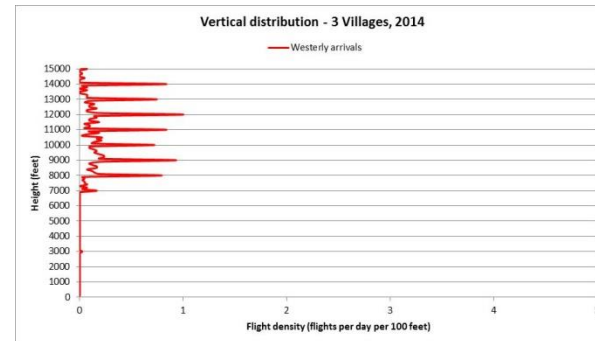
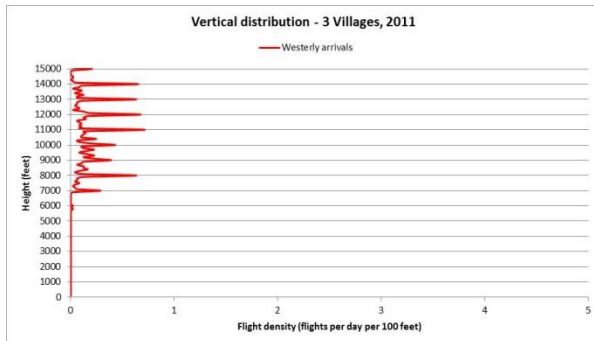
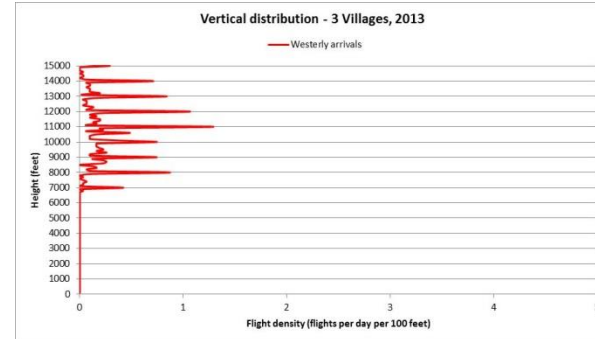
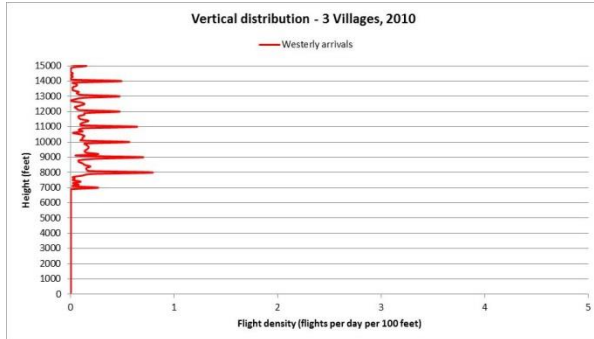




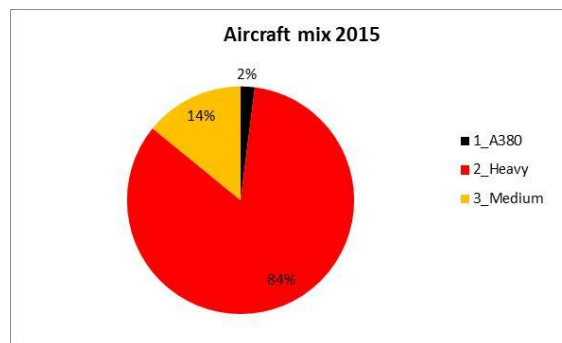
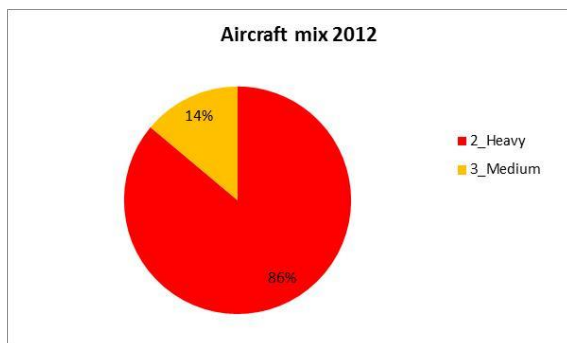
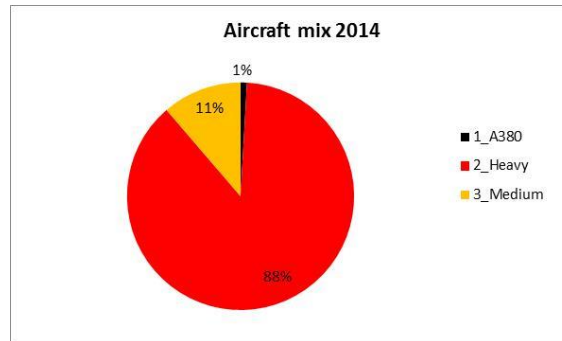
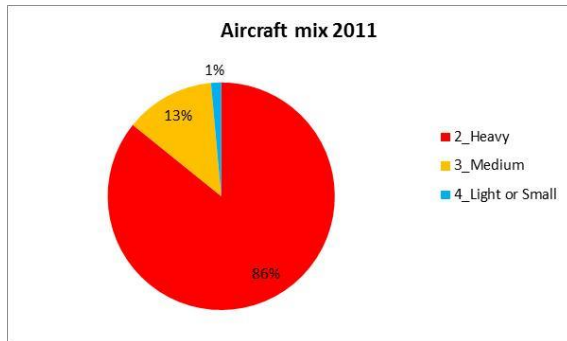
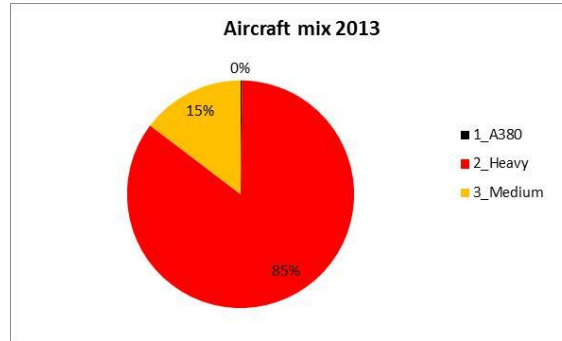
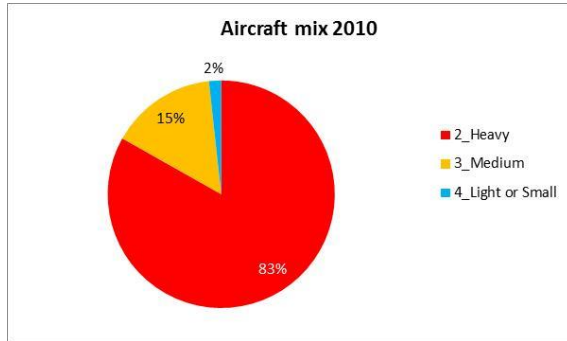
# Lateral distributions show a random distribution across the gate but with higher intensity towards the left hand (south eastern) side



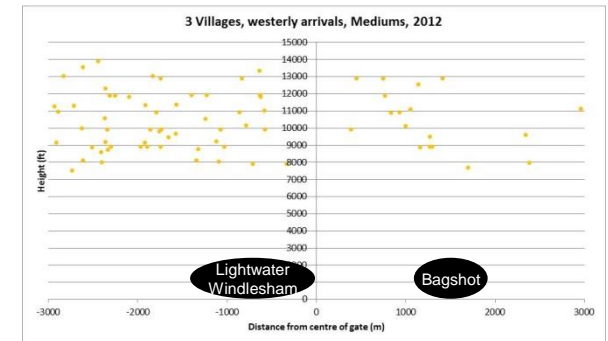
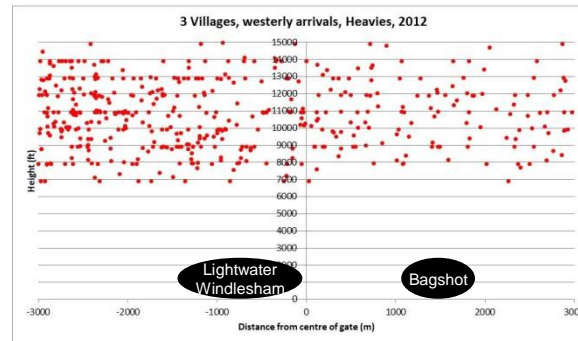
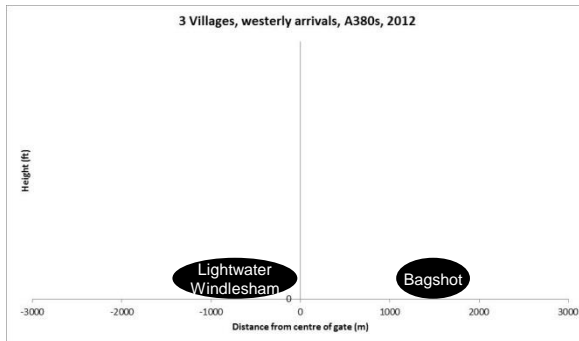
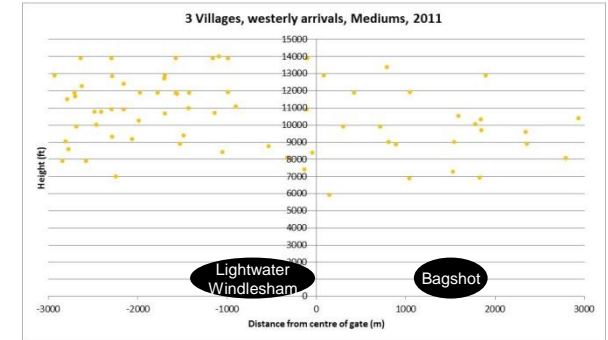
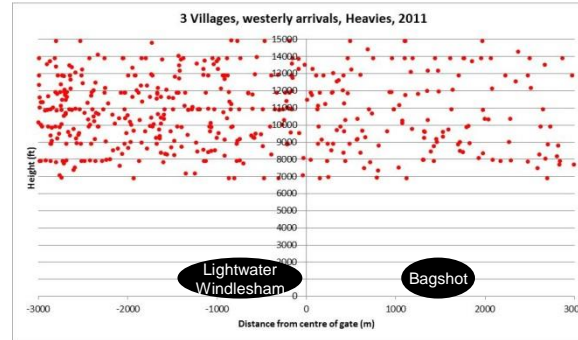
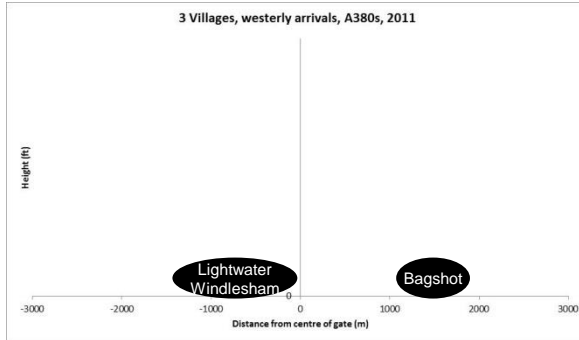
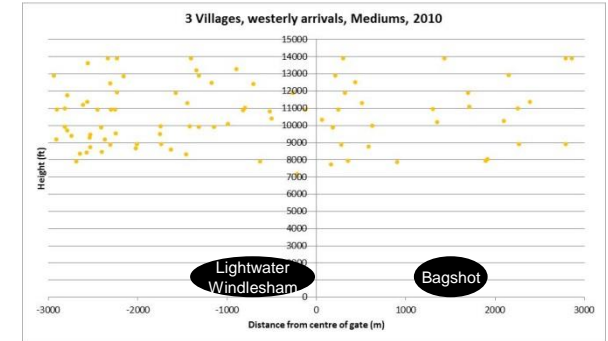
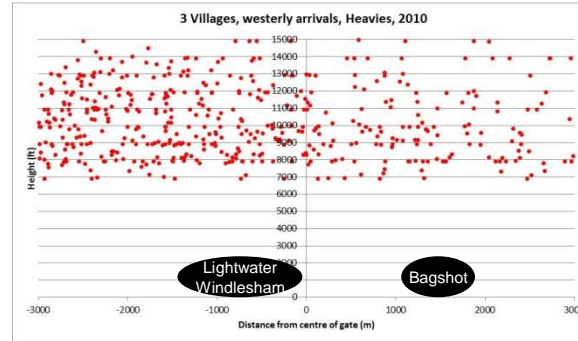
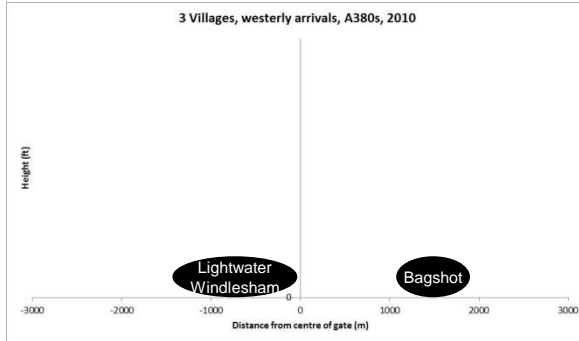
# Vertical distributions show the traffic is ordered at the stack flight levels



# The traffic mix is consistent at approximately 85% large aircraft, including 2% A380s, and 15% medium aircraft

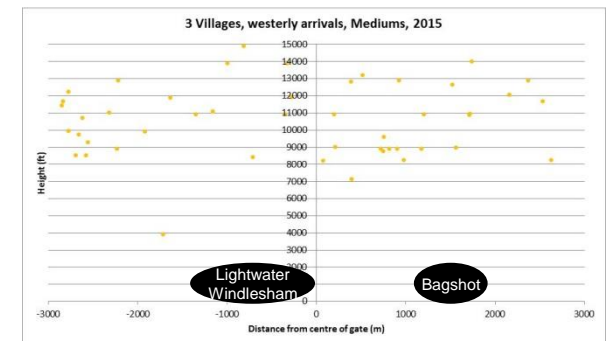
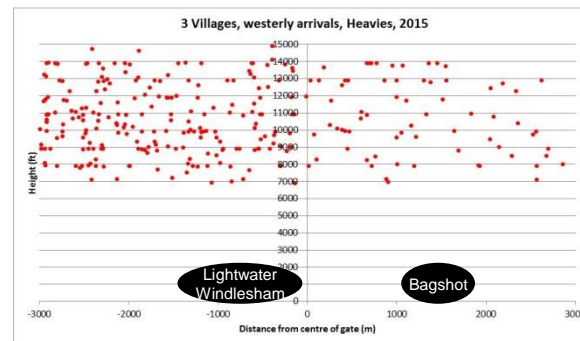
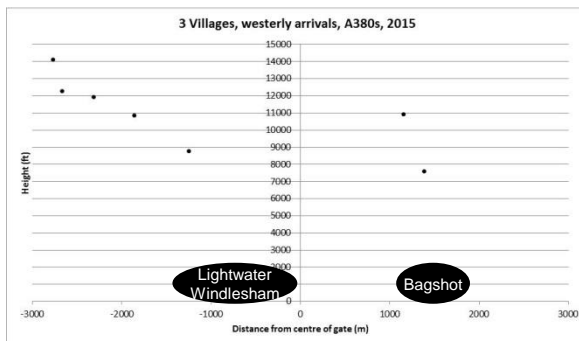
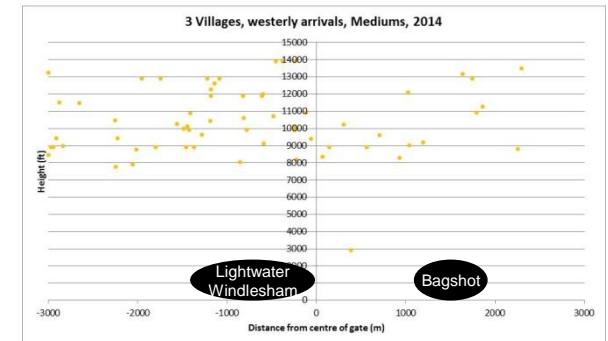
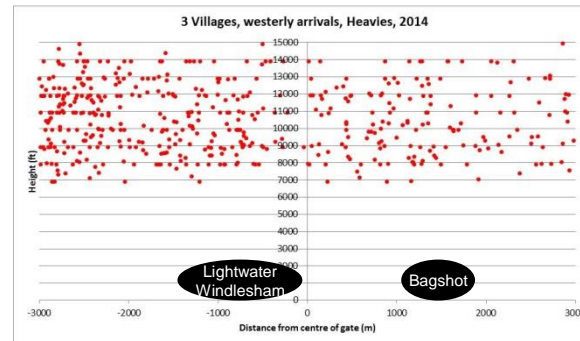
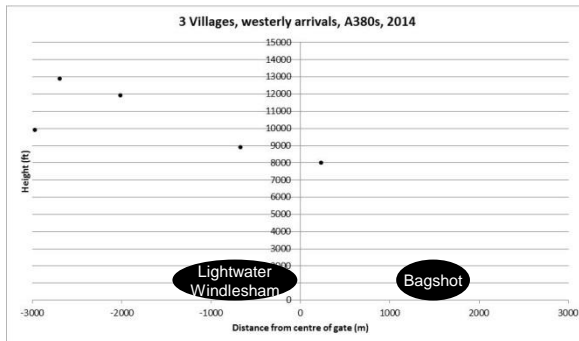
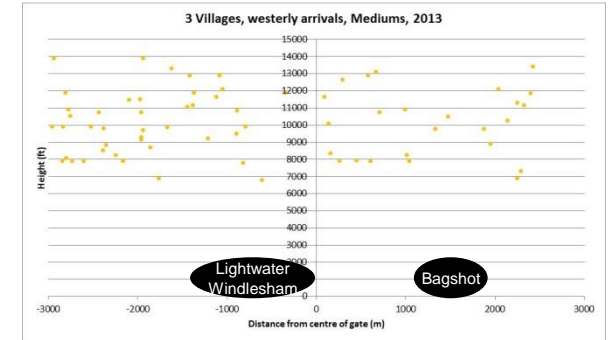
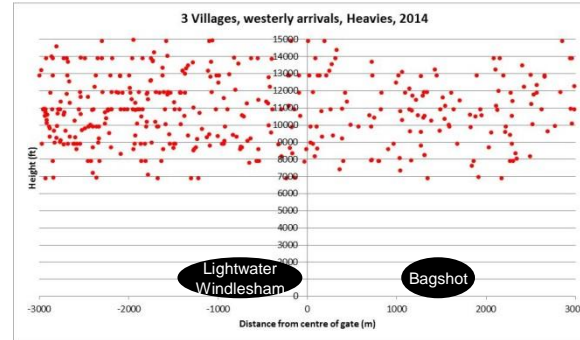
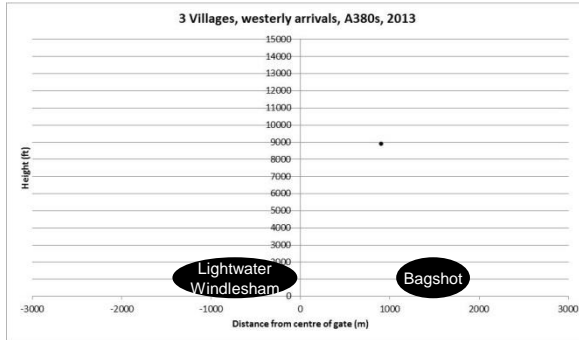


From 2010 to 2012 the distribution of the individual aircraft categories is similar to the overall distribution: there is no bunching by aircraft type

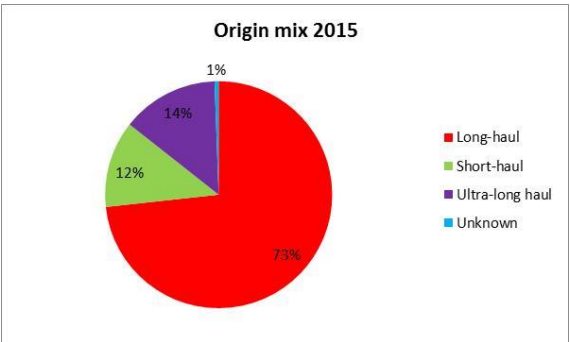
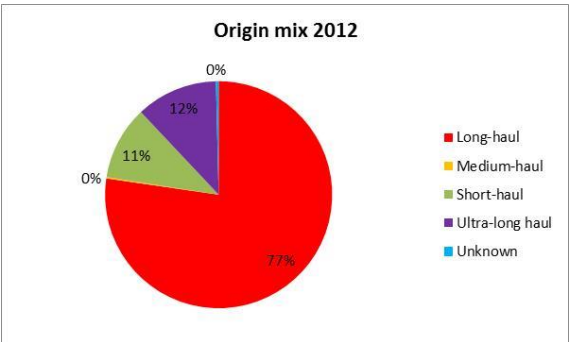
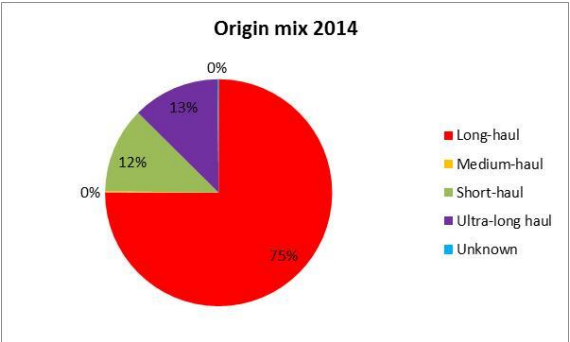
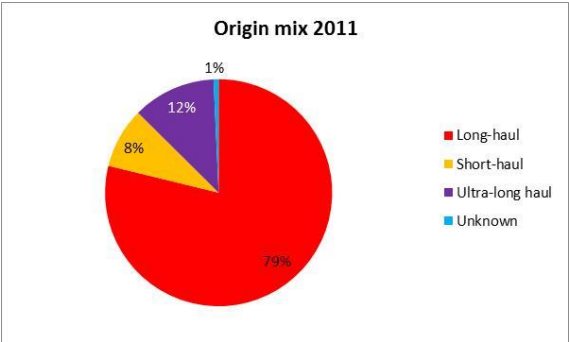
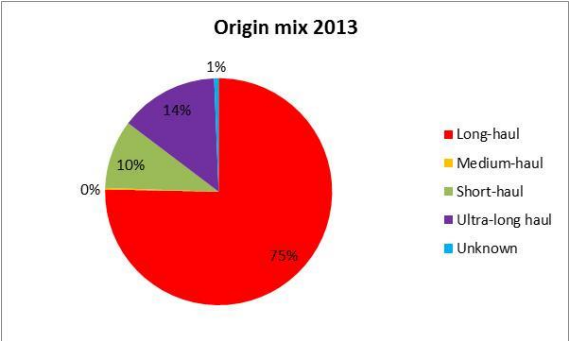
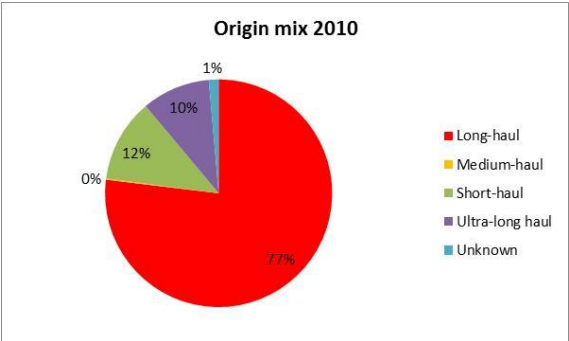




# Similarly there does not appear to be any bunching by aircraft type from 2013 to 2015



# Westerly inbound traffic is predominantly (~87% to 88%) arriving from ultra long and long-haul origins



Short-haul origins typically have flight times shorter than three hours

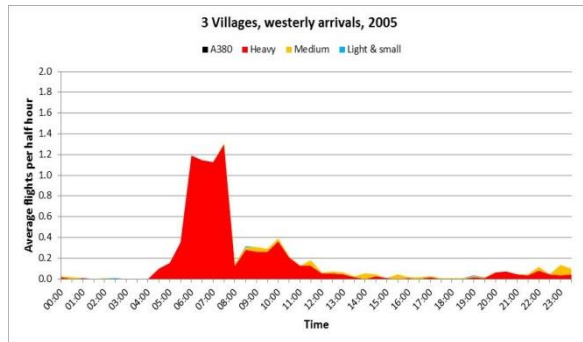
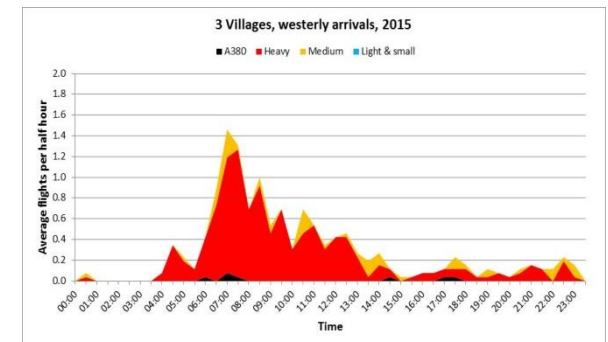
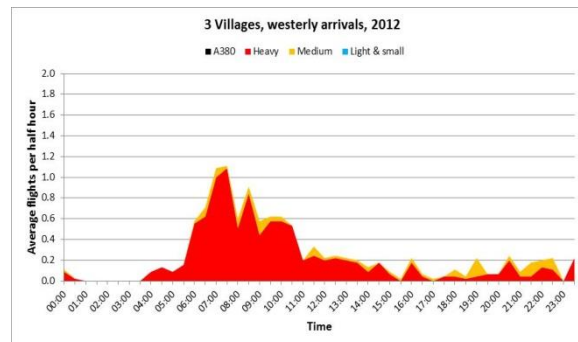
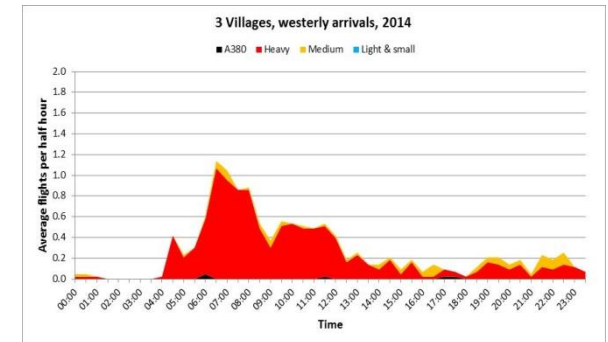
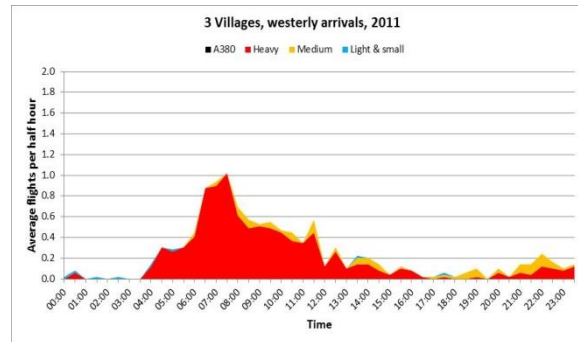
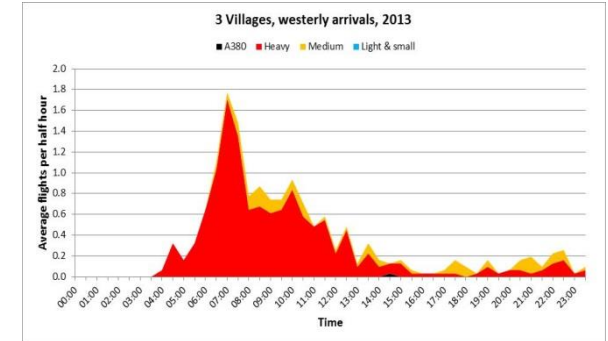
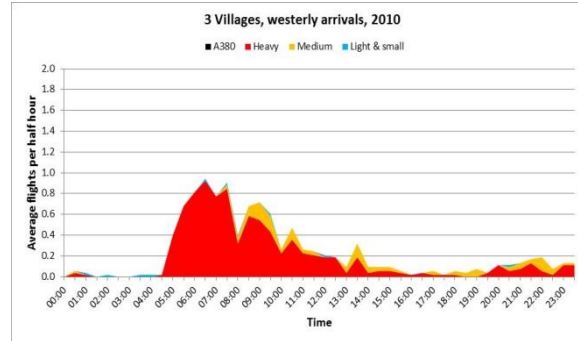
Medium-haul origins typically have flight times between three and six hours

Long-haul origins typically have flight times between six and nine hours

Ultra long-haul origins typically have flight times greater than nine hours

Origins marked as “unknown” do not have a recognised airport code associated with the flight in the data used for analysis

# Westerly arrivals are strongly peaked in the early morning and comprise mainly of heavy aircraft



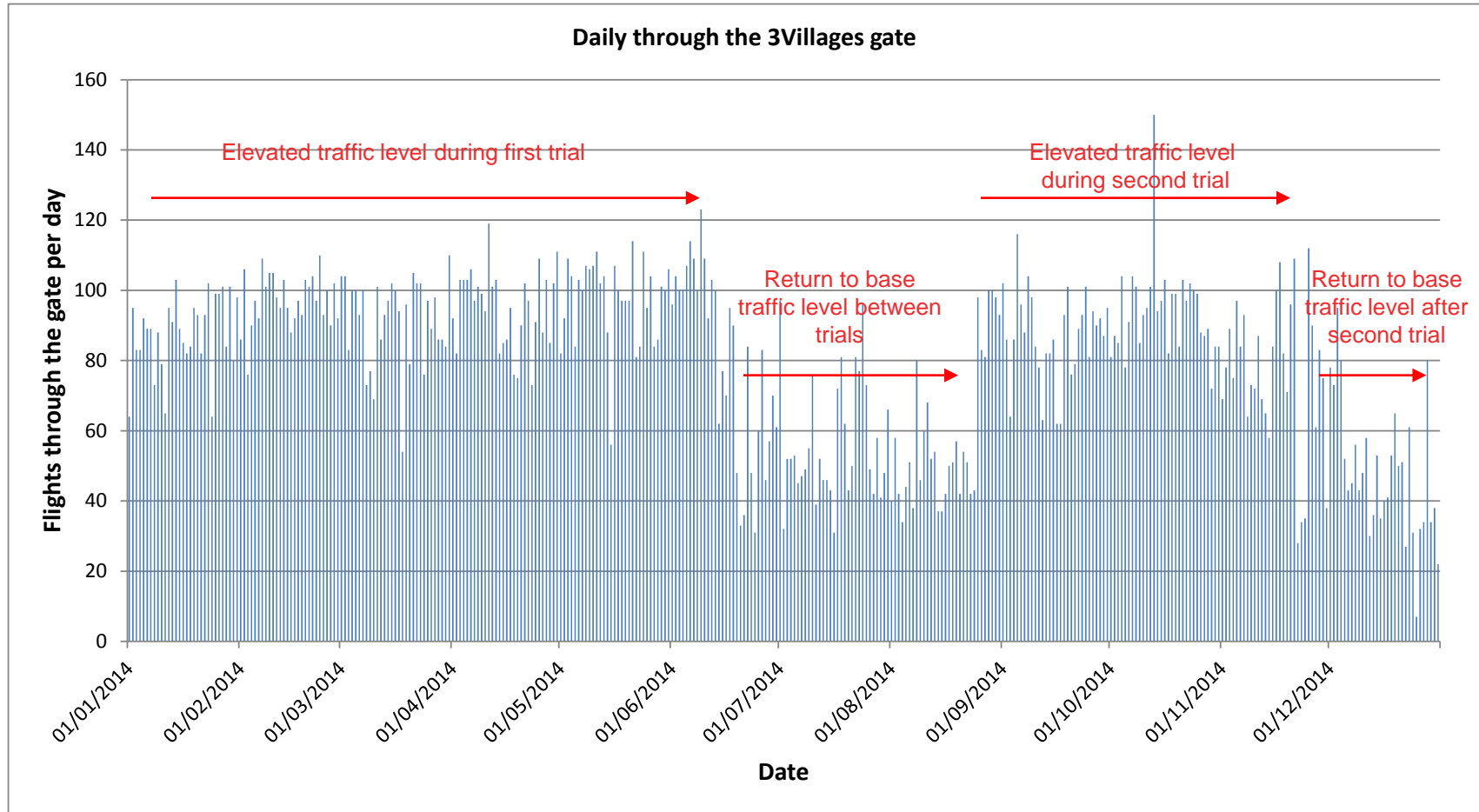


# CHANGES FROM AUGUST TO SEPTEMBER 2015

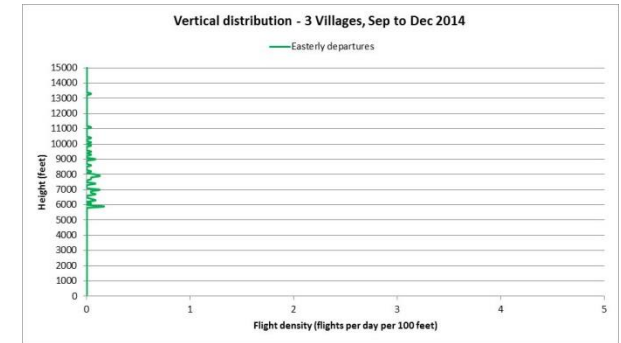
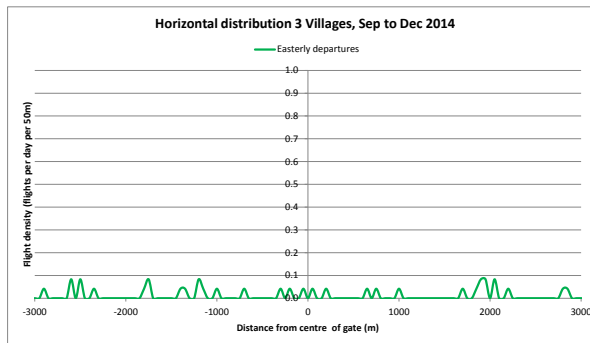
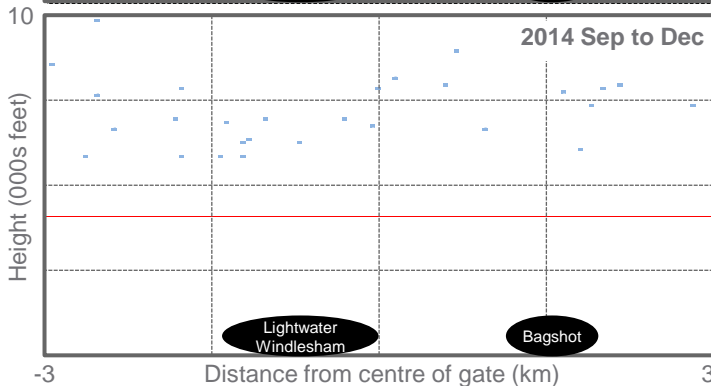
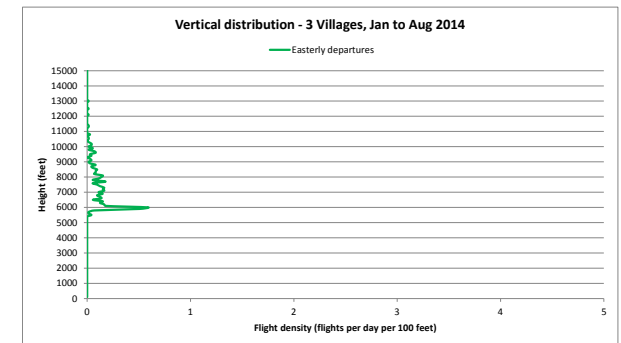
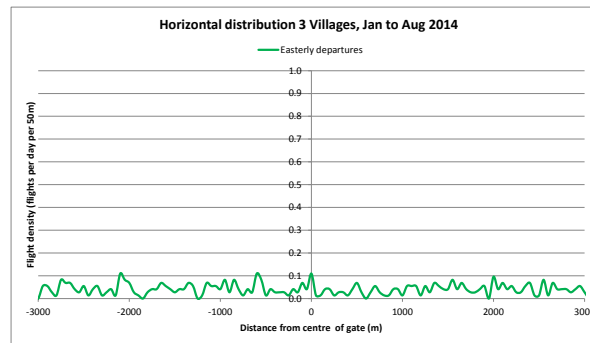
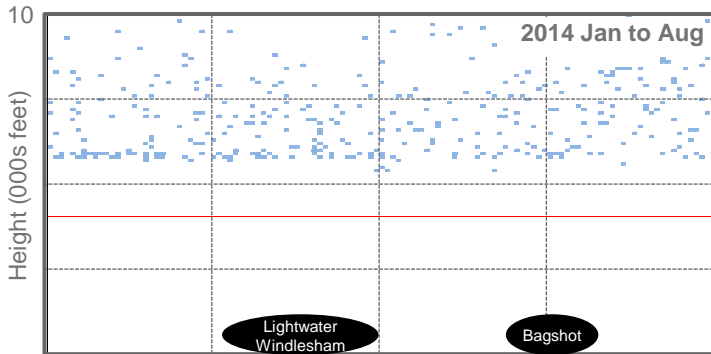
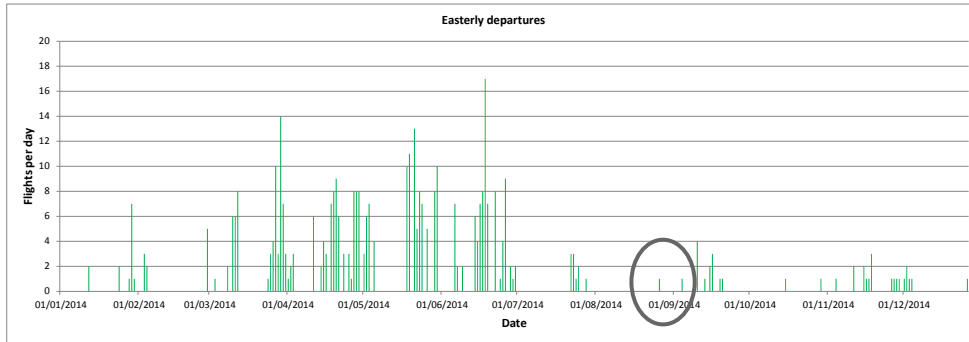
---

# 8

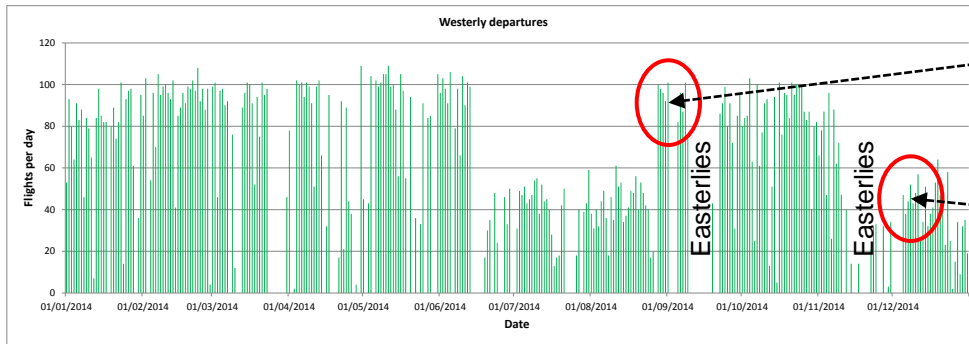
# The total traffic crossing the gate steps up from a reduced level at the beginning of September 2014 and then reverts to the lower level in December 2014



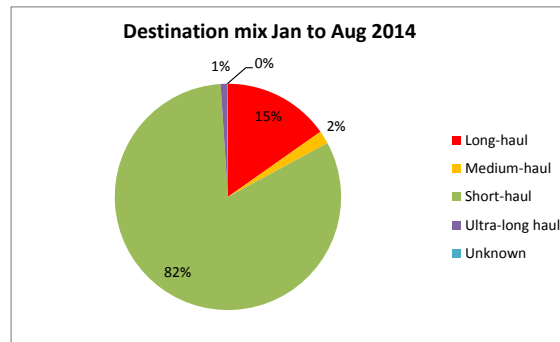
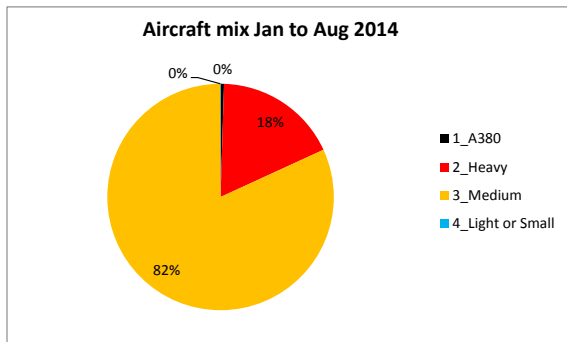
# Easterly departure traffic had virtually disappeared from the gate by September 2014



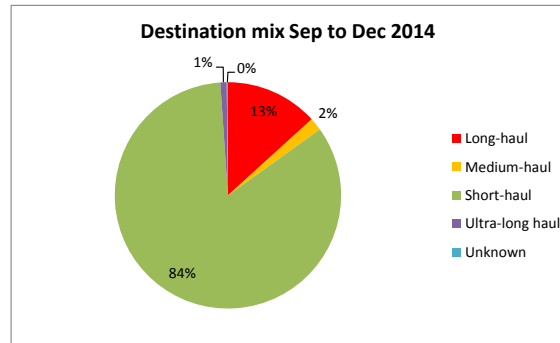
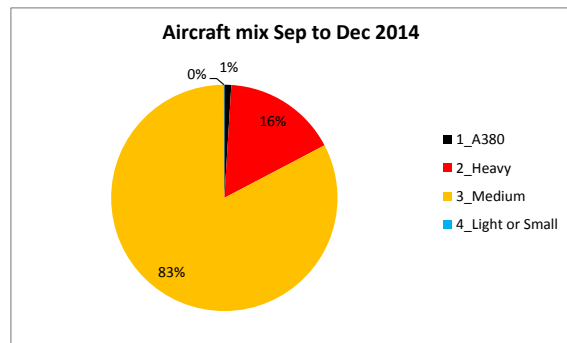
# There is a step change in the volume of westerly departures at the beginning of September with travel levels reverting at the beginning of December



There was approximately a doubling in westerly departure volume crossing the gate at the beginning of September 2014, to the levels experienced in the first trial period to mid-June 2014. Volumes revert to the lower level at the beginning of December after the end of the trial.

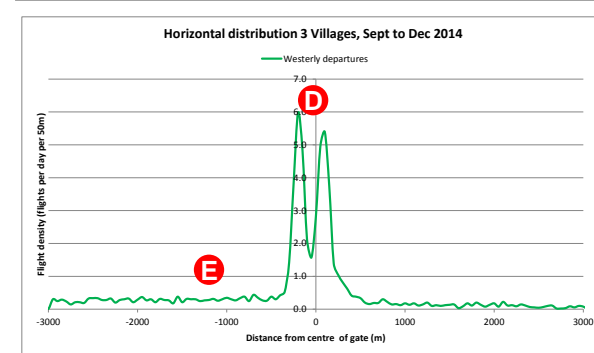
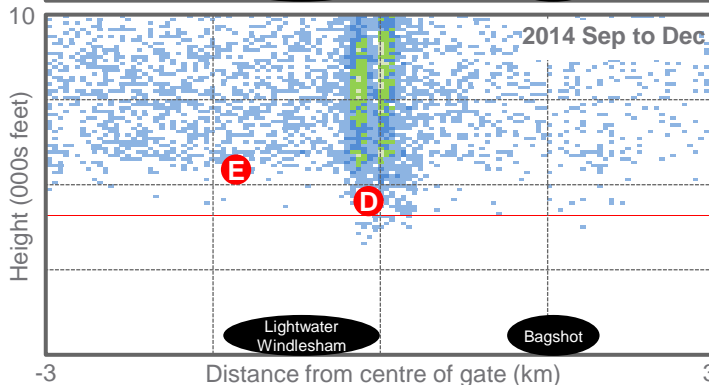
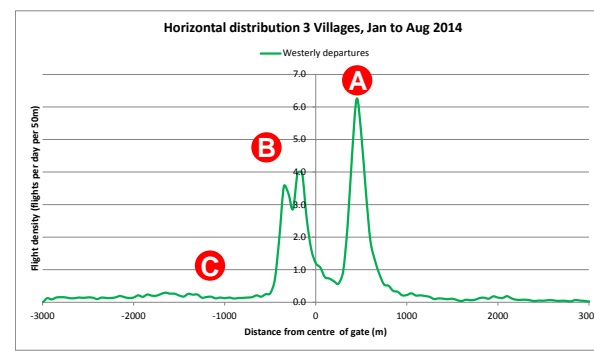
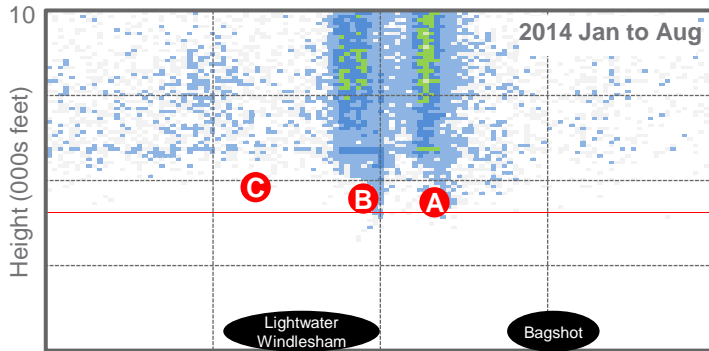
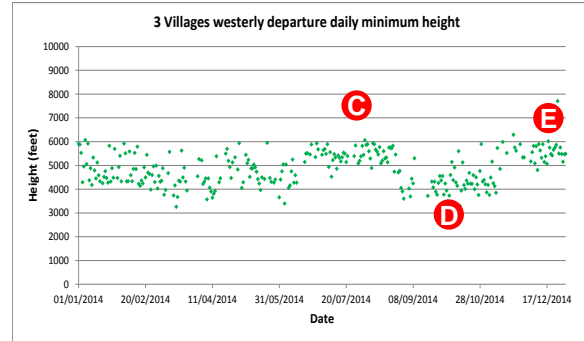
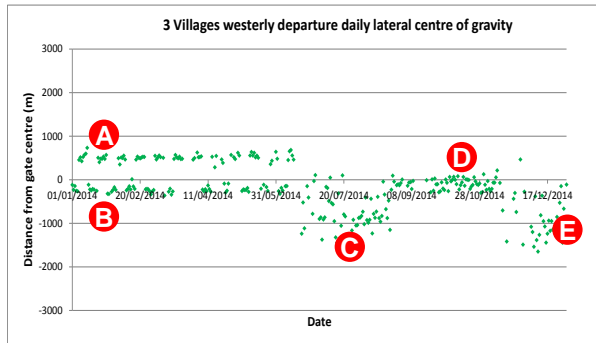


There was a slight increase in A380 and medium aircraft in the traffic mix from August to September with a corresponding decrease in heavy aircraft.



There was a 2% decrease in long haul destinations and a corresponding increase of 2% in short-haul destinations served by westerly departures crossing the gate from August to September 2014.

# There are very noticeable changes in flight profiles for westerly departures before and after 1 September 2014 due to the departure trials



At the beginning of 2014, westerly departure traffic through the gate was split into two streams, A and B in the charts, due to the first departure trial. These streams were approximately 200m to the left of centre of the gate (B) and approximately 500m to the right of centre (A). There was alternation between the streams on a weekly frequency, i.e. traffic followed stream A one week and stream B the next. Stream A was approximately 50% more intense than stream B. Minimum height of both streams was around 4000ft.

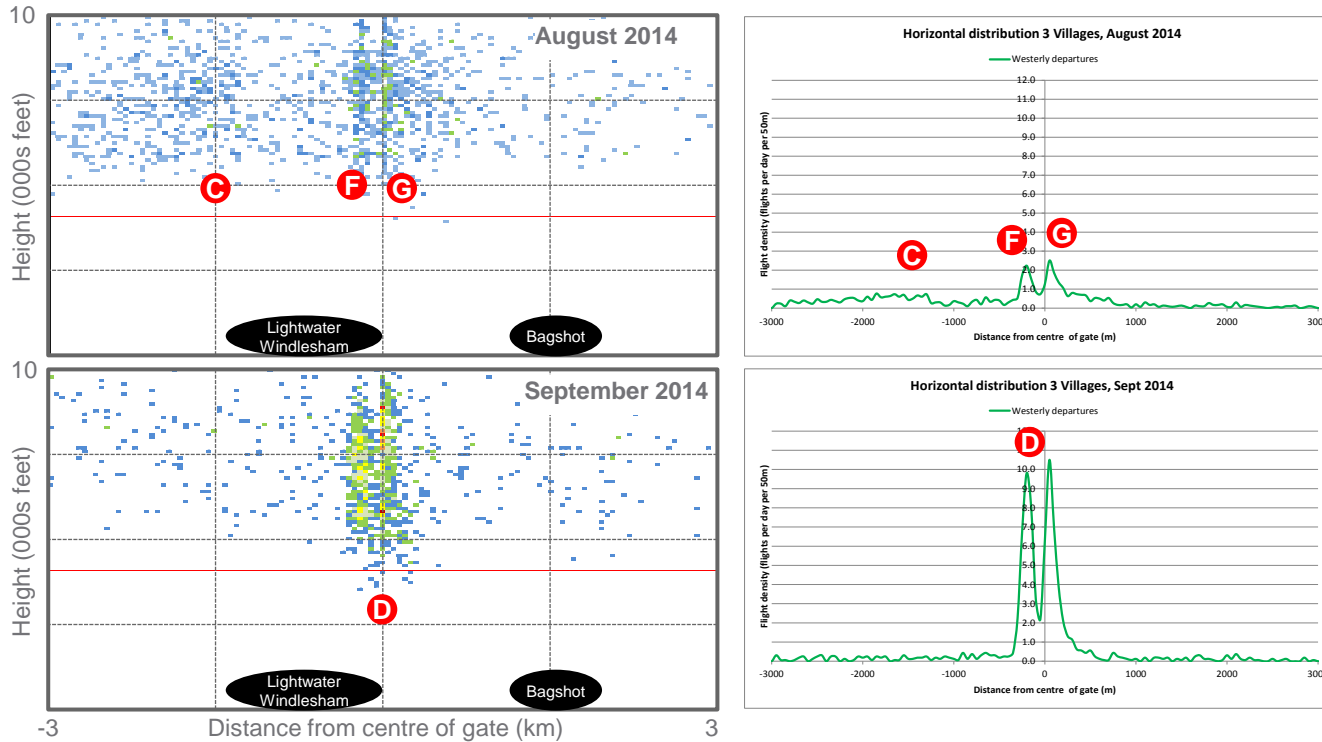
In June, after the first trial ended the traffic dispersed, became much lower in intensity and the centre of gravity shifted to approximately 1000m to the left of gate centre. The minimum height increased to approximately 5000ft. This period is shown as C on the charts.

At the beginning of September, D on the charts, the traffic concentrated near to the centre of the gate, again in two streams but very close together and intensity 50% higher than that shown in stream B.

At the beginning of December, the traffic structure reverted to the between-trials pattern, shown as E in the charts.

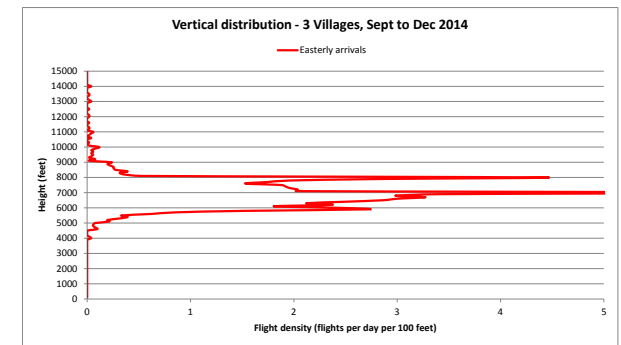
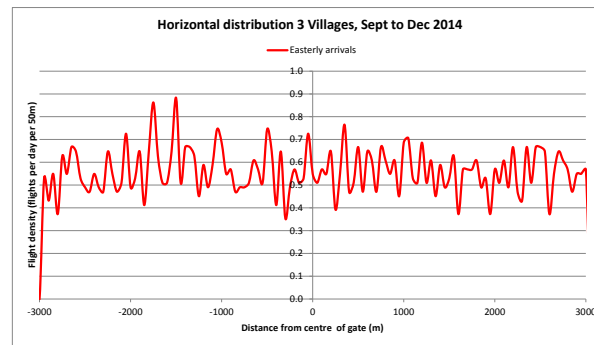
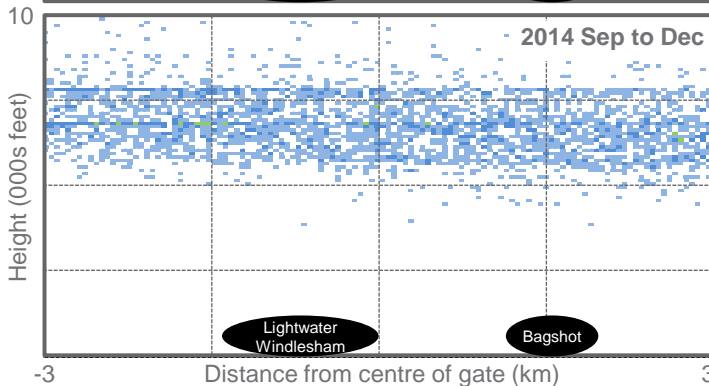
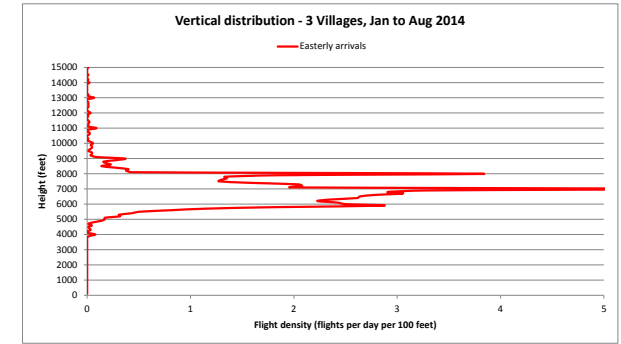
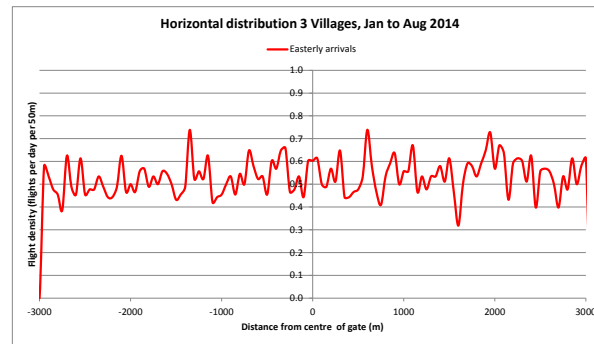
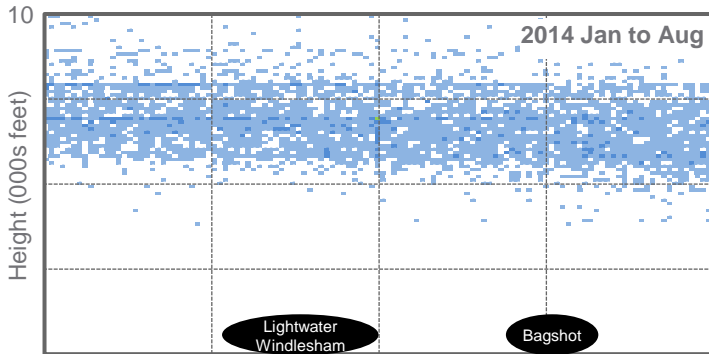
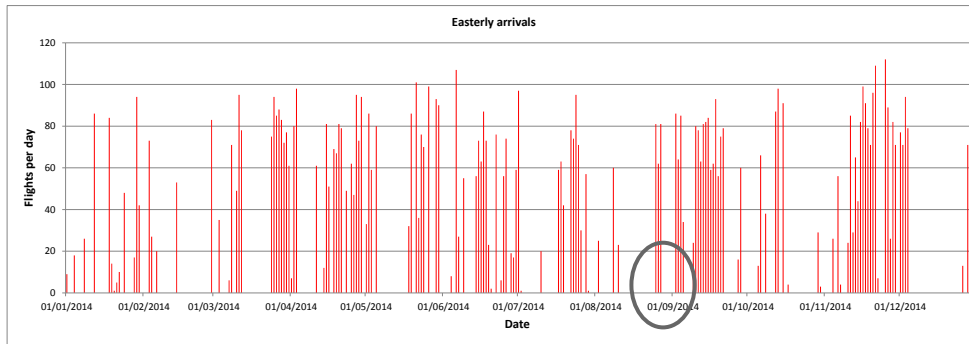


# Comparison of westerly departures for August and September 2014 shows a step change in traffic volume and concentration at the beginning of September due to the second departure trial

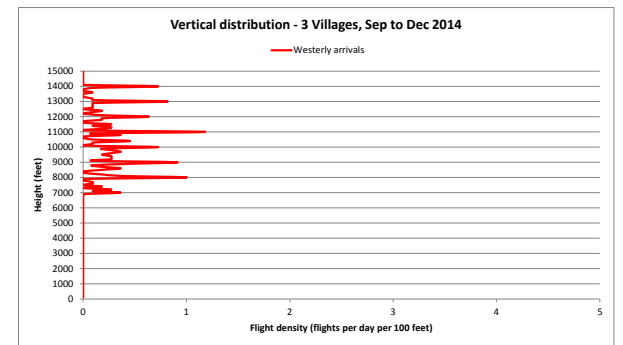
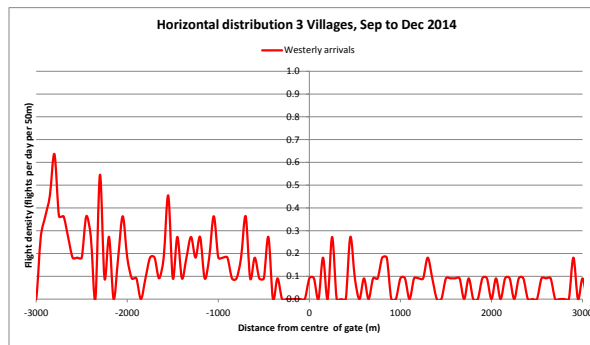
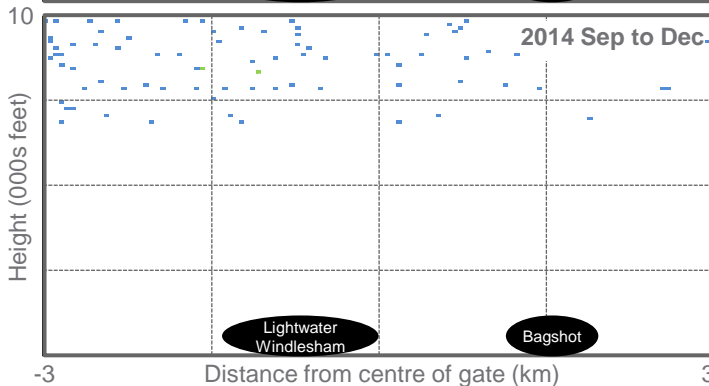
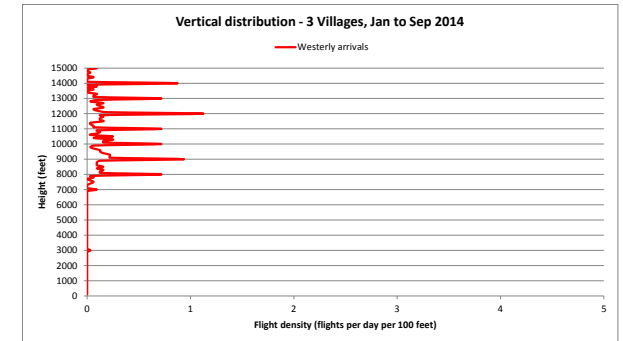
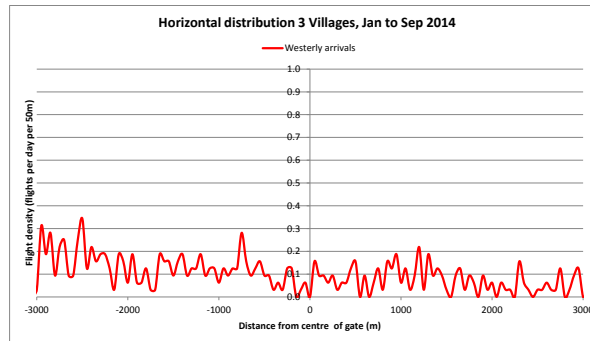
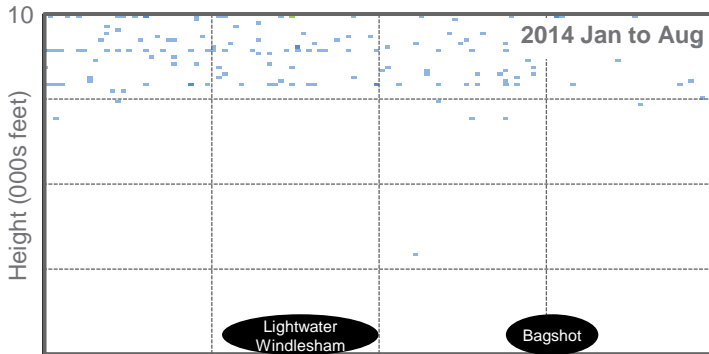
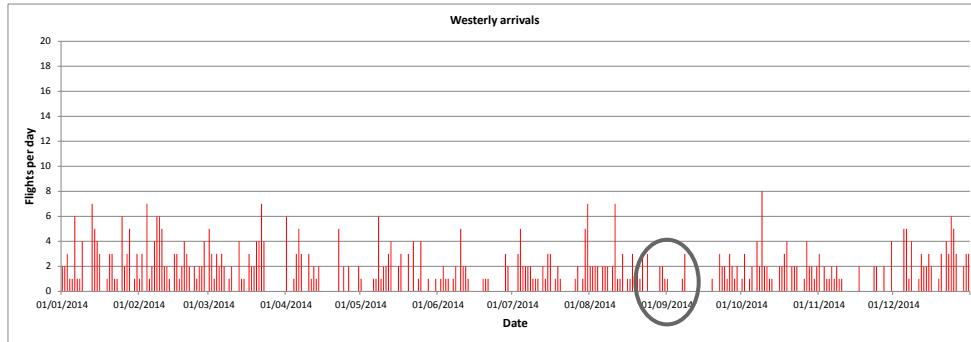


In August 2014, there were two small peaks of traffic concentration of westerly departures, F and G, near to the centre of the gate and a broad swath of dispersed traffic, C) to the left of the gate. In addition, to the large increase in volume from August to September, the traffic was almost completely concentrated in the two, closely spaced peaks, D, close to the centre of the gate. The intensity of these peaks is approximately five times that observed in August and is due to the departure trial that started on 25 August.

# There was no discernible change in the pattern of easterly arrival traffic at the beginning of August 2014



# Similarly there was no apparent change in westerly arrival traffic patterns between August and September 2014s





# FOCUS ON SPECIFIC FLIGHTS

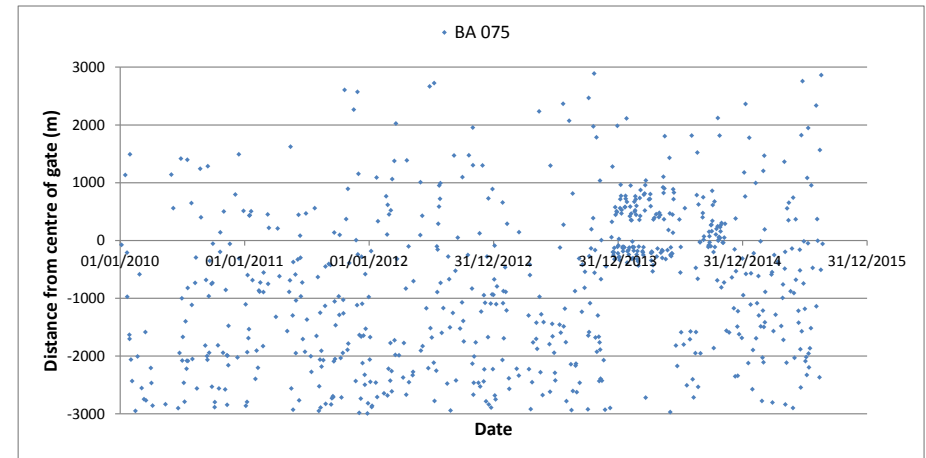
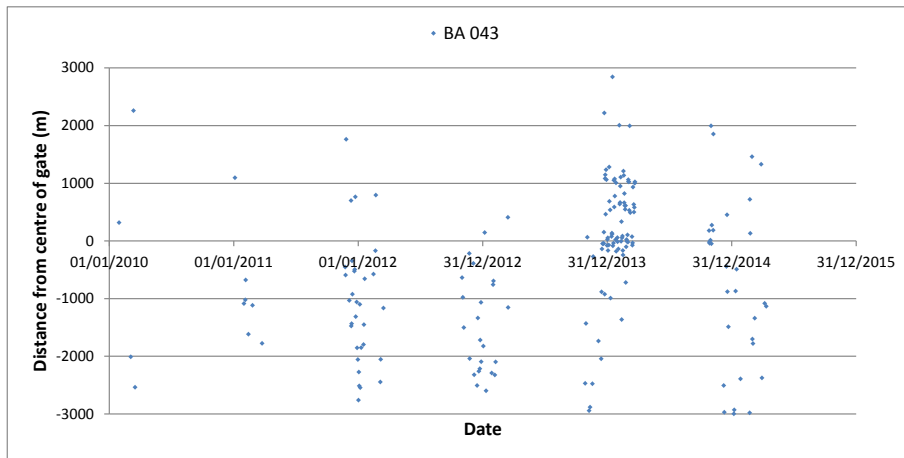
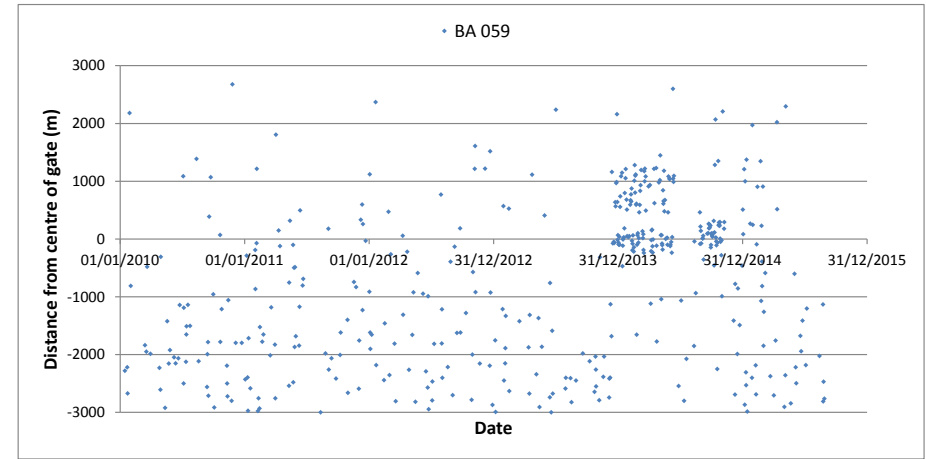
---

# 9

# BA043, BA059 and BA075 all concentrate on the trial SIDs during the trials but are widely dispersed across the gate at other times

The charts show the daily lateral displacement from gate centre of each flight when it crosses the gate. Each point represents the lateral position of the flight on an individual day. The flights shown cross the gate on westerly operations only.

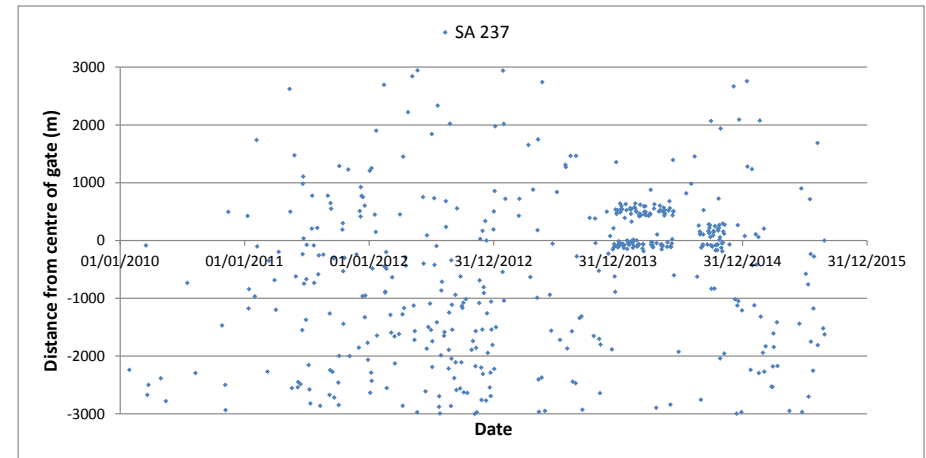
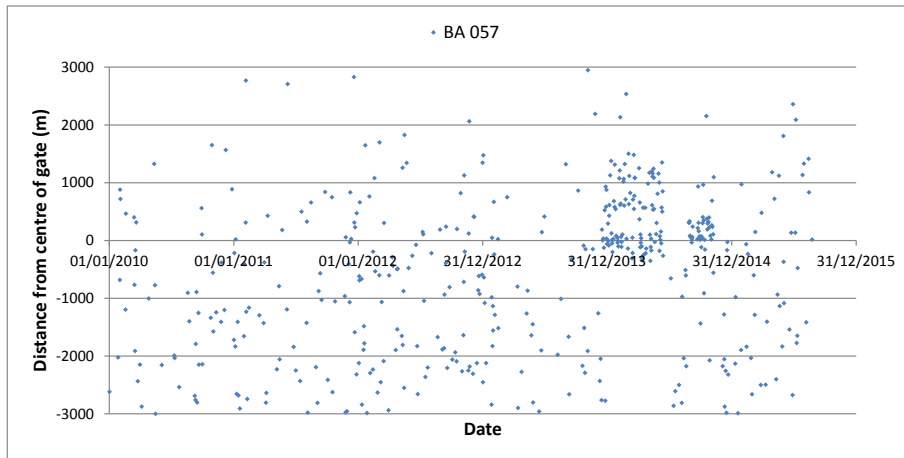
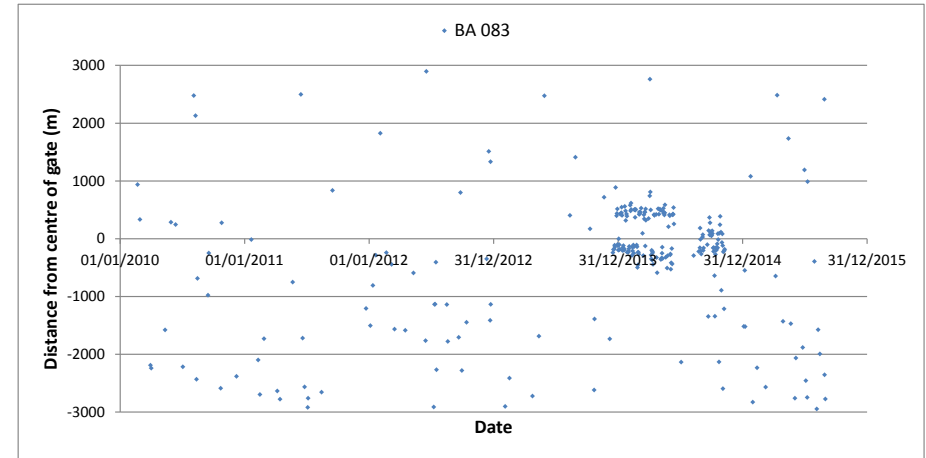
BA043 only crosses the gate during the winter season. The other flights cross the gate throughout the year.



# Similarly BA083, BA057 and SA237 cluster on the trials SIDs during the trial but are widely dispersed across the gate at other times

The charts show the daily lateral displacement from gate centre of each flight when it crosses the gate. Each point represents the lateral position of the flight on an individual day. The flights shown cross the gate on westerly operations only.

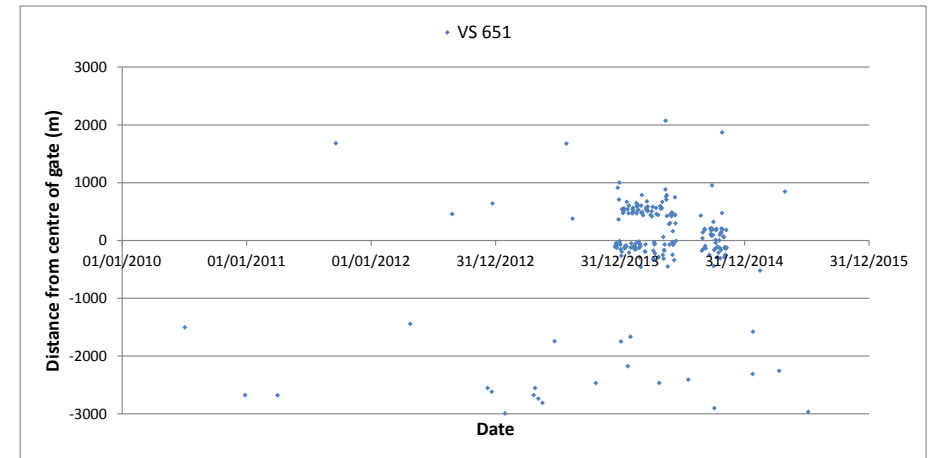
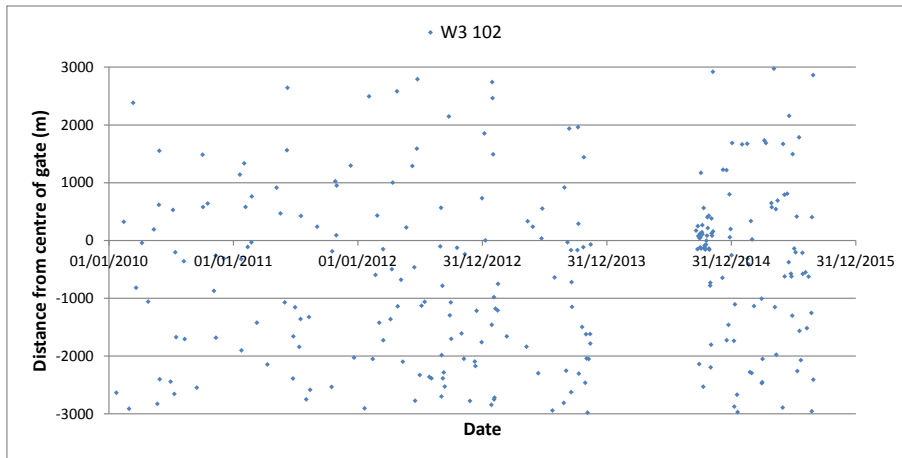
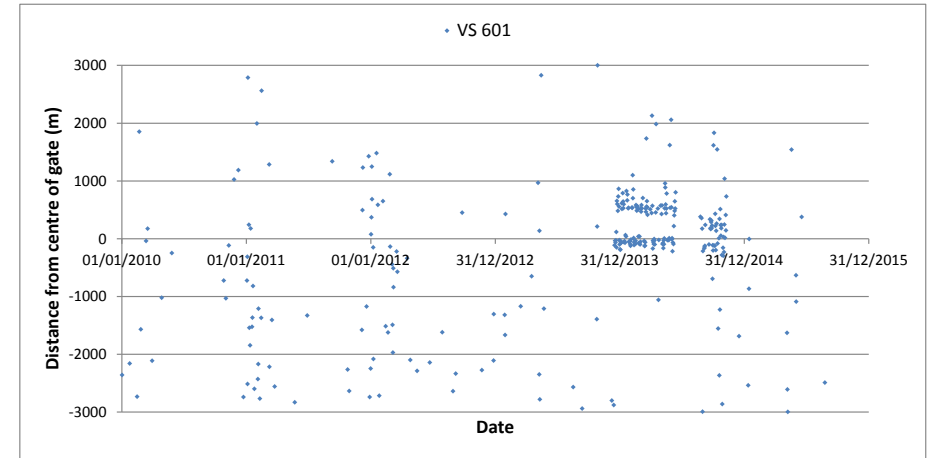
All three flights cross the gate throughout the year



# VS601 and VS651 cluster on the trial SIDs during trial periods W3102 clustered on the trial SID during the second trial period, having disappeared during the first

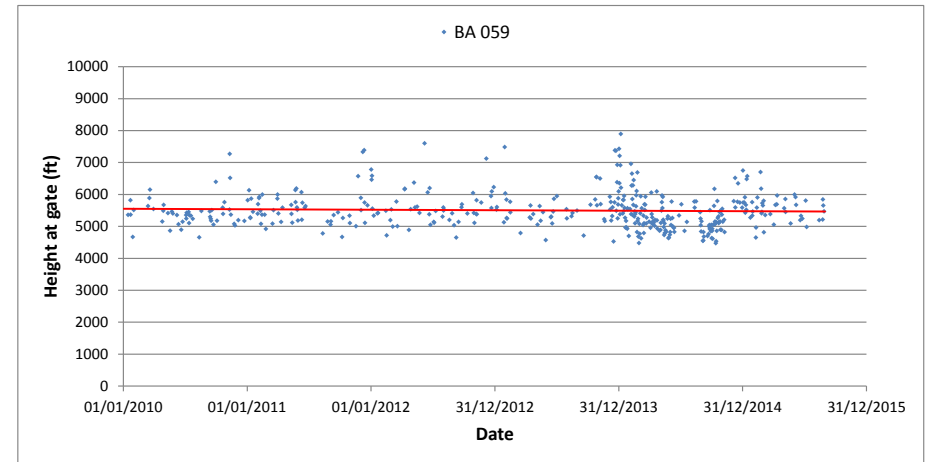
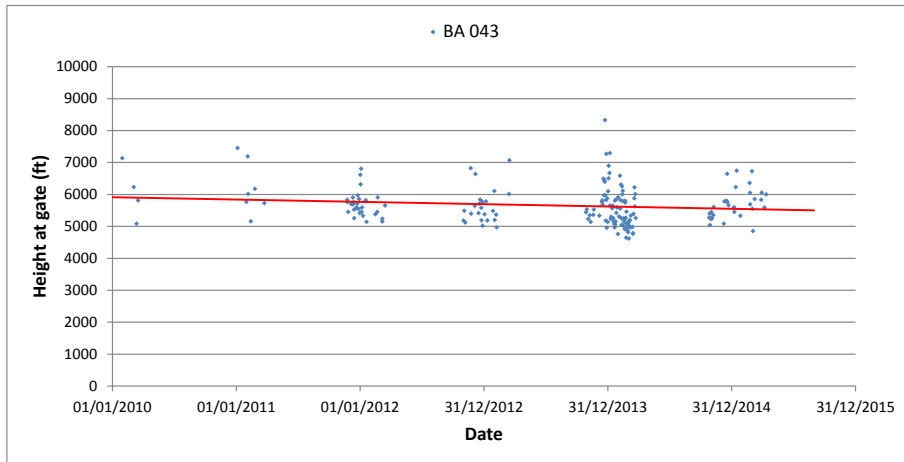
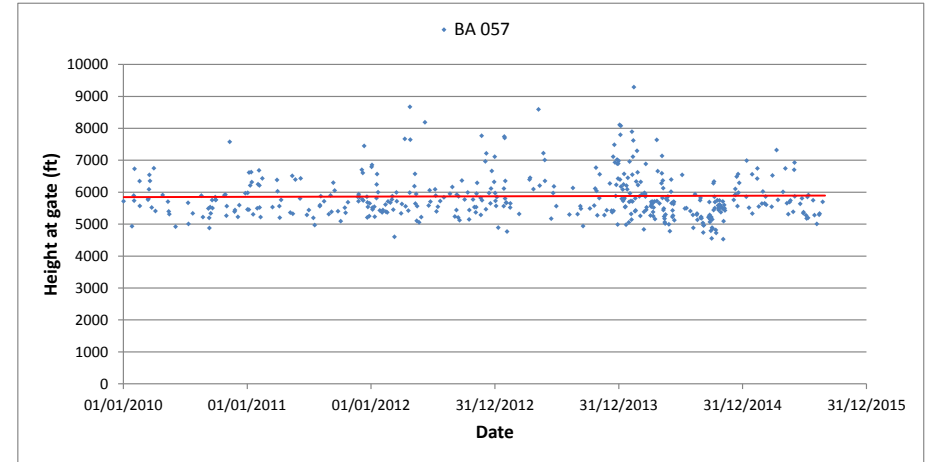
The charts show the daily lateral displacement from gate centre of each flight when it crosses the gate. Each point represents the lateral position of the flight on an individual day. The flights shown cross the gate on westerly operations only.

VS651 only rarely crosses the gate other than during the trial period. W3102 crosses the gate regularly except for during the first trial period when it disappeared to return at the start of the second trial period



# BA043, BA059 and BA075 all cross the gate at lower heights during the trial period and there is a downward trend on height for BA043 and BA059

The charts show the height of each flight as it crosses the gate. Each point represents the height of the flight on an individual day. The flights shown cross the gate on westerly operations only

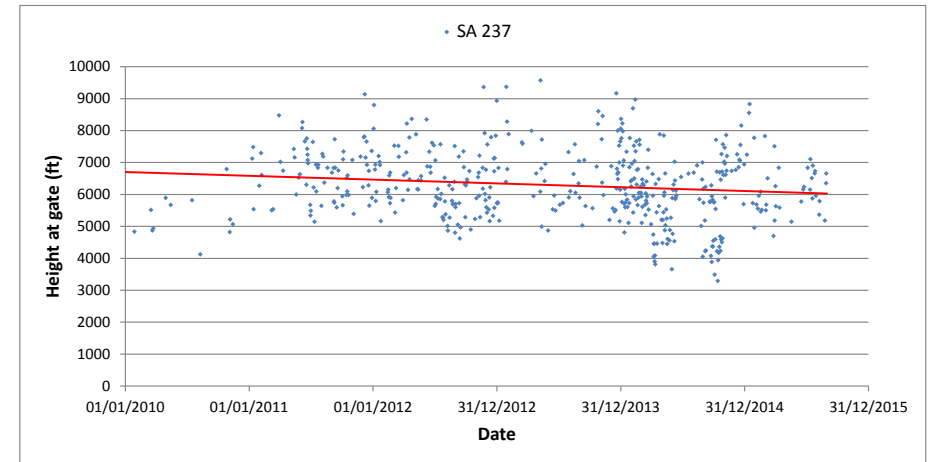
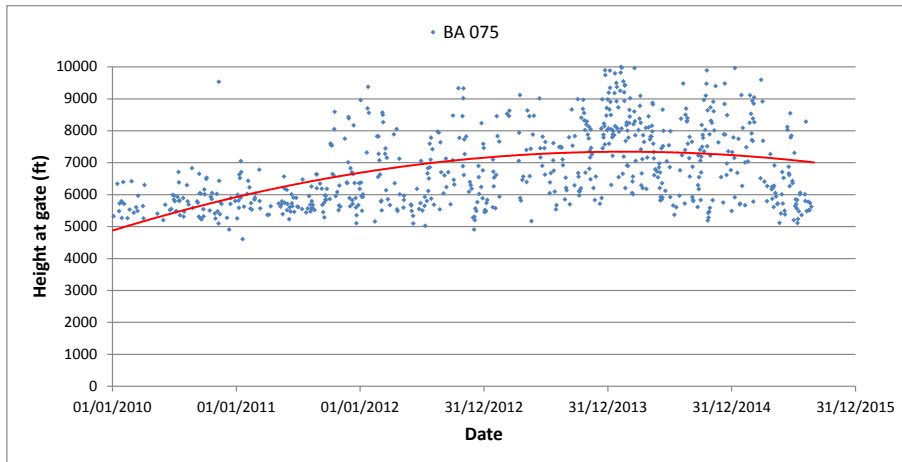
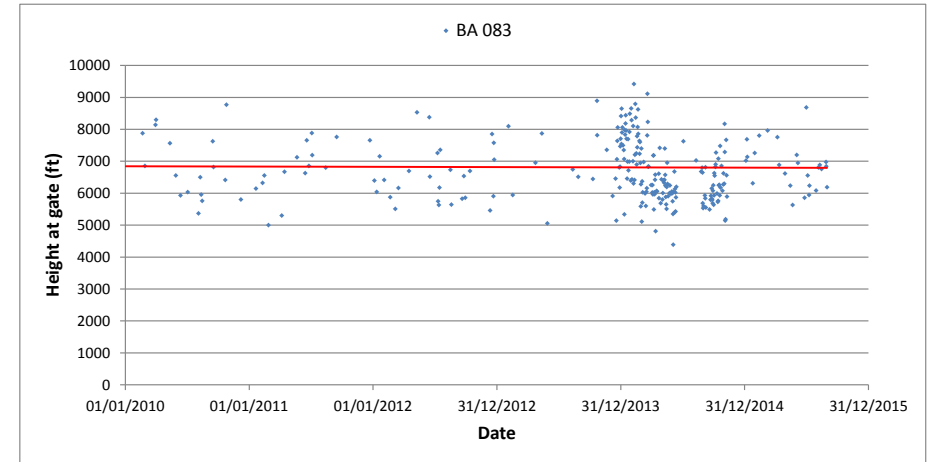




# BA075 crossed the gate at higher than normal heights during the trials but BA083 and SA237 crossed that gate lower than normal during the trials

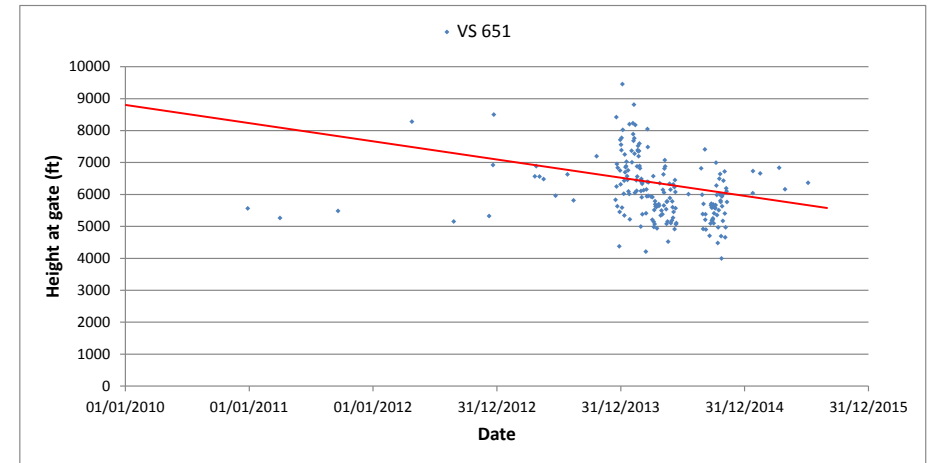
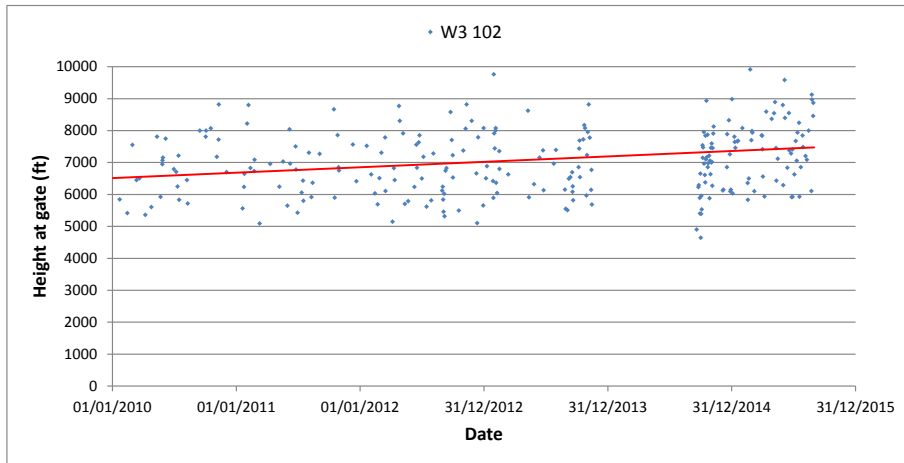
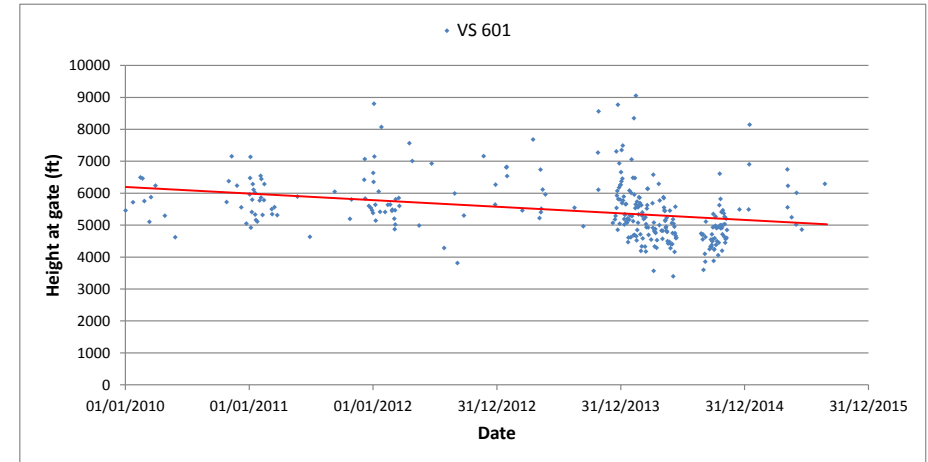
The charts show the height of each flight as it crosses the gate. Each point represents the height of the flight on an individual day. The flights shown cross the gate on westerly operations only.

BA075 crossed the gate higher than normal during the trials but reverted after the trials. BA083 and SA237 crossed the gate considerably lower than normal during the trials and have overall downward trends on height.



# Both VS601 and VS651 show a strong downward trend in height at the gate but W3102 shows an upward trend

The charts show the height of each flight as it crosses the gate. Each point represents the height of the flight on an individual day. The flights shown cross the gate on westerly operations only





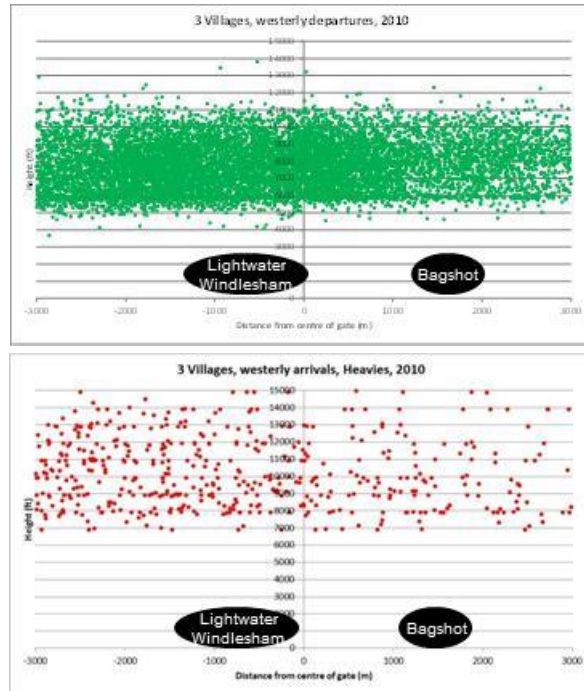
# ANNEX ANALYSIS APPROACH

---

# A

The spatial distribution of flights (the swath) is indicated on scatter plots with the flights classified by easterly or westerly operations or aircraft category

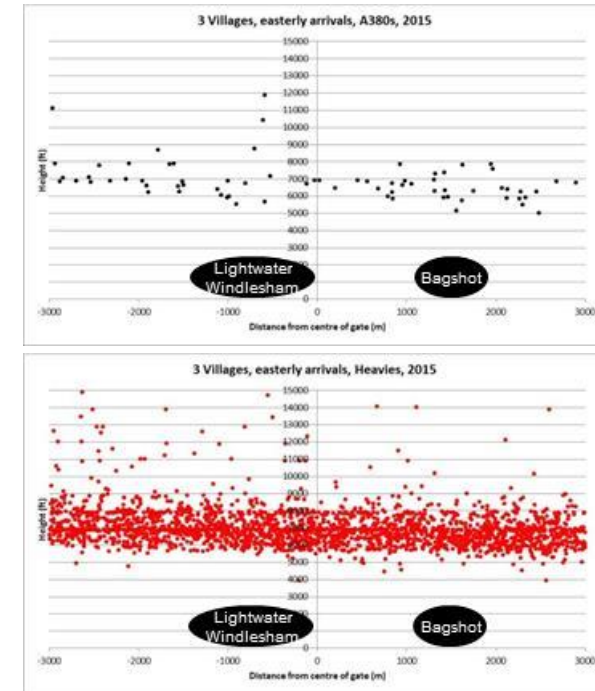
### Scatter plots for westerly departures & arrivals



Each point represents the coordinates of a single flight crossing the gate during the analysis period: the horizontal axis is distance from the centre line (negative to the left, positive to the right) and the vertical axis is height above the ground

Flights are colour coded according red for arrivals and green for departures. Easterly and westerly operations are analysed separately

### Scatter plots for aircraft type

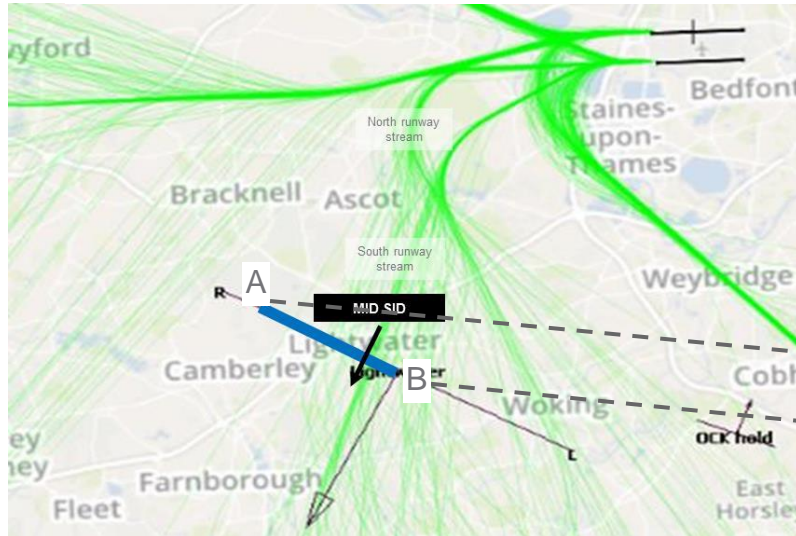


Again each point represents the coordinates of a single flight crossing the gate during the analysis period. In this case, however, all flights, east, west, arrivals and departures are shown on the same graph. Flights are colour coded according to the type of aircraft

- red for heavy aircraft
- gold for medium aircraft
- black for A380s

# Penetration gate analysis investigates the spatial distribution of flight paths passing through the window in space defined by the gate

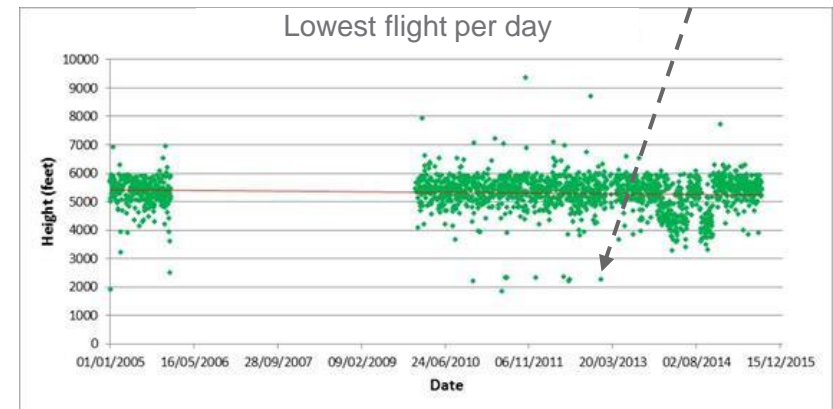
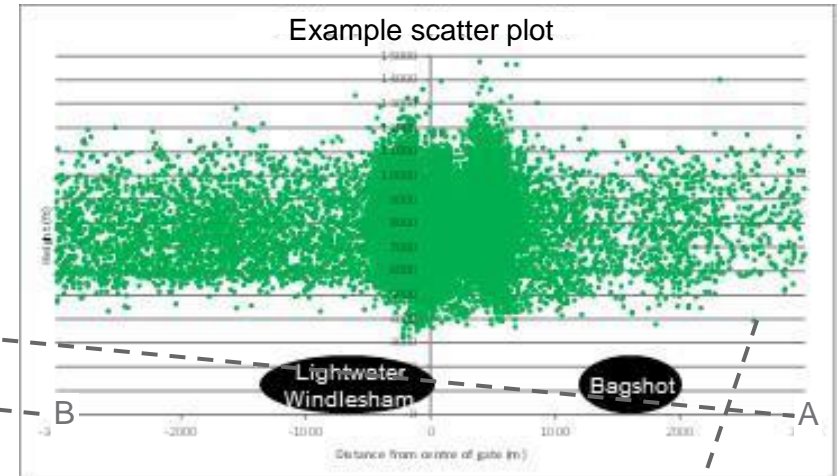
## Position of the gate relative to the associated departure flows



Each point on the upper right-hand chart represents the position of an individual flight crossing the gate. The gate distribution or flight path swath is the pattern of points where flights pierce the gate over a period of time, in this case calendar year.

The lowest flight in the swath each day has been used as a measure of variation in the height of aircraft piercing the gate during the analysis period. Each point on the lower right hand chart represents the lower limit of the swath (lowest flight) on a daily basis. The solid line is the best straight line fit as a guide to the eye of the overall trend of the lowest flight

## Spatial distribution of flight paths within the window defined by the gate



## The density or intensity of flights across the gate is calculated and displayed as a heat map

The simple scatter plots show the position of each flight passing through the gate during the analysis period

Because there are large numbers of flights crossing the gate during each analysis period, the points on the plot are superimposed and give little indication on the density or intensity of flights across the gate

Heat maps have been produced by counting the number of flights per pixel crossing the gate to give a measure of flight density across the gate

The heat maps are normalised to the number of days affected during each measurement period so that different measurement periods and different gates are directly comparable

Heat maps are divided into pixels, approximately 50m horizontally by 30m vertically

The unit of intensity is flights per day per pixel

