TEDDINGTON FLIGHT PATH ANALYSIS FINAL REPORT

October 2015

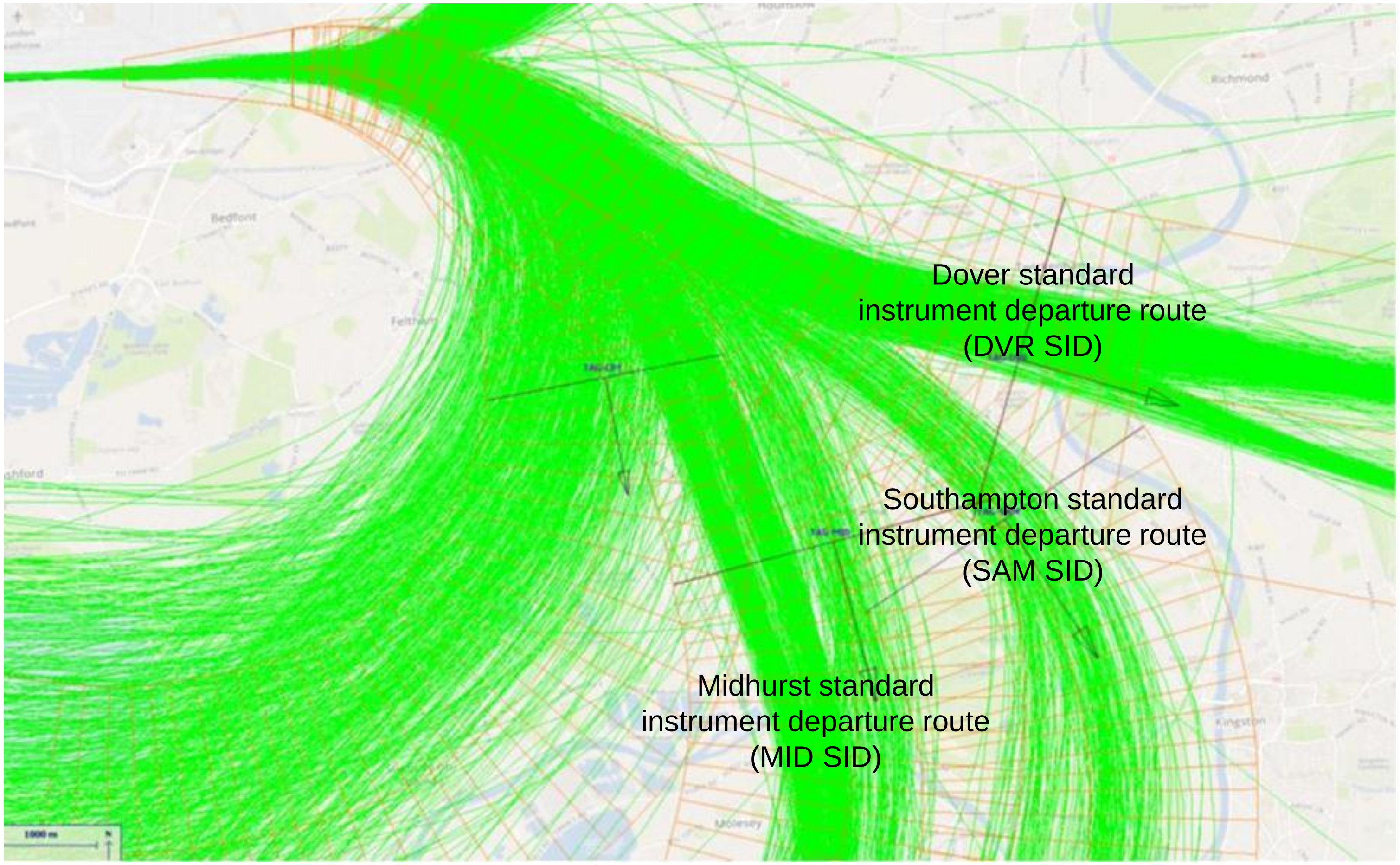
Contents

INTRODUCTION

1

Teddington and surrounding areas are overflown by three of Heathrow's departure routes on easterly operations

Typical easterly departure patterns



Note: During the analysis period covered in this report the designation on the DVR SID has changed to Detling (DET) so that the route is now referred to as DET SID. The report retains the previous DVR designation

A series of operational trials have been performed to investigate and inform potential re-design of airspace and more flexible departure operations

Operational freedoms

Period of trial:

- 1 July 2012 to 31 January 2013

Departure routes affected:

- DVR
- MID

Purpose of trial:

- to test the effectiveness of early vectoring of departing traffic to increase the departure runway throughput rate

Easterly departure trial 1

Period of trial:

- 16 December 2013 to 15 June 2014

Departure routes affected:

- MID

Purpose of trial:

- to test the feasibility of alternating traffic on a weekly basis between two temporary SIDs on either side of the existing MID routes but still within the boundaries of the NPR

Easterly departure trial 2

Period of trial:

- 28 July 2014 to 12 November 2014

Departure routes affected:

- CPT
- SAM
- MID

Purpose of trial:

- CPT: to test a new RNAV1 SID classified as PIBUG.
- MID: to test an RNAV1 SID as close as possible to the existing MID SID.
- SAM: to test a RNAV1 SID with the initial turn changed to match the MID initial turn

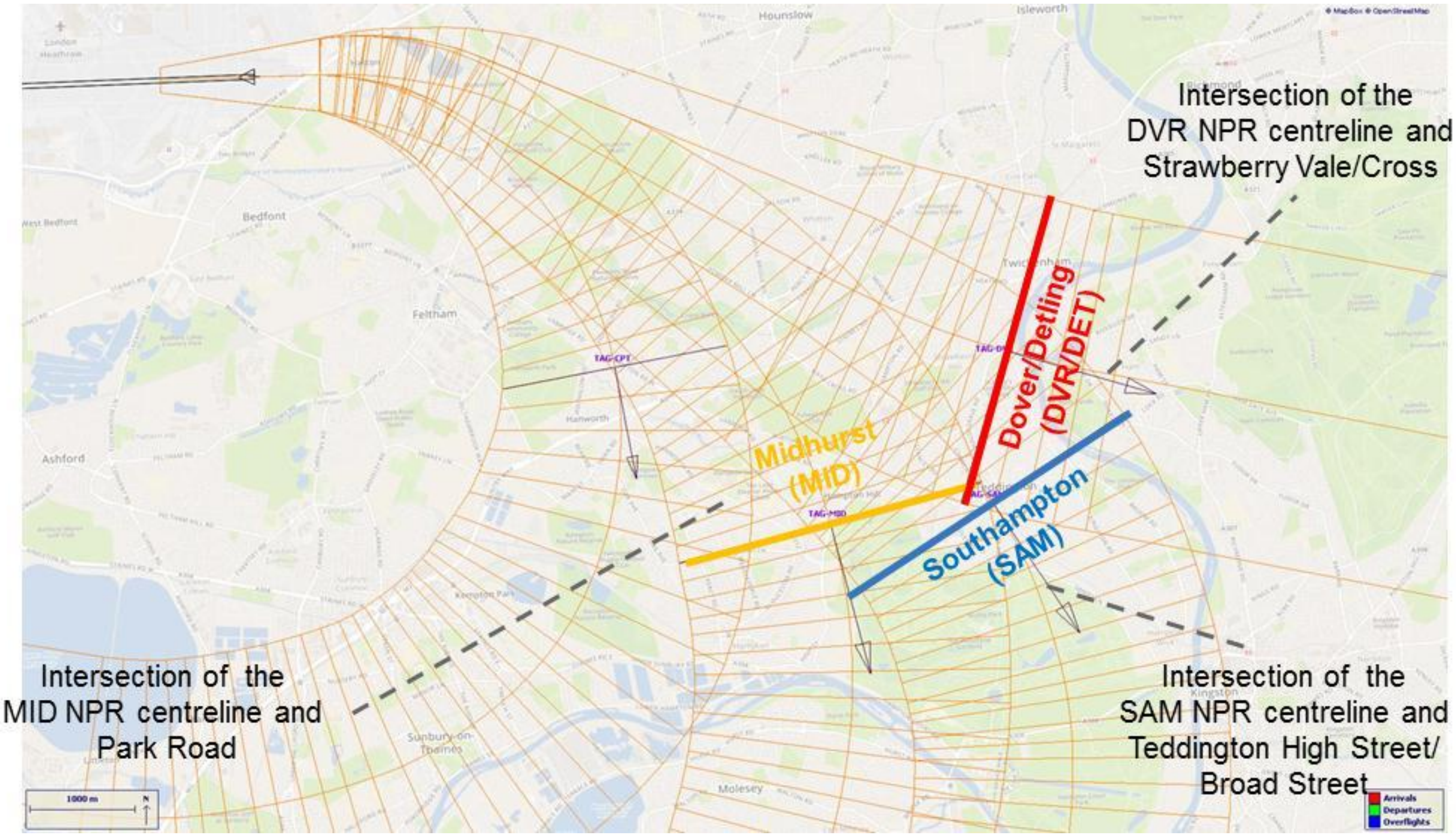
The Teddington Action Group (TAG) has highlighted concerns relating to changes in flight paths and noise impact after the end of the trial period. This study has investigated traffic distributions over a period of time, pre-, during and post-trial to identify and understand the changes that have occurred

ANALYSIS APPROACH

2

Traffic distributions have been investigated at three of the locations specified by the Teddington Action Group

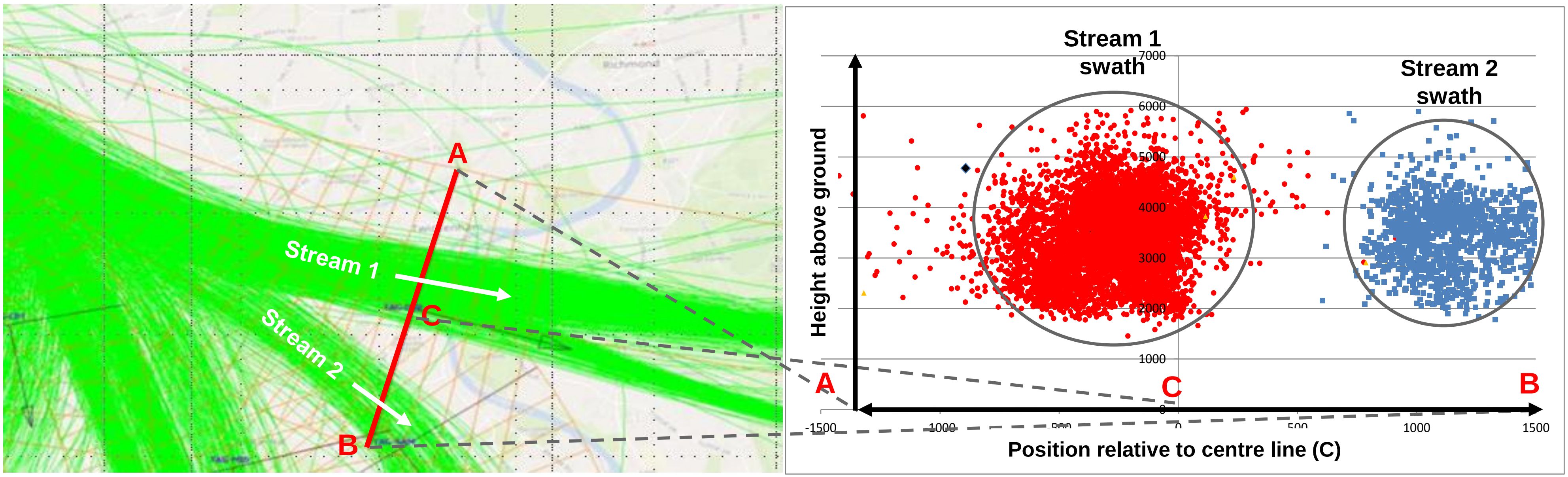
Location of the penetration gates used for flight path analysis



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

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



Each point on the right-hand chart represents an individual flight (here they are colour coded according to whether they are assigned to the stream 1 or stream 2 swaths)

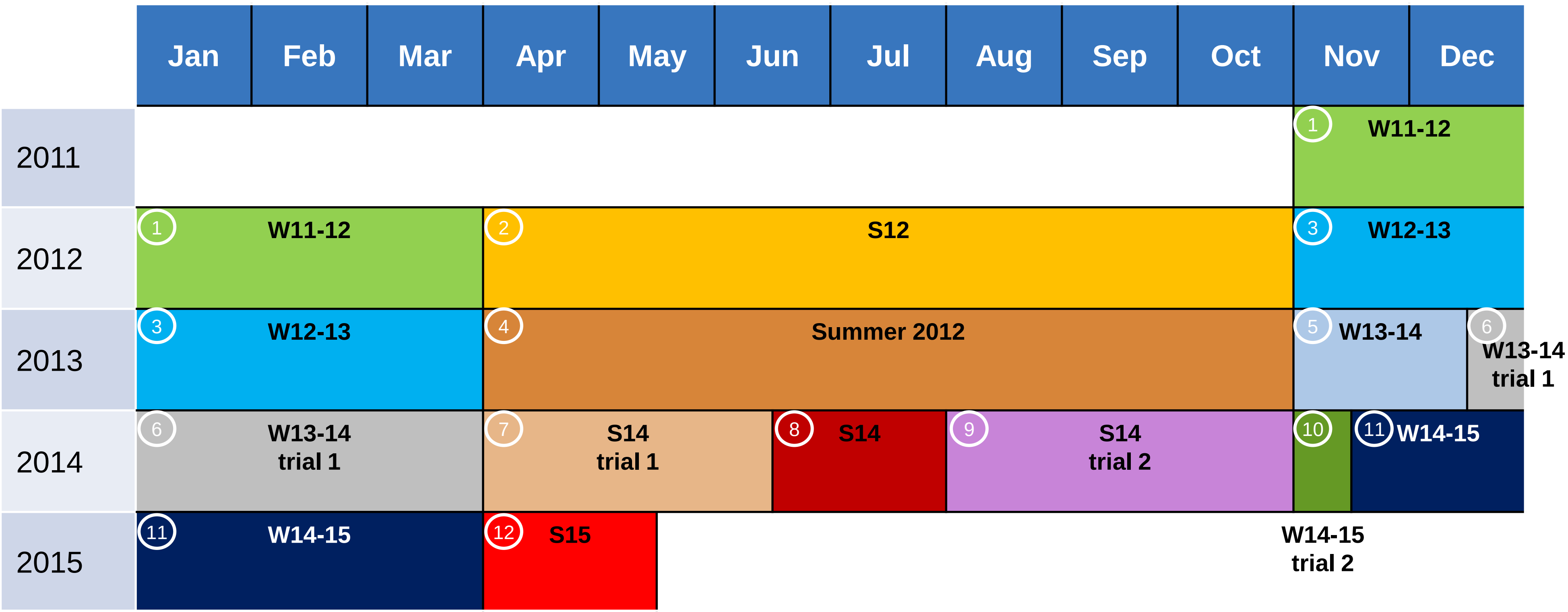
The gate distribution or flight path swath is the pattern of points where flights pierce the gate over a period of time. The swath is characterised by:

- **centre of gravity**: the mean average of the distribution of the flights within the swath as an indicator of the position of the core of the swath (this is not necessarily the point of highest intensity)
- **dispersion:** the standard deviation of the distribution of all the flights within the swath as an indicator of the spread of the swath
- **minimum height:** the position of the lowest flight in the swath over the time period

Analysis over the period from November 2011 to May 2015 has been undertaken to understand residents' observations of significant changes to pre-trial flight paths

The analysis period has been broken down into twelve periods to isolate the effects of schedule changes from summer-to-winter-to-summer, as well as the impacts of the two sets of departure trials

The twelve time periods for analysis



Because different types of aircraft operate differently and have varying degrees of noise and visual impact, the analysis classifies aircraft into five broad categories

Examples of types of aircraft in each category

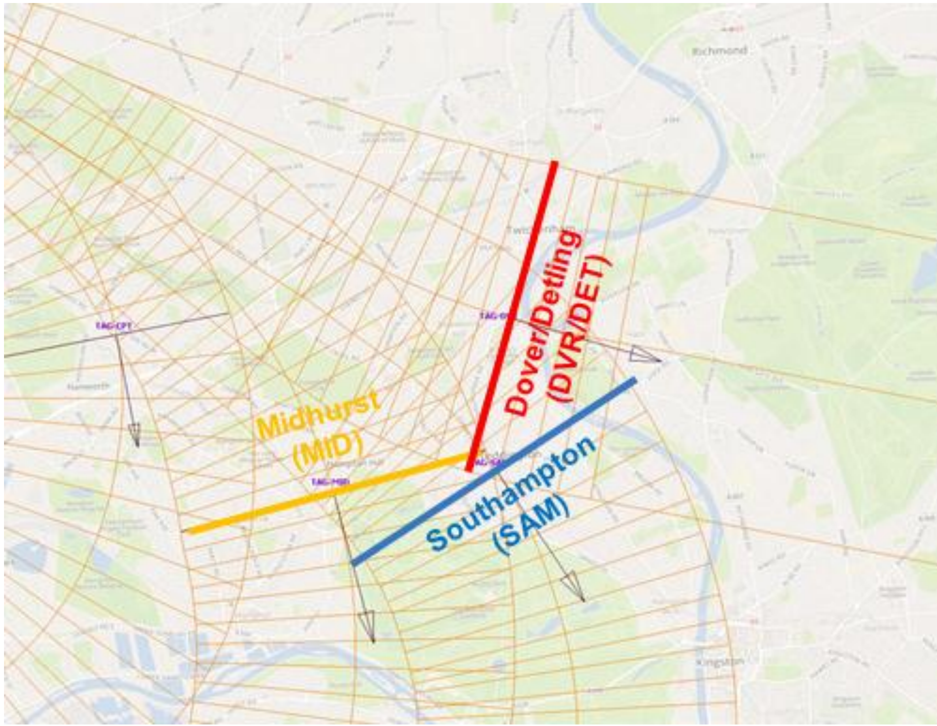
A380	Heavy	Medium	Small	Light
Aircraft weighing over 560 tonnes, e.g.: • A380	Aircraft weighing over 136 tonnes, e.g.: • B747 • B767 • B777 • B787 • A330 • A340	Aircraft weighing between 40 and 136 tonnes, e.g.: • B737 • B757 • A320 • A319 • A318 • A321	Aircraft weighing between 17 and 40 tonnes, e.g.: • Gulfstream	Aircraft weighing less than 17 tonnes, e.g.: • Cessna Citation • Learjet

These classifications are based on aircraft size and do not necessarily give an indication of the noise produced, although broadly speaking larger aircraft are likely to have a greater perceived impact than smaller aircraft. Generally, aircraft within each category might also be expected to exhibit similar flight performance, e.g. climb rate. However, aircraft performance is also strongly influenced by

- on-board electronics, particularly the software used in navigation systems, which can vary within aircraft type
- airline standard operating procedures, which can vary markedly from airline-to-airline
- the destination which influences the weight of the aircraft and hence its climb performance

The analysis is based on gate data extracted on a flight-by-flight basis from Heathrow's ANOMS system over the period 1 November 2011 to 1 May 2015

The three gates



The data fields

Data fields for flights crossing each gate
Scheduled departure time
Flight number
Aircraft type
Departure runway
Lateral position relative to centre line at gate
Height above ground at gate
Date and time of crossing gate
Ground speed
Direction of crossing gate
Designated departure route (SID)

ANOMS – Airport Noise and Operational Management System

The objective of the analysis is to understand traffic patterns before, during and after the trials and to identify any changes that have occurred

The main indicators calculated during the analysis

Volume of traffic

- Number of flights crossing the gate per day classified by assigned departure route and aircraft category
- Number of flights occurring before 08:00 hours local time and after 20:00 hours local time classified by aircraft category
- Number of flights crossing the gate each day at heights below 2000 feet and 3000 feet

Distribution of traffic

- The swath defined by the lateral and vertical position of each flight track as it crosses the penetration gate during each analysis period, classified by:
  - designated departure route; and
  - aircraft category
- The lateral and vertical centre of gravity of the swath on a daily basis, showing the centre of the flight paths (note: this Is not necessarily the point of highest concentration of flights)
- The lateral and vertical extent of the swath on a daily basis, showing the spread of flights crossing the gate
- The lower extreme of the swath on a daily basis, showing the height of the lowest aircraft to cross the gate on that day
- The concentration of the traffic across the swath for each of the time periods analysed

The first dimension of the analysis is to understand the evolution of the volume of traffic over time

The total number of flights crossing the gate each day is counted and classified into the main aircraft categories:

- A380, shown as black bars on the charts
- heavy, shown as red bars on the charts
- medium, shown as yellow bars on the charts

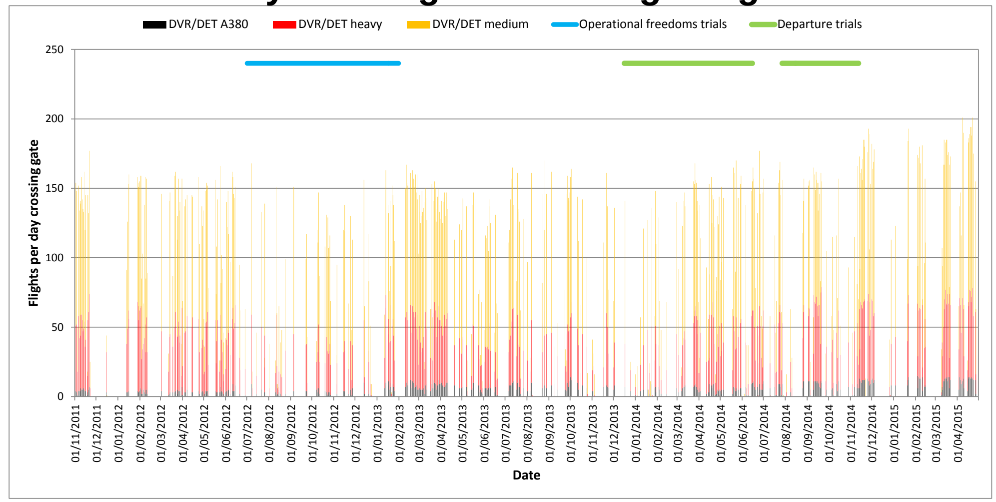
As an indicator of night flights, the number of flights crossing the gate before 08:00 hours and after 20:00 hours local time are counted and classified into the three main aircraft categories

Small and light aircraft types are not shown because of the very small volume of aircraft in this class

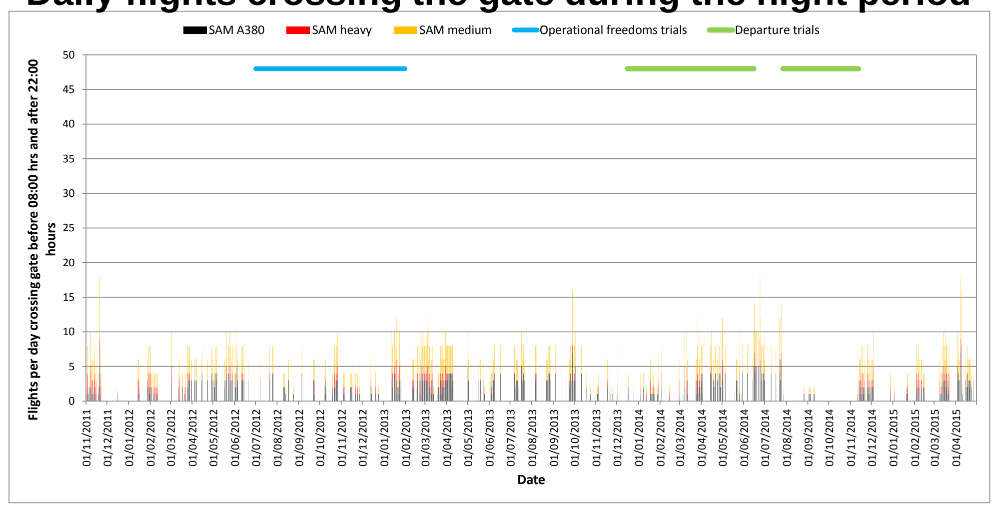
On days when the airport is operating in the westerly direction, there are no flights crossing the gate and there are gaps in the chart

The periods covered by the trials are indicated as bars at the top of the chart for reference

Daily total flights crossing the gate

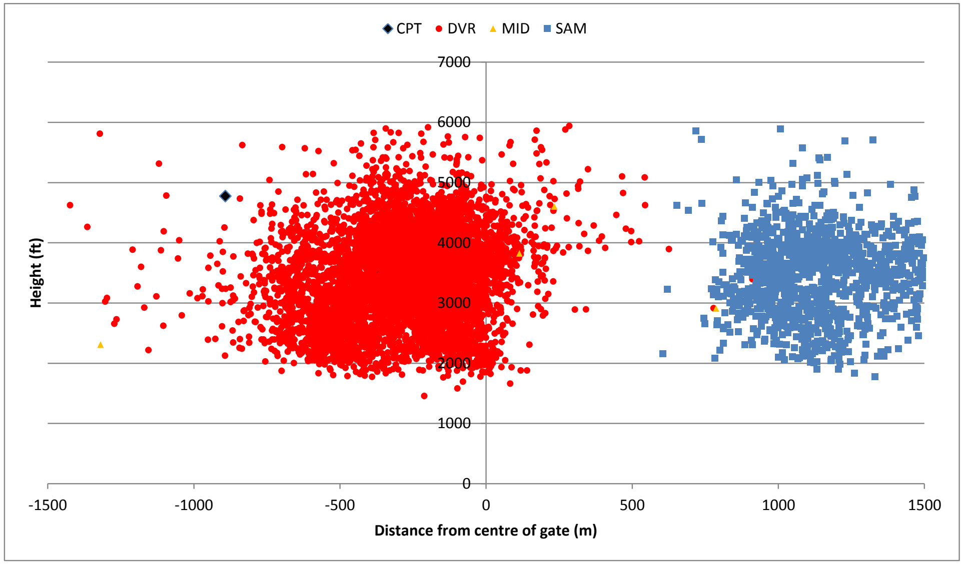


Daily flights crossing the gate during the night period



The spatial distribution of flights (the swath) is indicated on scatter plots with the flights classified either by departure route or aircraft type

Scatter plots for departure route

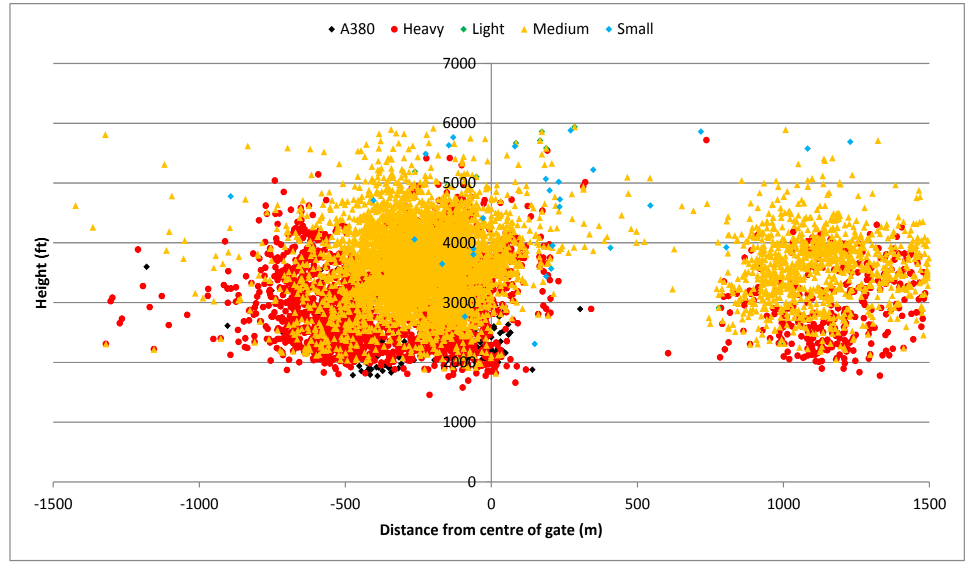


Each point represents the coordinates of a single flight crossing the gate during the analysis period: the horizontal axis is distance from the centre line (negative to the left, positive to the right) and the vertical axis is height above the ground

Flights are colour coded according to their designated departure route (SID):

- red for DVR
- blue for SAM
- gold for MID
- black for other SIDs

Scatter plots for aircraft type



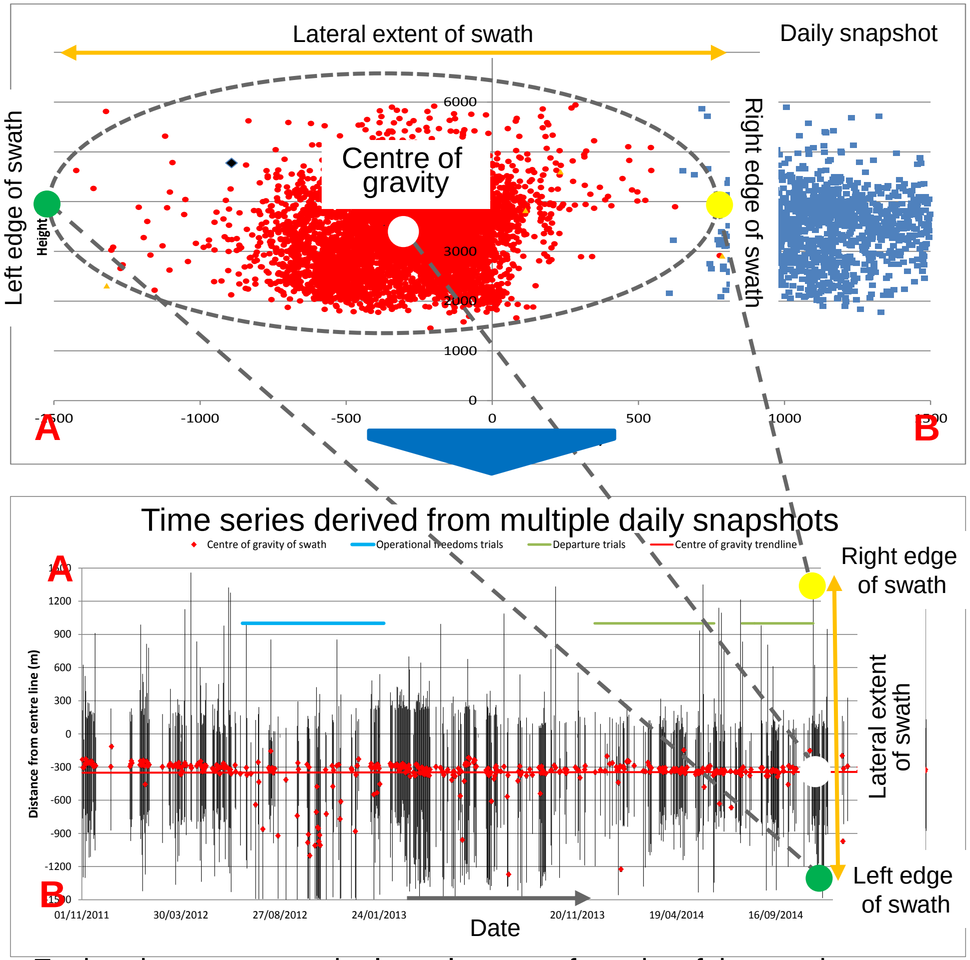
Each point represents the coordinates of a single flight crossing the gate during the analysis period: the horizontal axis is distance from the centre line (negative to the left, positive to the right) and the vertical axis is height above the ground

Flights are colour coded according to the type of aircraft

- red for heavy aircraft
- gold for medium aircraft
- black for A380s
- blue for light aircraft (very low numbers)
- light blue for small aircraft (very low numbers)

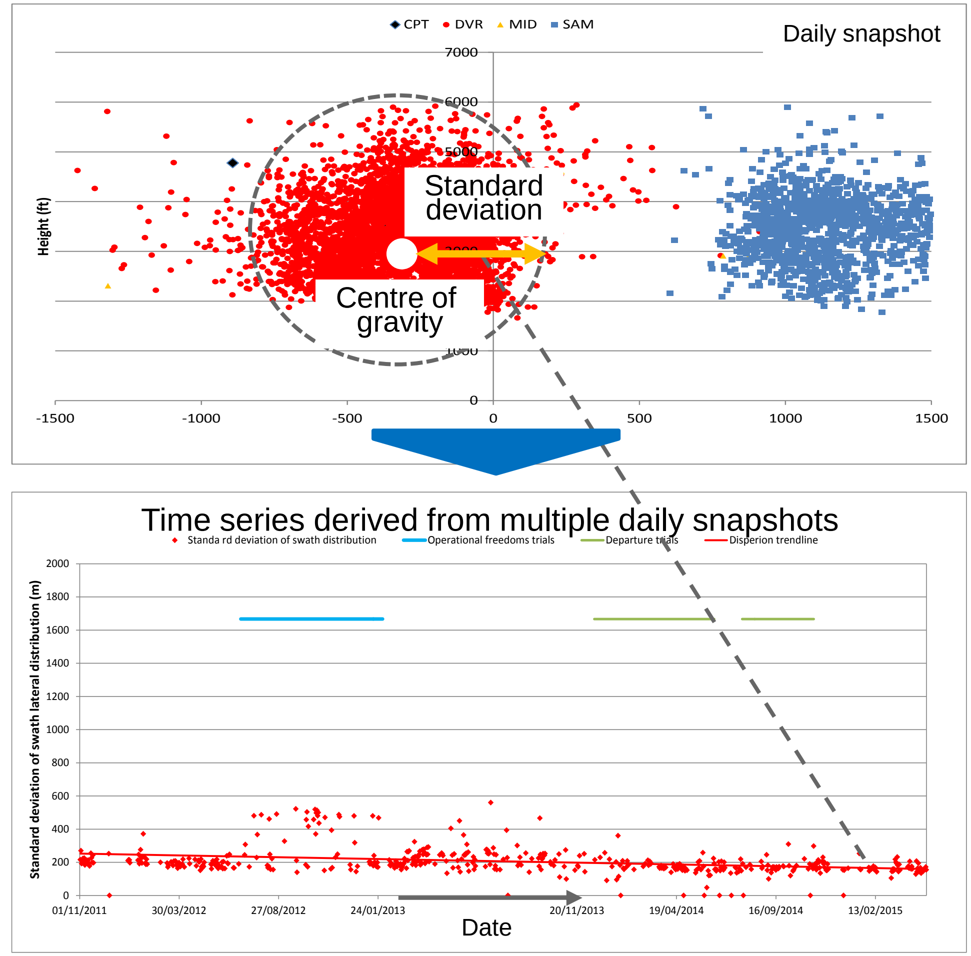
The variation of lateral centre of gravity (mean average), lateral extent and lateral dispersion (standard deviation) of the swath is analysed on a daily basis

Lateral centre of gravity and extent of swath



Each point represents the lateral centre of gravity of the swath on a daily basis. Each bar represents the lateral extent of the swath. The solid red line is the best straight line fit to the centre of gravity

The spread of the swath

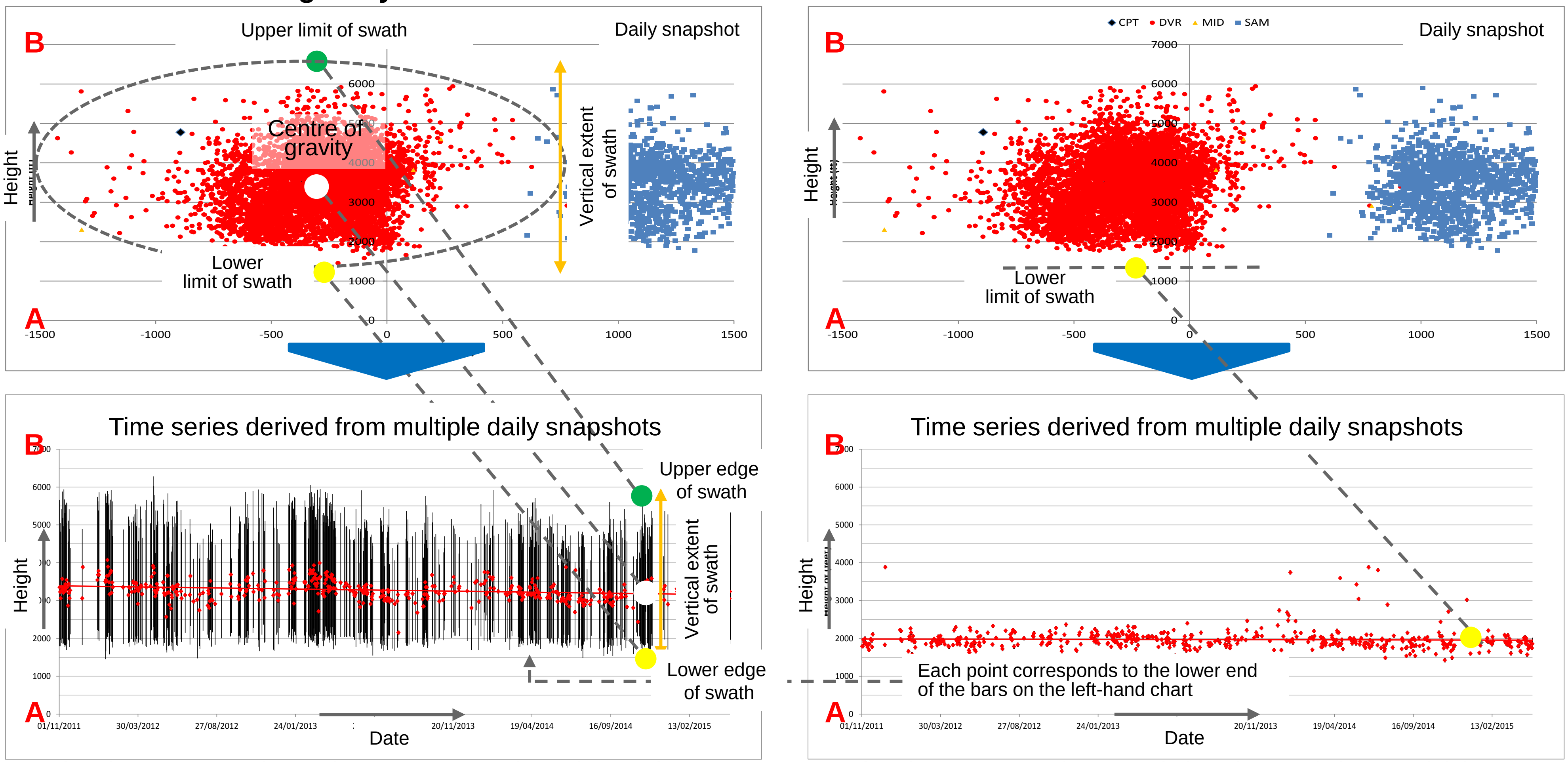


Each point represents the standard deviation of the lateral swath distribution as a measure of the lateral spread or dispersion of the swath. The solid red line is the best straight line fit to the dispersion

Similarly, the vertical centre of gravity and the bottom limit of the swath are used to describe the swath's vertical characteristics on a daily basis

Vertical centre of gravity and extent of swath

Lower limit of the swath

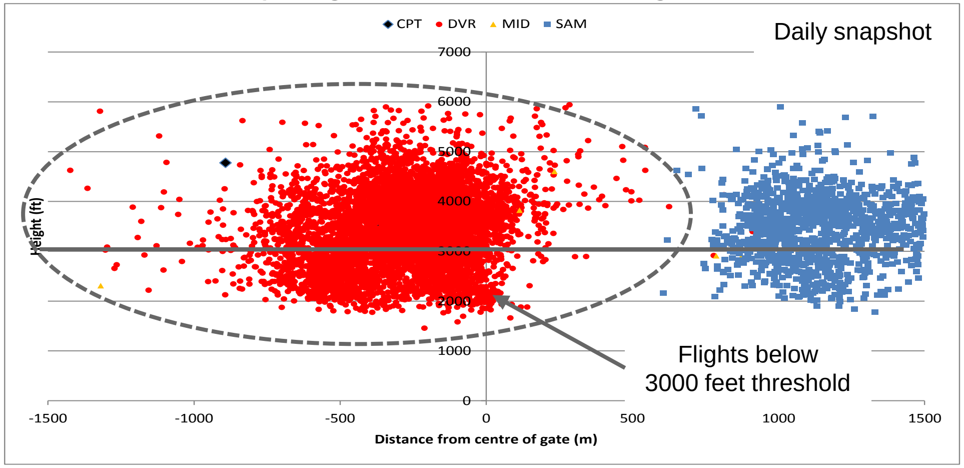


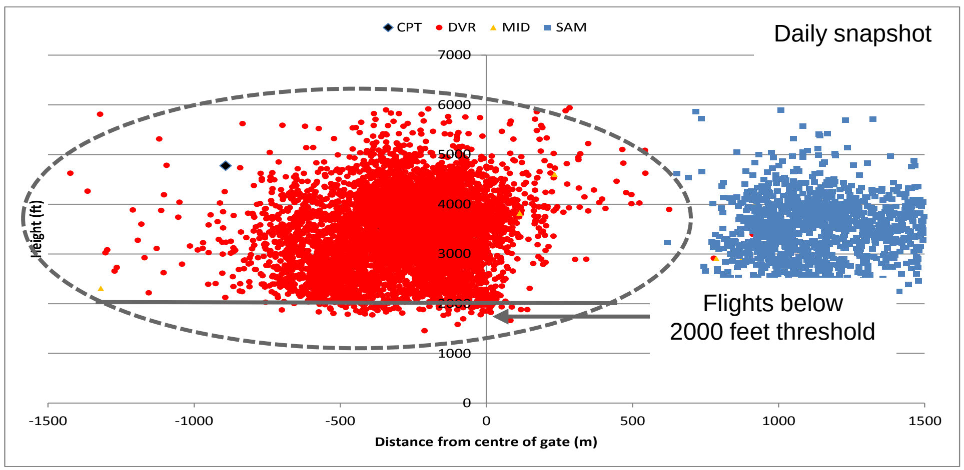
Each point represents the vertical centre of gravity of the swath on a daily basis. Each bar represents the vertical extent of the swath. The solid red line is the best straight line fit to the centre of gravity

Each point represents the lower limit of the swath (lowest flight) on a daily basis. The solid red line is the best straight line fit

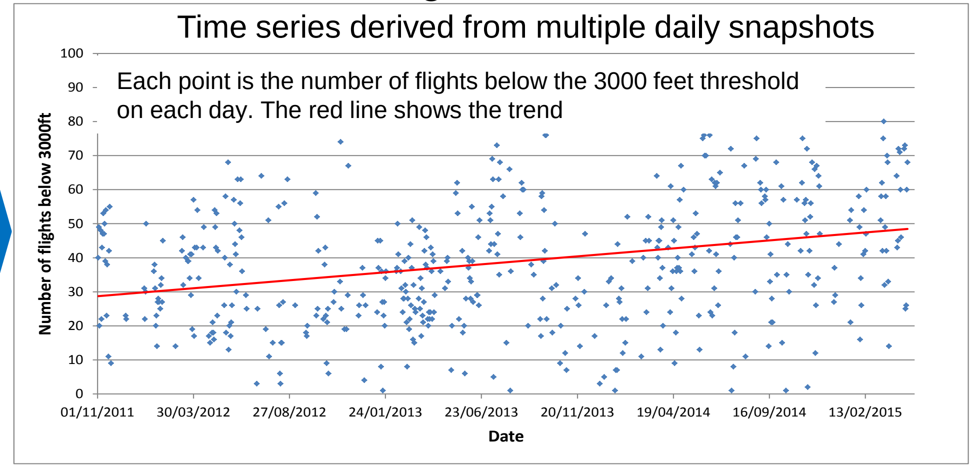
The daily number of flights below thresholds of 3000 feet and 2000 feet are used as additional measures to quantify height performance

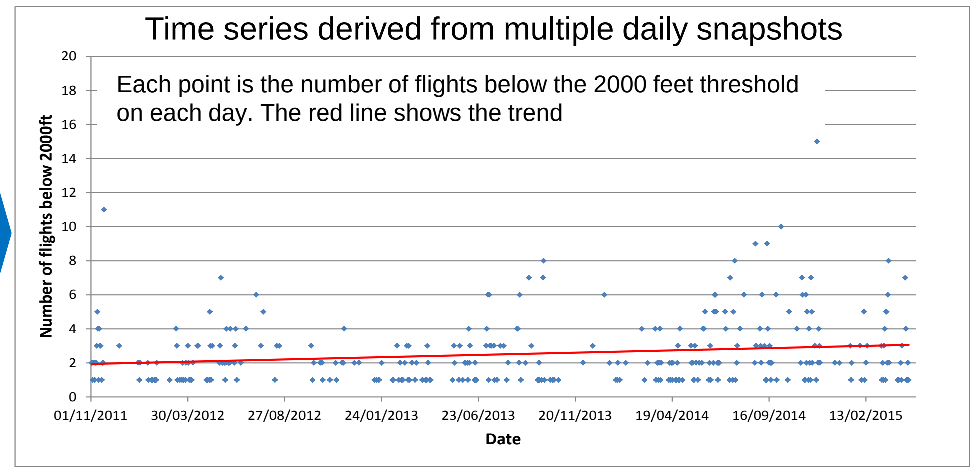
Daily flight distribution at gate





Number of flights below threshold





Each point represents the number of flights assigned to a SID below the threshold. The red line represents the best straight line fit

The concentration 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

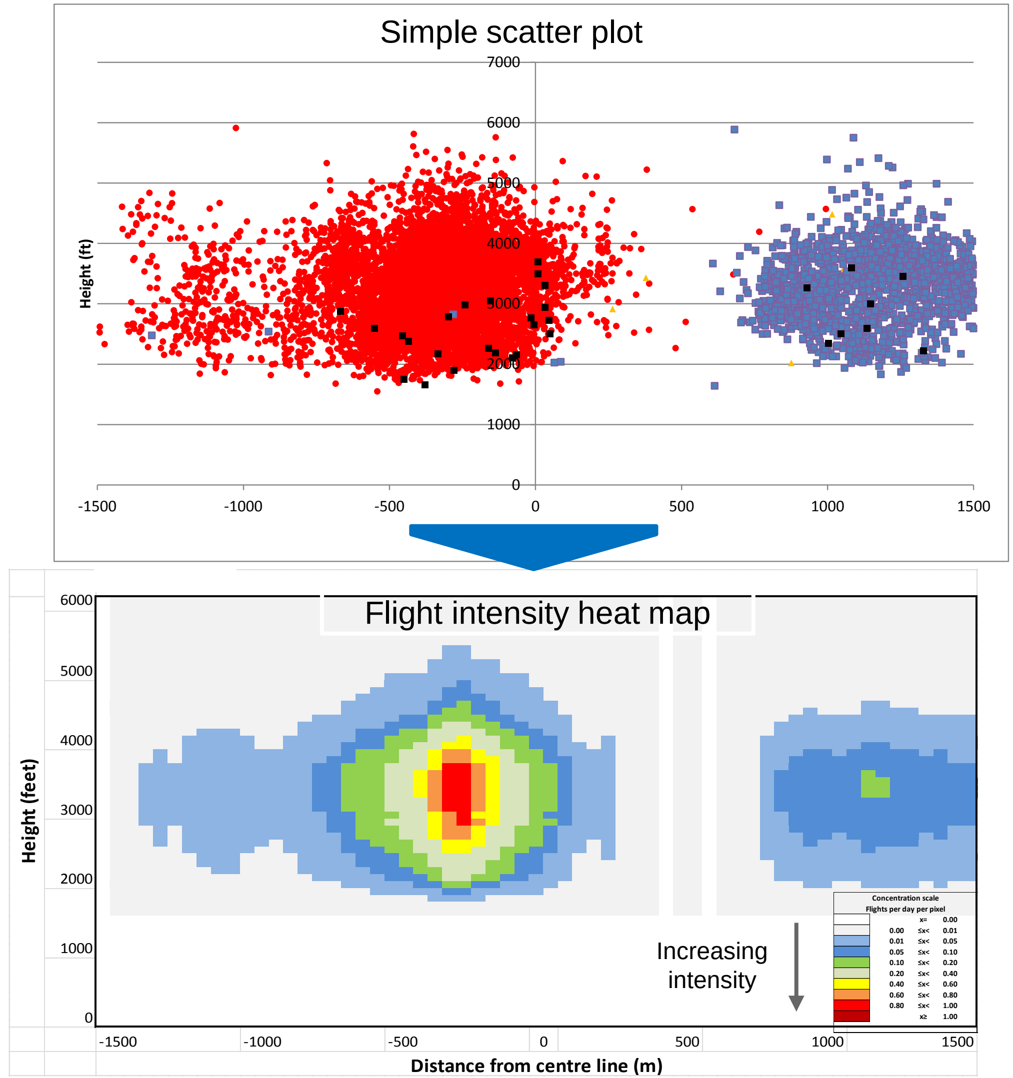
Because there are large numbers of flights crossing the gate during each analysis period, the points on the plot are superimposed and give little indication on the concentration or intensity of flights across the gate

Heat maps have been produced, using statistical distributions derived from the scatter plots, to give a measure of this concentration, derived from the statistical distributions of the flights

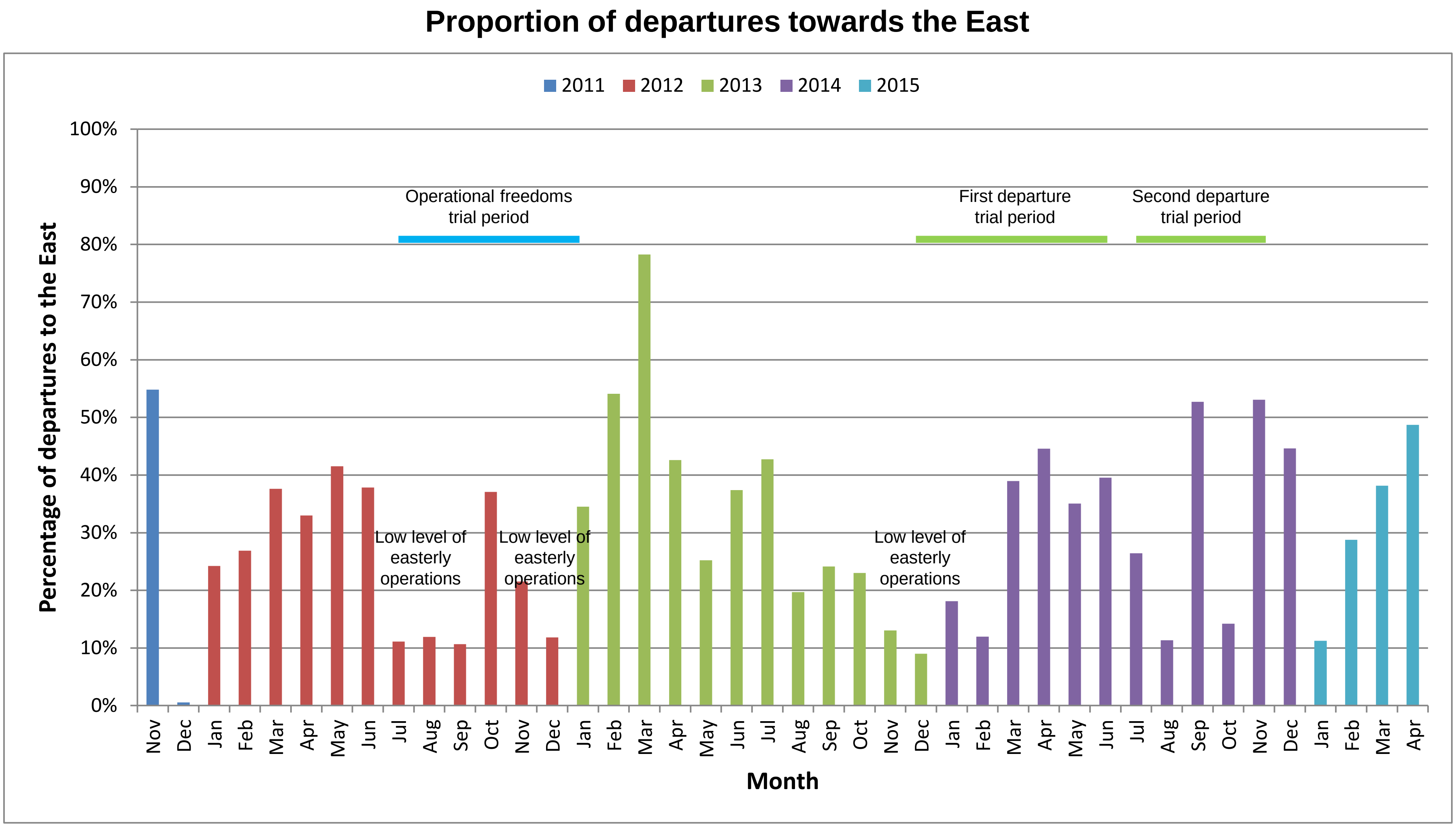
The heat maps are normalised to the number of days affected during each measurement period so that different measurement periods and different gates are directly comparable

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

The unit of intensity is flights per day per pixel



Finally the analysis must be understood in the context of the easterly:westerly split that influences the number of flights operating during the measurement period



DOVER NPR RESULTS

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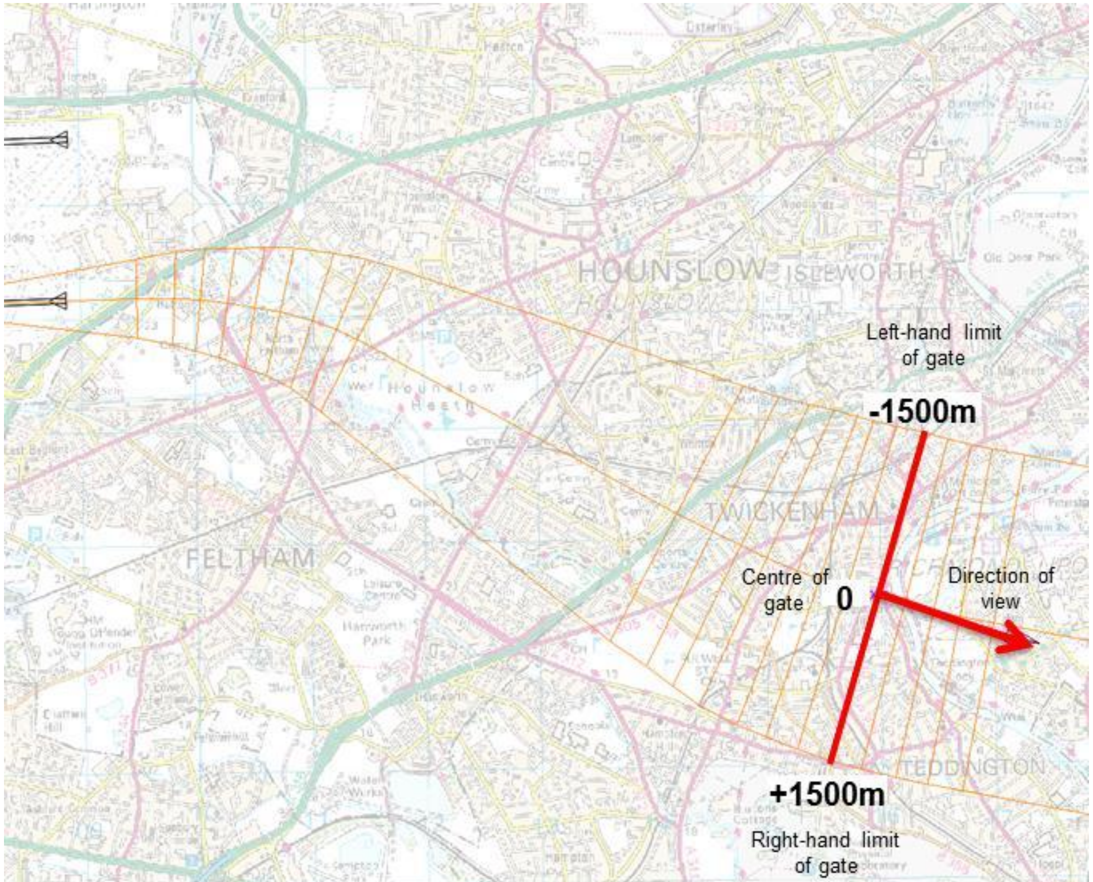
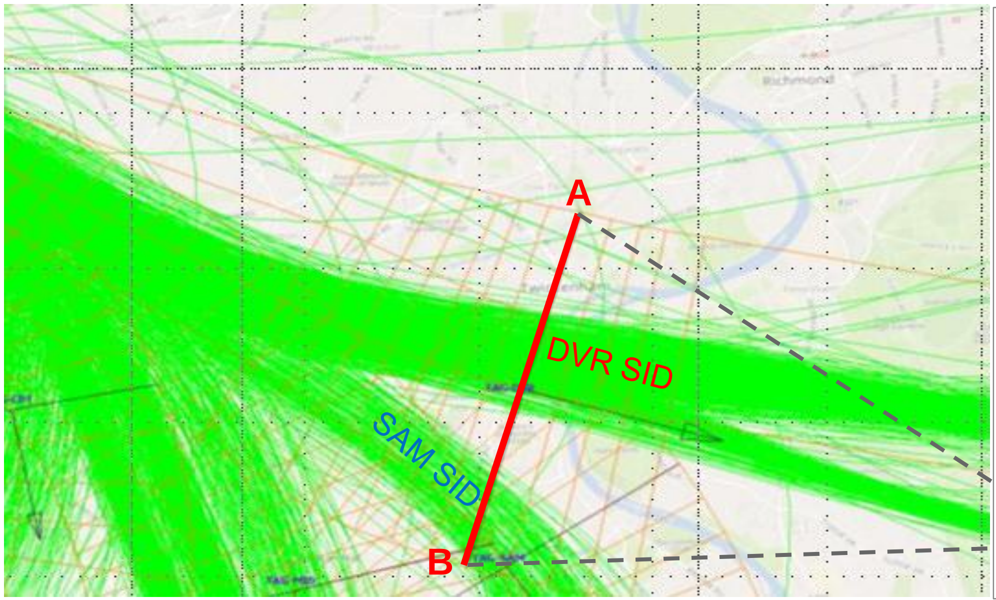
The DVR gate is located at the intersection of the DVR noise preferential route (NPR) centreline and Strawberry Vale/Cross

Location of the DVR NPR gate

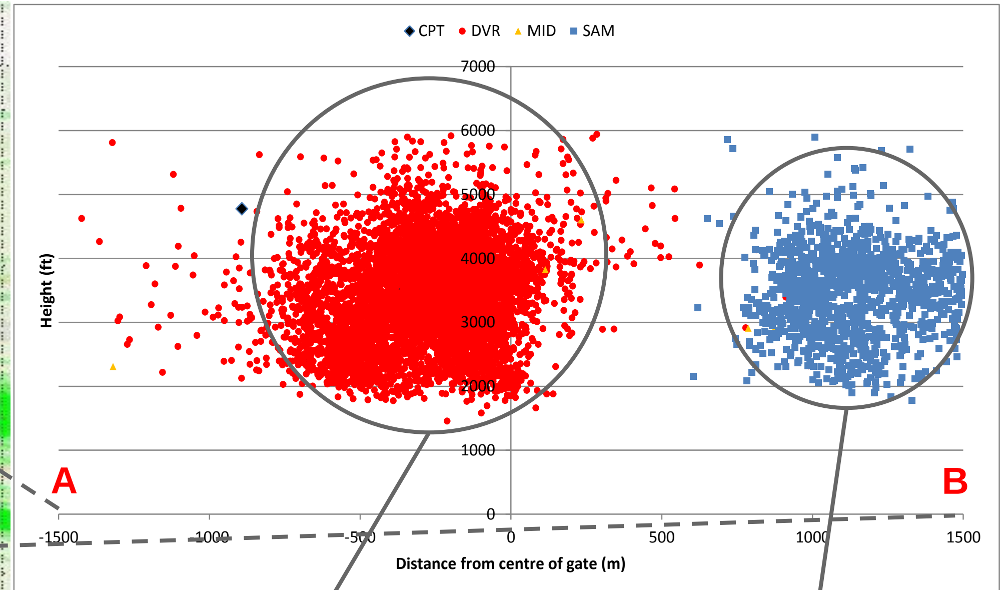


The DVR gate captures traffic using the DVR SID, near to its centre, and traffic using the SAM SID at its right hand extreme

Position of the DVR NPR gate and associated departure flows



Typical horizontal and vertical traffic distribution at the DVR NPR gate

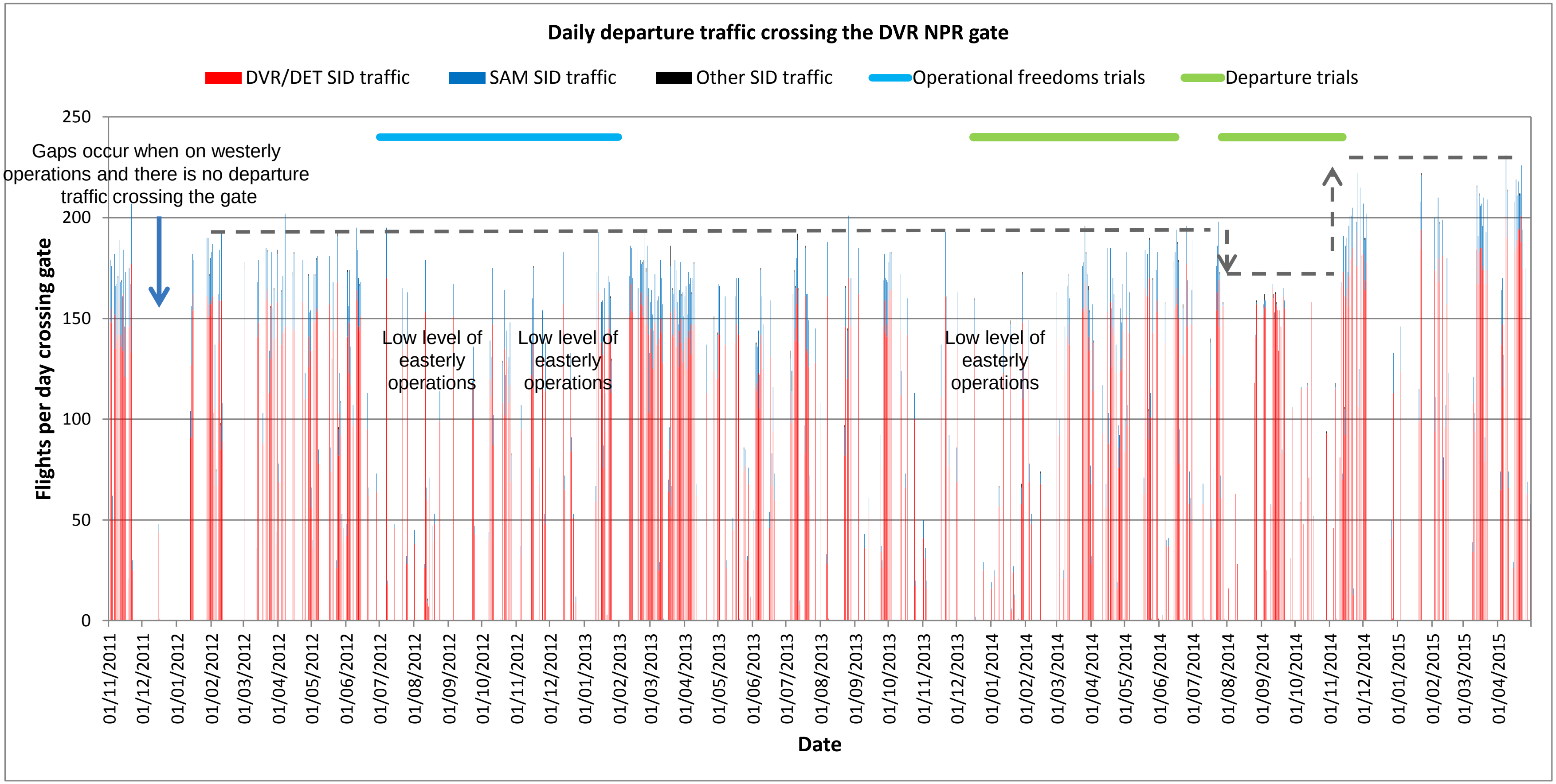


Traffic departing along the DVR SID

Traffic departing along the SAM SID but falling within the DVR NPR

The traffic volume crossing the DVR gate per day was fairly flat until the start of the winter season 2014-15 when it increased

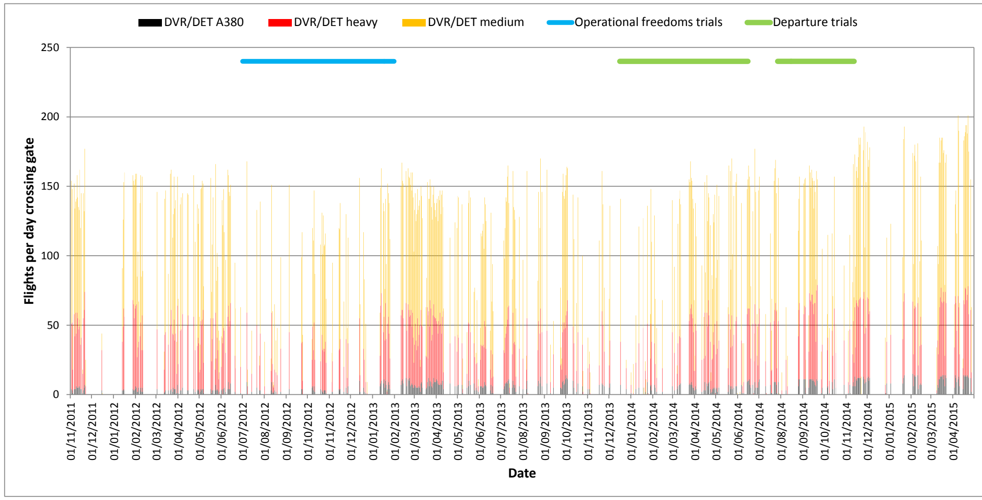
Daily departure traffic through the DVR NPR gate classified by SID



Reduction in volume due to SAM traffic being shifted out of the gate during the second departure trial

The number of A380s using the DVR SID has increased steadily from 2012 and, since autumn 2014, there has been an increase in the overall traffic volume

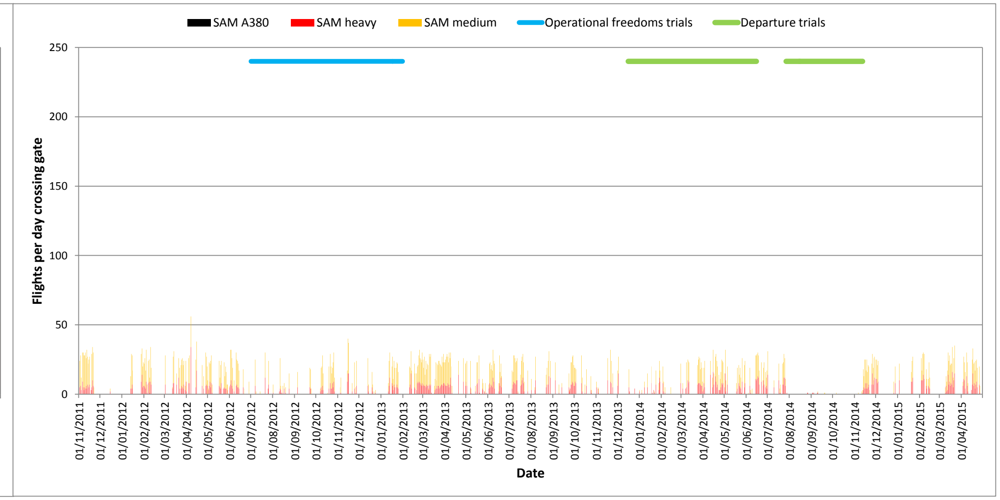
Daily DVR SID traffic through the DVR gate by aircraft type



Except for a decrease during the operational freedoms trial period, the total volume of daily traffic using the DVR SID was fairly consistent: approximately 150 flights per day from late 2011 until the beginning of the 2014-15 winter season. At this point the volume of traffic increased to around 180 per day.

The mix of aircraft using the route has also changed slightly over the analysis period. The number of A380s using the route has increased from four per day in late 2011 to, typically, 11 to 14 per day in 2015. The number of heavy aircraft using the route has also increased from 50 per day in 2011 to approximately 70 per day at present.

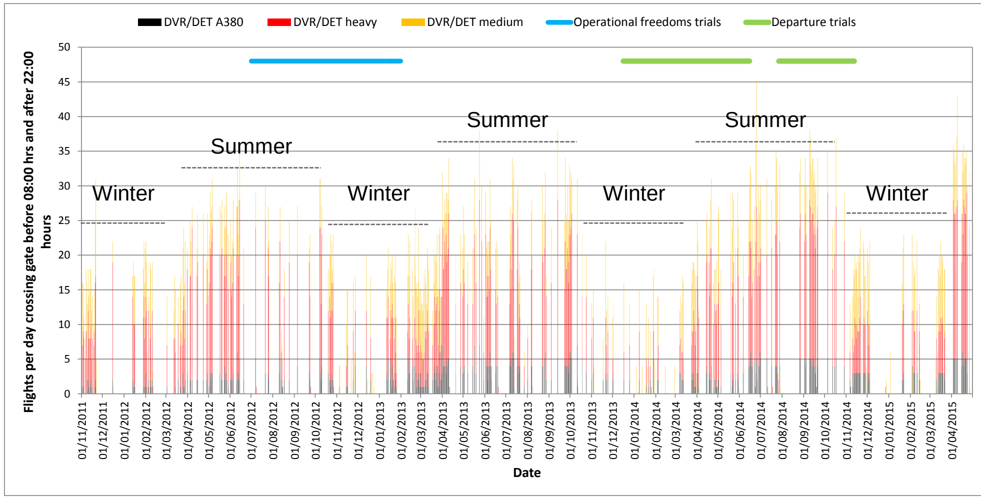
Daily SAM SID traffic through the DVR gate by aircraft type



Except during the operational freedoms and second departure trials periods, where there was a decrease, the volume of traffic crossing the DVR gate using the SAM SID has remained consistent at approximately 30 flights per day. The traffic is made up of heavy and medium aircraft with few A380s observed in the data.

The volume of traffic using the DVR SID before eight in the morning and after eight in the evening is cyclical with season and also appears to be increasing

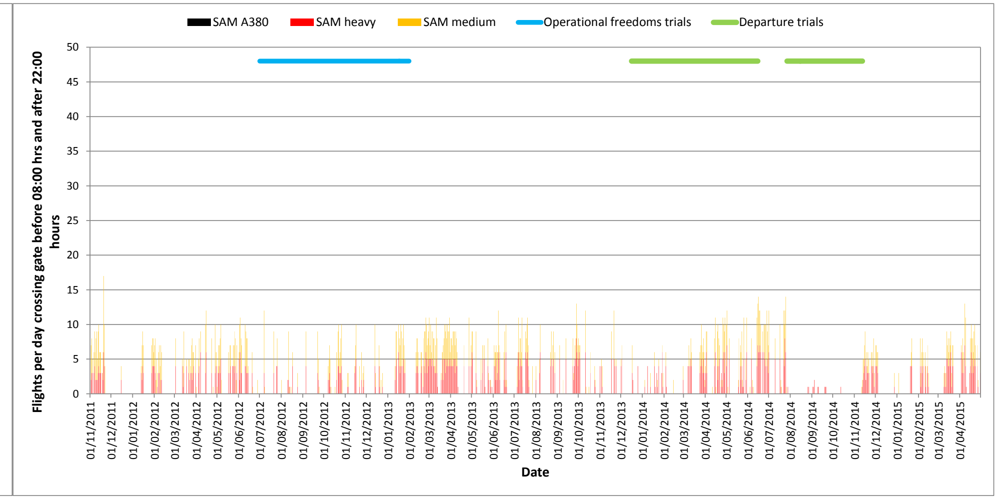
DVR SID traffic traversing the DVR gate before 08:00 hours and after 20:00 hours



The number of DVR SID flights traversing the DVR gate before 08:00 hours and after 20:00 hours has increased from approximately 20 flights per day in early 2012 to approximately 30 flights per day in 2013 and further to approximately 35 flights per day in early 2015. The volume of traffic is higher in summer than in winter.

At least 50% of these flights are by large aircraft and this often increases to higher proportions. Until the start of the 2013, there were only one or two A380s in the traffic mix: this has increased since then and is now typically three to five.

SAM SID traffic traversing the DVR gate before 08:00 hours and after 20:00 hours

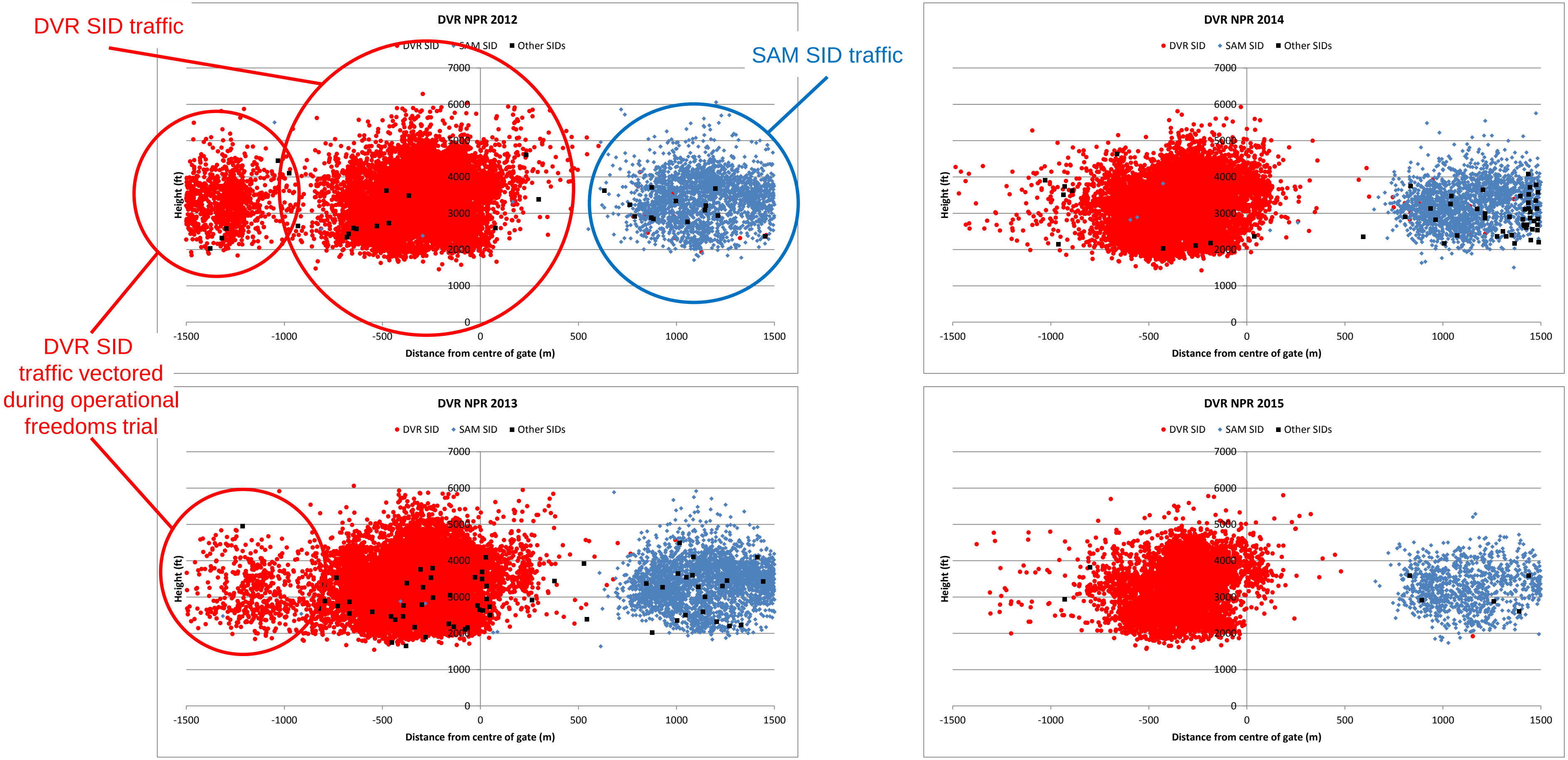


Apart from the period at the end of the first departure trial and during the second departure trial, the number SAM SID flights traversing the DVR gate before 08:00 hours and after 20:00 hours has remained consistent at between five and ten per day. During the end of the second trial period there appears to have been a slight increase in the number of flights whereas the flights disappear during the second departure trial.

Slightly over 50% of the flights during this time window appear to be made by heavy aircraft although there are no A380s in the mix.

The DVR gate captures the DVR SID traffic, most of the SAM SID traffic and occasional flights assigned to other SIDs

Annual spatial distribution of traffic crossing the DVR gate classified by SID

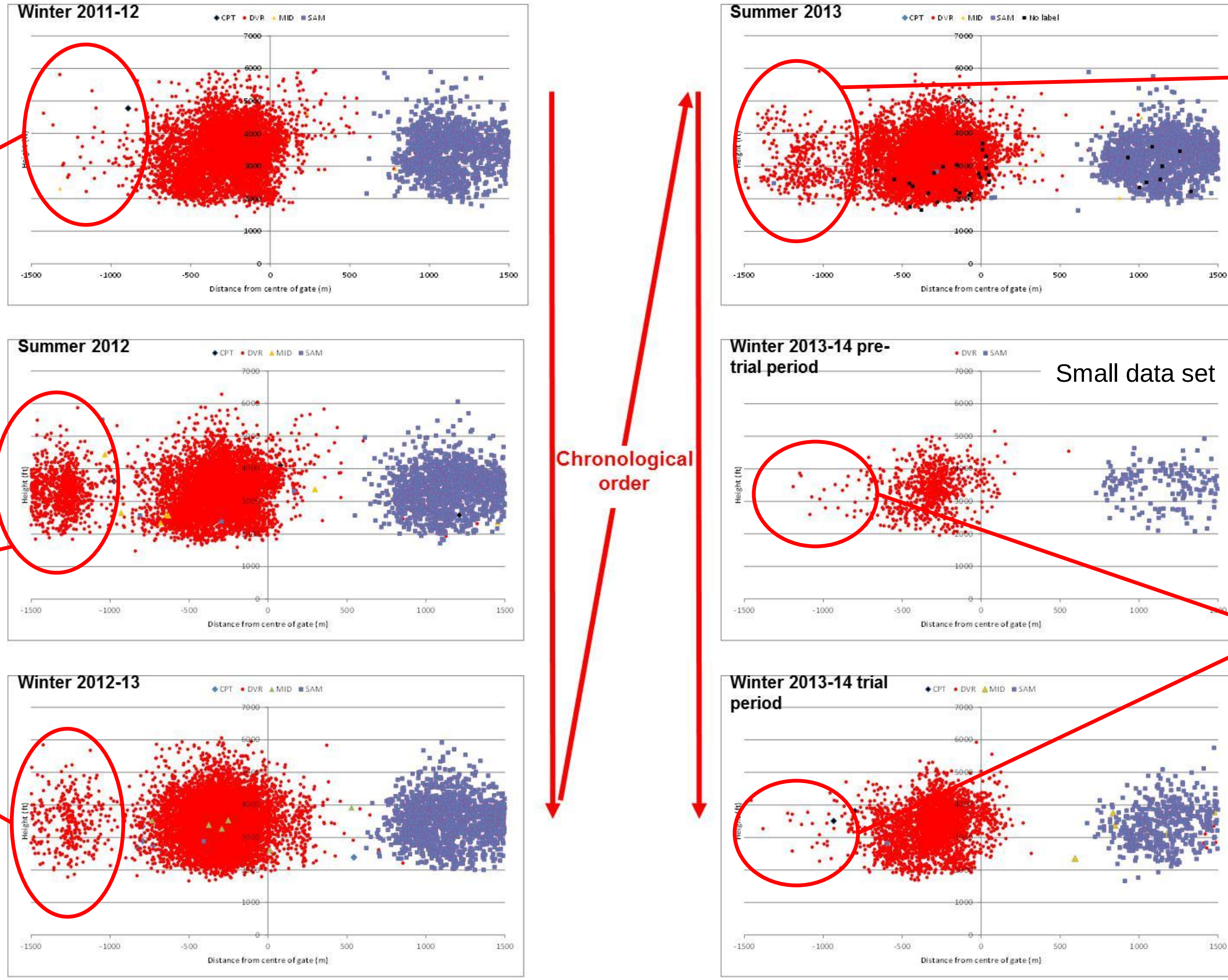


The DVR swaths clearly identify the effect of operational freedoms vectoring in 2012 and early 2013

Distribution of traffic crossing the DVR gate classified by SID for the first six analysis periods

The few flights to the left of the main swath outside of the trials periods are presumably flights subject to vectoring, e.g. because of weather

DVR SID traffic vectored during operational freedoms trial

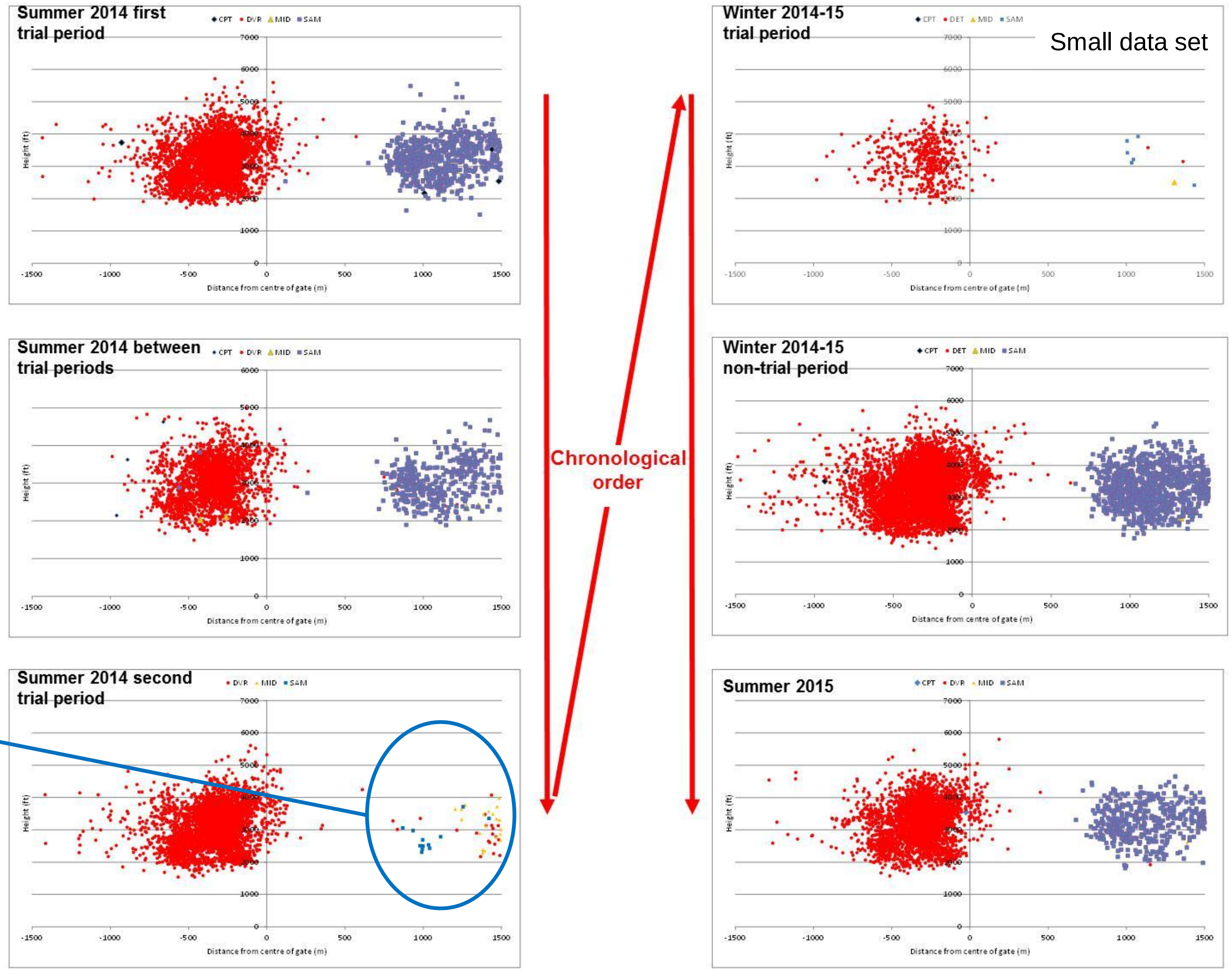


DVR SID traffic vectored during operational freedoms trial

The few flights to the left of the main swath outside of the trials periods are presumably flights subject to vectoring, e.g. because of weather

The effect of the second departure trial period is to move the SAM SID traffic out of the DVR gate with no perceivable effect on the DVR SID traffic

Distribution of traffic crossing the DVR gate classified by SID for the final six analysis periods



SAM SID
traffic disappears from
DVR gate during second
trial period

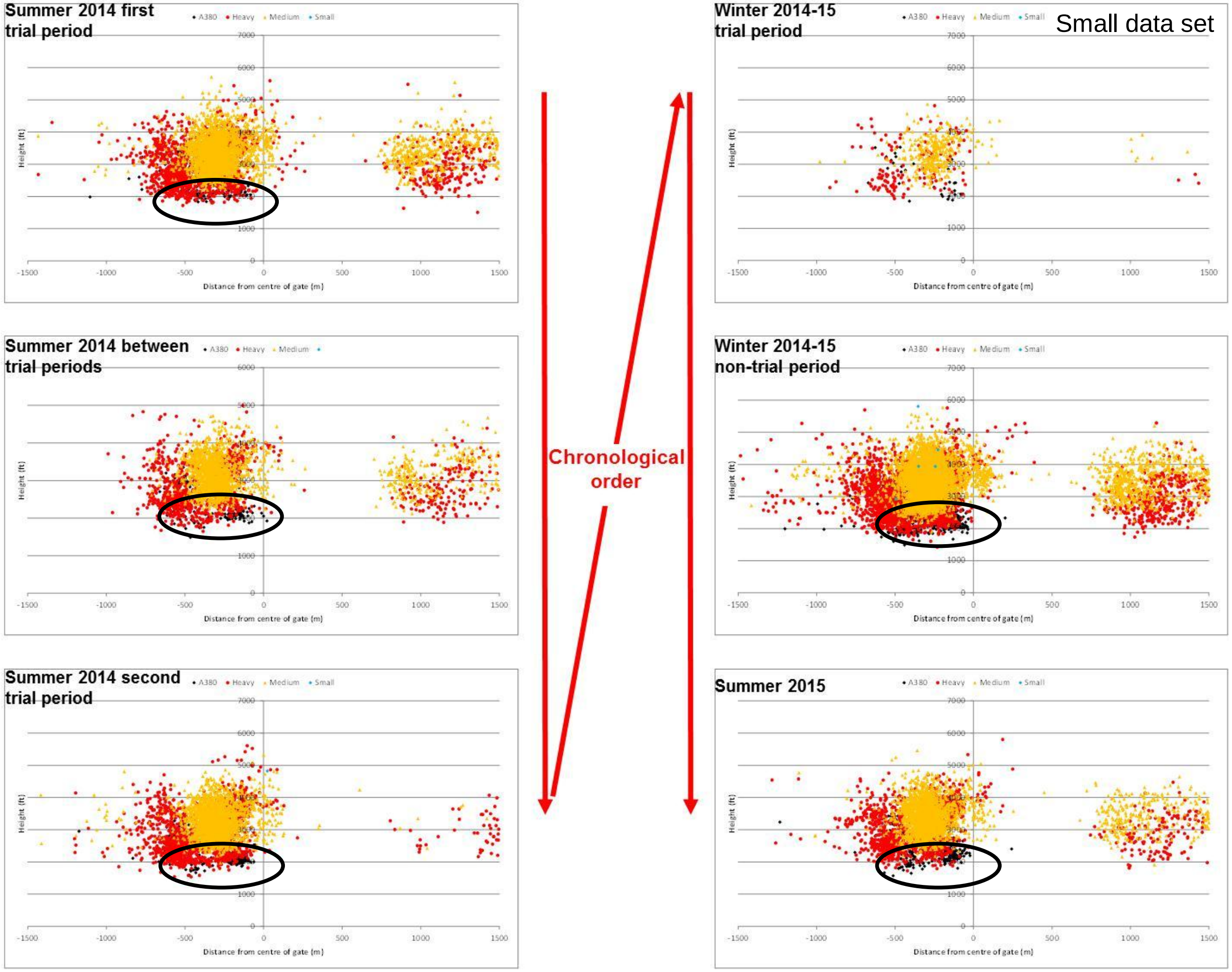
In 2012, the traffic vectored during the operational freedoms trial was mainly made up of medium aircraft: in 2013 it included more heavy aircraft and some A380s

Distribution of traffic crossing the DVR gate classified by aircraft type for the first six analysis periods

Over the period from late 2011 to spring 2015, the number of A380s can be seen to be increasing at the lower levels of the DVR SID swath

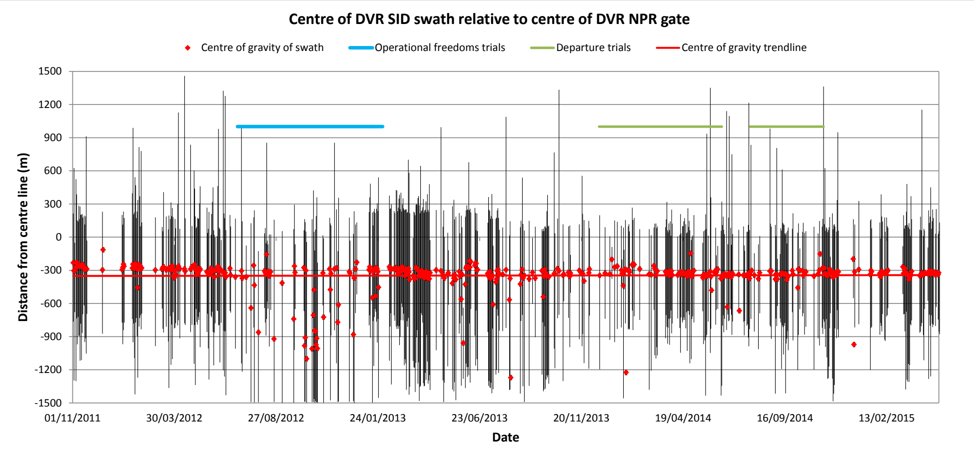
Distribution of traffic crossing the DVR gate classified by aircraft type for the final six analysis periods

Focus on A380s

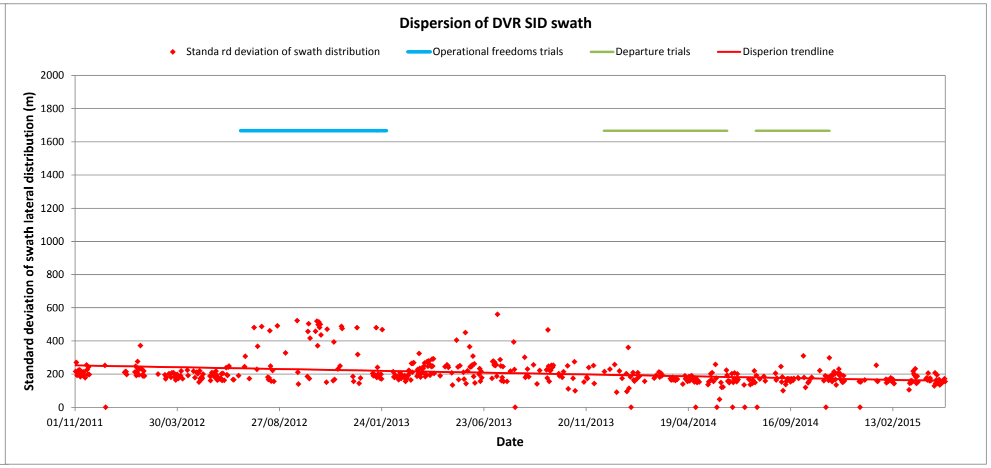


The lateral position of the DVR swath appears to be static but the traffic is becoming more concentrated

Lateral centre of gravity and extent of the DVR SID swath



Lateral dispersion of the DVR SID swath



The lateral centre of gravity of the DVR SID swath is fairly consistent at approximately 300m to the left of the centre line. Where there are fluctuations of the lateral centre of gravity from this position, the shift tends mostly to be further to the left of the centre-line and is most marked during the operational freedoms trial during the second half of 2012. It seems likely, therefore, that shifts of the centre of gravity from its normal position are due to controllers vectoring aircraft on the SID, as in the operational freedoms trial.

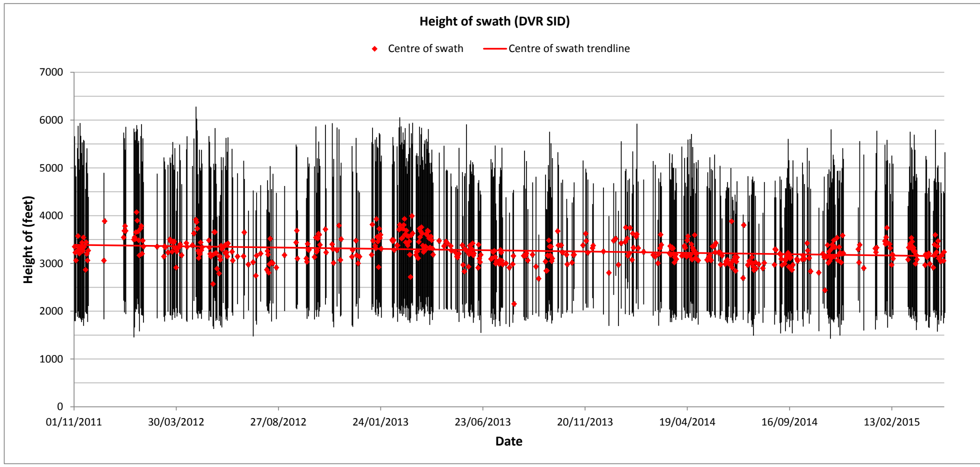
The lateral extent of the swath is very variable. This variation does not appear to be systematic. The lateral extent ranges from approximately 1200m to over 2.5km.

The lateral dispersion, defined as the standard deviation, gives a quantitative measure of the width of the swath. The chart above shows that the lateral dispersion of the swath was largest during the operational freedoms trial, caused by the vectoring of aircraft away from the usual centre of gravity. The overall trend in the dispersion is downwards, from approximately 250m in late 2011 to approximately 175m in April 2015. This implies that the traffic is becoming more concentrated around the centre of gravity.

Note the points with zero dispersion in the chart are associated with days with very low traffic, i.e. when operations are predominantly westerly

Over the analysis period, there appears to be a downward trend in the height of the DVR SID swath

Vertical centre of gravity and extent of the DVR SID swath at the DVR gate

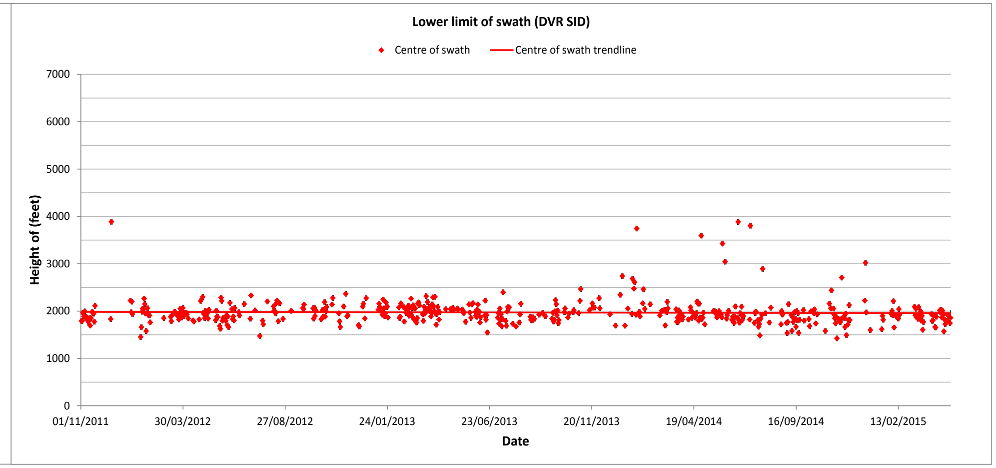


The vertical centre of gravity of the DVR SID swath fluctuates around an average value of approximately 3200 feet. At the 95% level the vertical centre of gravity of the swath ranges between 2800 feet and 3800 feet.

The vertical extent of the swath extends from approximately 1400 feet to approximately 6200 feet. The top of the swath appears to be getting lower.

The trend of the height of the centre of gravity appears to be downwards. The trend-line suggests a decrease from approximately 3400 feet in late 2011 to approximately 3100 feet at the end of April 2015.

Lower limit of the DVR SID swath at the DVR gate

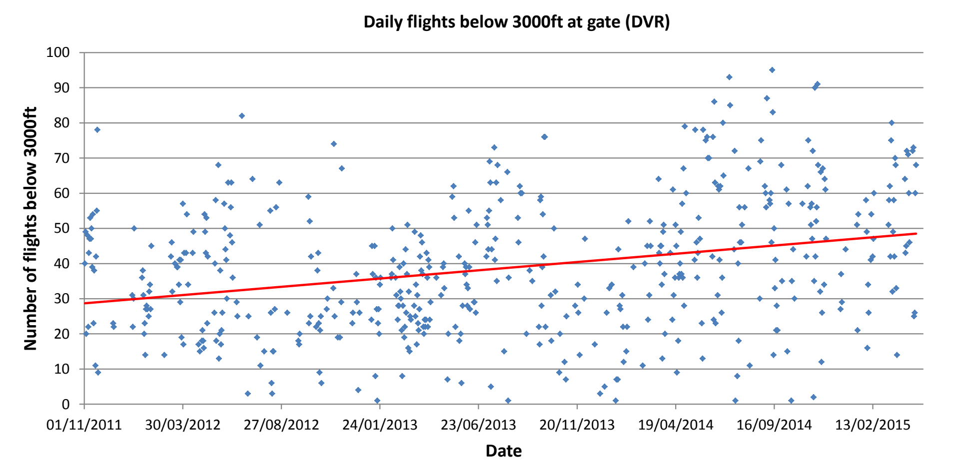


The lower limit of the swath is defined by the lowest aircraft flying on the DVR SID traversing the gate each day. On average, this height is approximately 2000 feet. There is a perceptible trend in this over the analysis period from slightly above 2000 feet in late 2011 to slightly below 2000 feet in spring 2015.

There are daily fluctuations above and below the trend line. The bounds of these fluctuations are that on 95% of days the lower limit of the swath is between 1600 feet and 2600 feet. During the measurement period, the lowest aircraft traversed the gate at a height of 1423 feet.

There is also a increasing trend in the number of aircraft crossing the gate at heights below 3000 feet and below 2000 feet

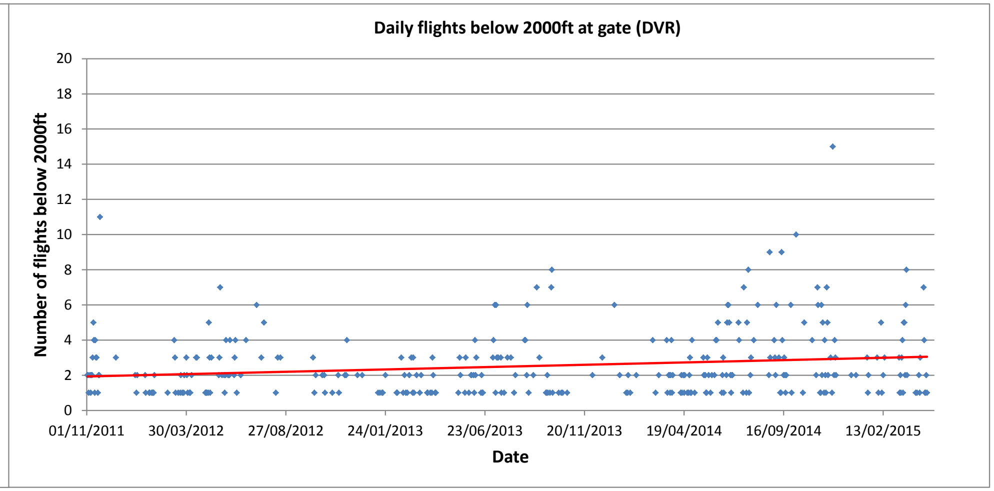
Daily number of flights along the DVR SID below 3000 feet at the DVR gate



The number of flights on the DVR SID crossing the gate at a height of less than 3000 feet varies very widely and randomly from fewer than 10 on some days to, occasionally, over 90 per day.

The best straight line fit to the data, shown as the red line in the chart above, indicates that trend on the number of DVR SID flights crossing the gate below 3000 feet is upwards.

Daily number of flights along the DVR SID below 2000 feet at the DVR gate



The number of DVR SID flights crossing the gate at below 2000 feet varies from a minimum of one per day up to 15 on one single occasion.

The trend on the number of flights crossing the gate at below 2000 feet appears to be slightly upwards but only increasing from two flights per day in late 2011 to three flights per day by April 2015.

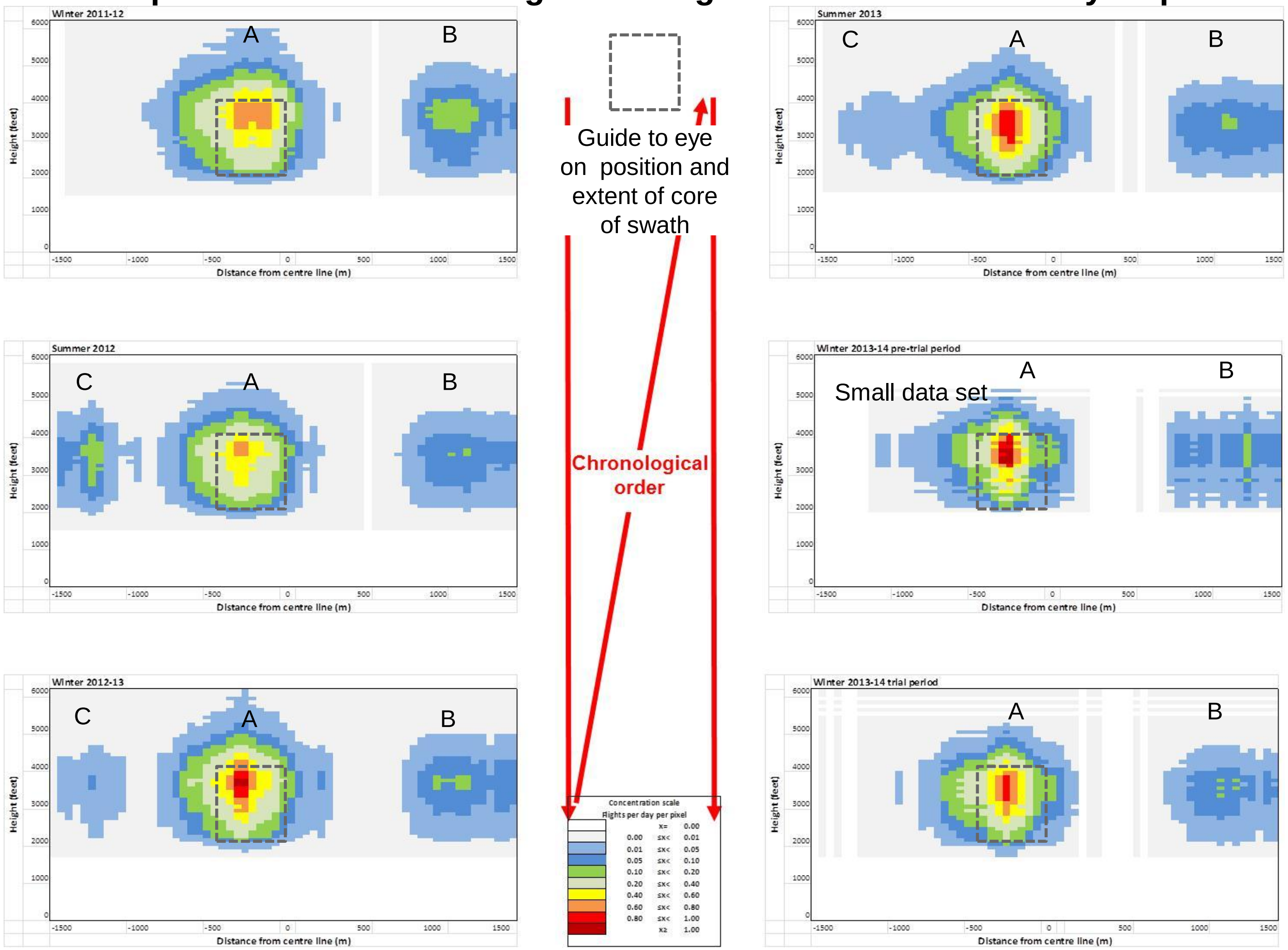
During 2012 and 2013, heat maps show the core of the DVR SID traffic at approximately 300m to the left of the centre line and between 3000 and 4000 feet

Heat maps of the traffic crossing the DVR gate for the first six analysis periods

There are two hot spots in the DVR NPR gate, A, for the DVR SID and B for the SAM SID. A is more intense that B

Due to vectoring during the operational freedoms trial, the hot spot in the DVR SID splits, with A remaining at the core of the main swath and C appearing at the edge of the gate, with lower intensity

During the winter period of the operational freedoms trial the hot spot at the core of the DVR swath increases in intensity and C at the left hand edge decreases



The hot spot A increases in size and intensity. The cooler hot spot C has virtually disappeared as operational freedoms ends.

The size of the sample is too small to allow reliable interpretation

The DVR hot spot, A, persists in approximately the same position

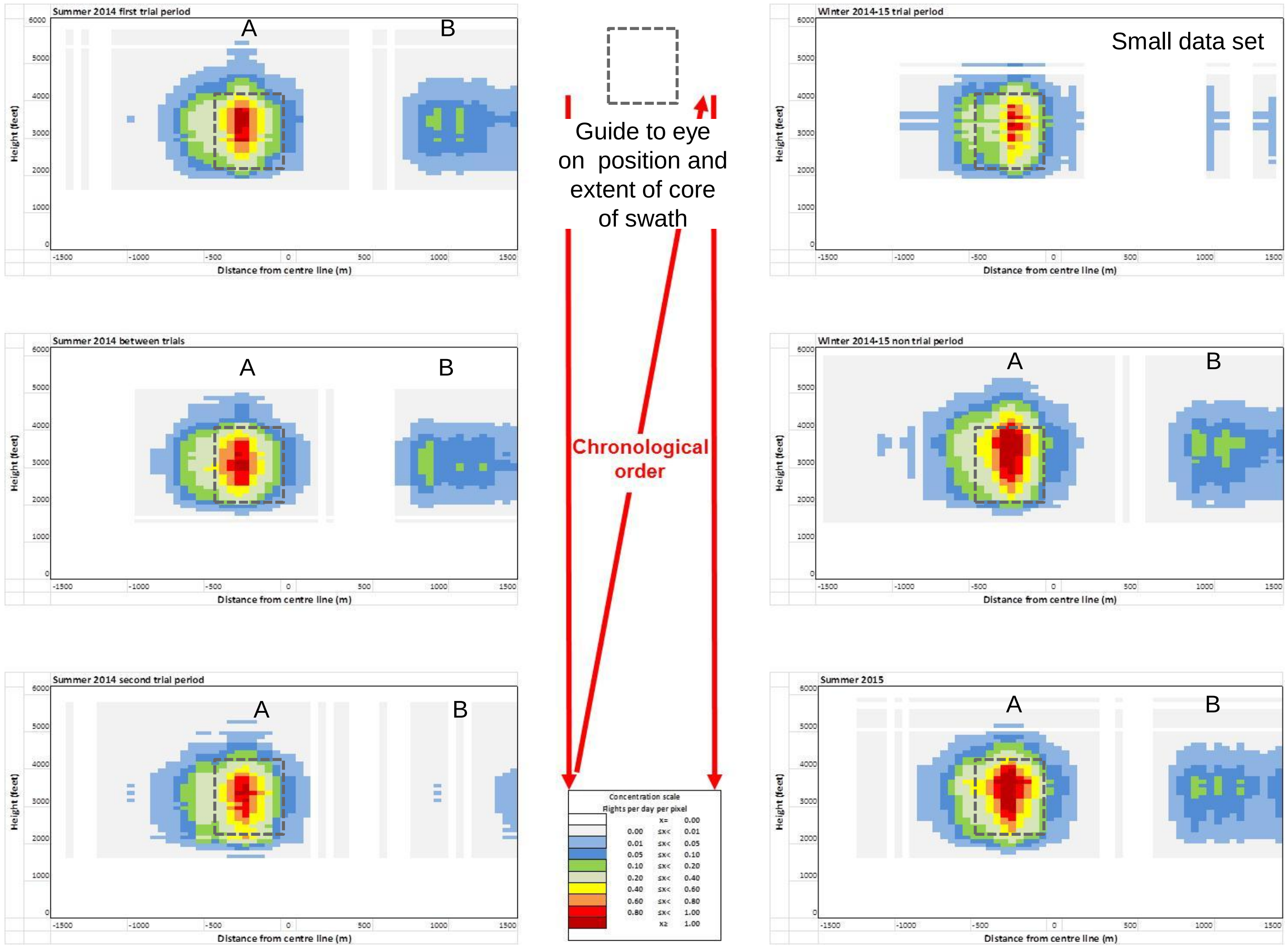
The heat maps show the traffic at the core of the DVR swath is becoming more concentrated and extending to lower heights

Heat maps of the traffic crossing the DVR gate for the final six analysis periods

The intense region at the core of the DVR swathe hot spot increases in size and becomes more intense

The pattern of the heat structure is very similar to the previous period, with the intense core of the hot spot A becoming broader

The heat pattern of the DVR swath is very similar to the previous period. The SAM SID swath disappears from the gate due to the second trial



The size of the sample is too small to allow reliable interpretation

The SAM hot spot returns to the gate. The core of the DVR hot spot has increased in size and intensity and extends to lower heights than previously

The trend for increase in size and intensity of the DVR hot spot continues

Over the analysis period there have been some measurable changes in the traffic pattern using the DVR SID at the DVR gate

Conclusions concerning the DVR SID at the DVR gate

Traffic volume & mix

The post trial traffic volumes at the **DVR gate** (comprising DVR and SAM traffic) are higher than pre-trial levels. There is a decrease during the second trial period due to SAM traffic being shifted out of the DVR gate

After remaining approximately constant (~150) from late 2011 to summer 2014, the daily volume of traffic using the **DVR SID** increased to ~180 per day at the start of the 2014 winter season (November 2014), continuing through to 2015. Similarly the number of flights crossing the gate before 08:00 hours and after 20:00 hours has also increased latterly. The pattern of these night flights is cyclical with higher volume in the summer season than the winter season.

The proportion of large aircraft using the DVR SID has also increased: A380s have increased from 4 per day in late 2011 to up to 14 per day in early 2015. The volume of other large aircraft has also increased, up to 70 per day from 40 to 50 per day. A380 aircraft typically fly at the bottom of the traffic swath and other heavy aircraft tend to fly lower than medium aircraft

Lateral position

Other than during the operational freedoms trials, the lateral position of the centre of gravity of the DVR SID has not moved appreciably. The DVR route was unaffected by the 2013-14 departure trials

The traffic using the DVR SID has become much more concentrated in the core of the swath at point approximately 300m to the left of the centre-line of the NPR. As well as increasing in intensity, the core of the swath has increased in size, extending both laterally and to lower heights

Height

The analysis suggests that the trend for aircraft using the DVR SID is to fly lower than previously:

- heat maps show that the core of the traffic has become more concentrated and is extending to lower heights
- the vertical centre of gravity of the swath (not necessarily the centre of concentration) has decreased in height from approximately 3400 feet in 2011 to approximately 3100 feet in 2015
- the trend on the number of aircraft flying below 2000 feet and 3000 feet is increasing
- the minimum aircraft height at the gate appears to be decreasing and now is typically just below 2000 feet. On 95% of days the lower limit of the swath is between 1600 and 2000 feet
- the absolute minimum height at the gate over the period was 1423 feet

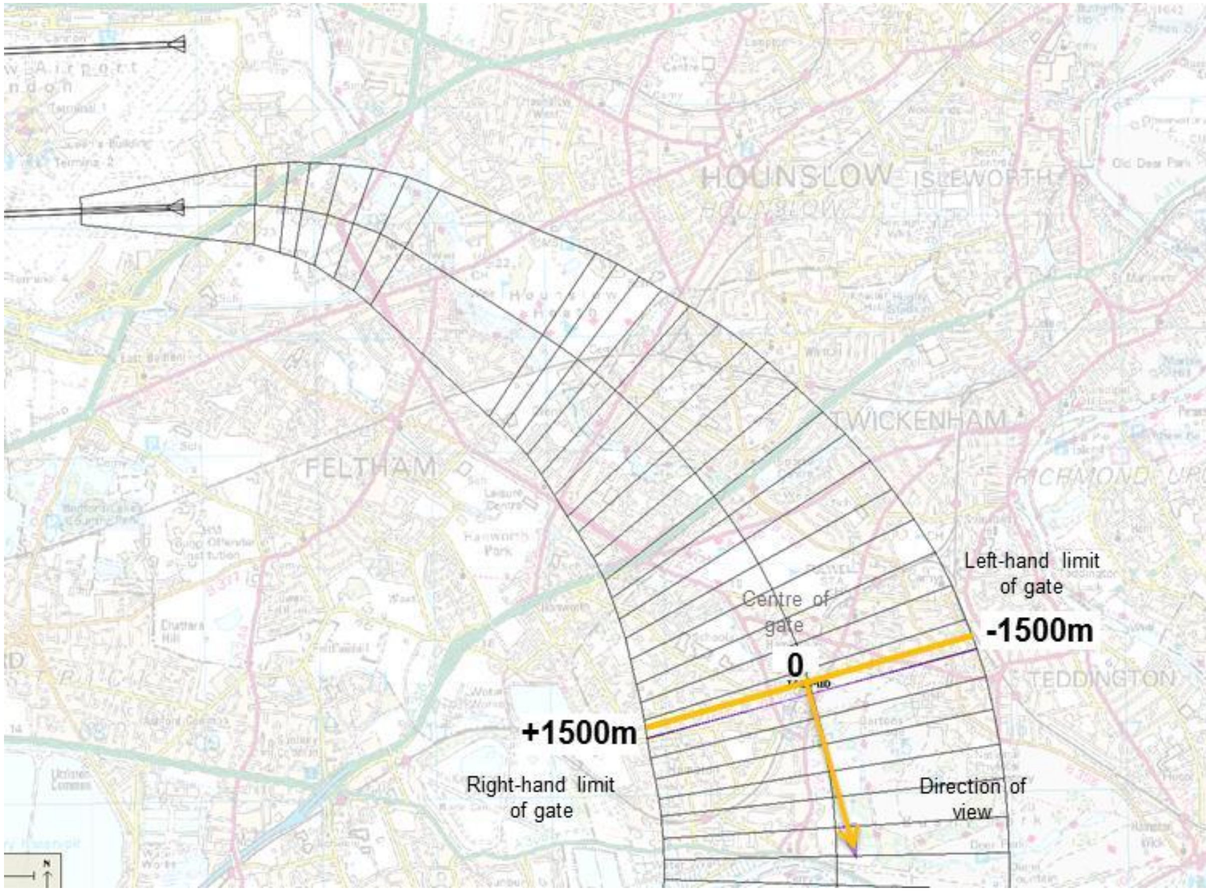
Note: Detailed conclusions concerning the SAM SID are drawn in section 5

MIDHURST NPR RESULTS

4

The MID gate is located at the intersection of the MID NPR centreline and Park Road

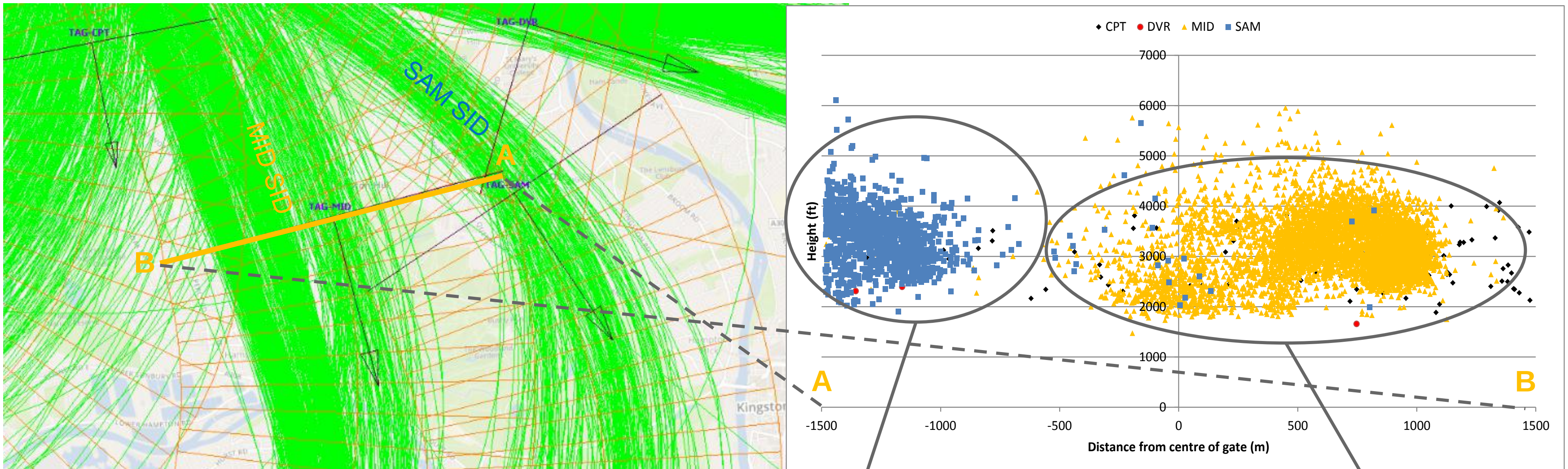
Location of the MID NPR gate



The MID gate captures traffic using the MID SID, slightly to the right hand side, and traffic using the SAM SID at the left hand extreme

Position of the MID NPR gate and associated departure flows

Typical horizontal and vertical traffic distribution at the MID NPR gate

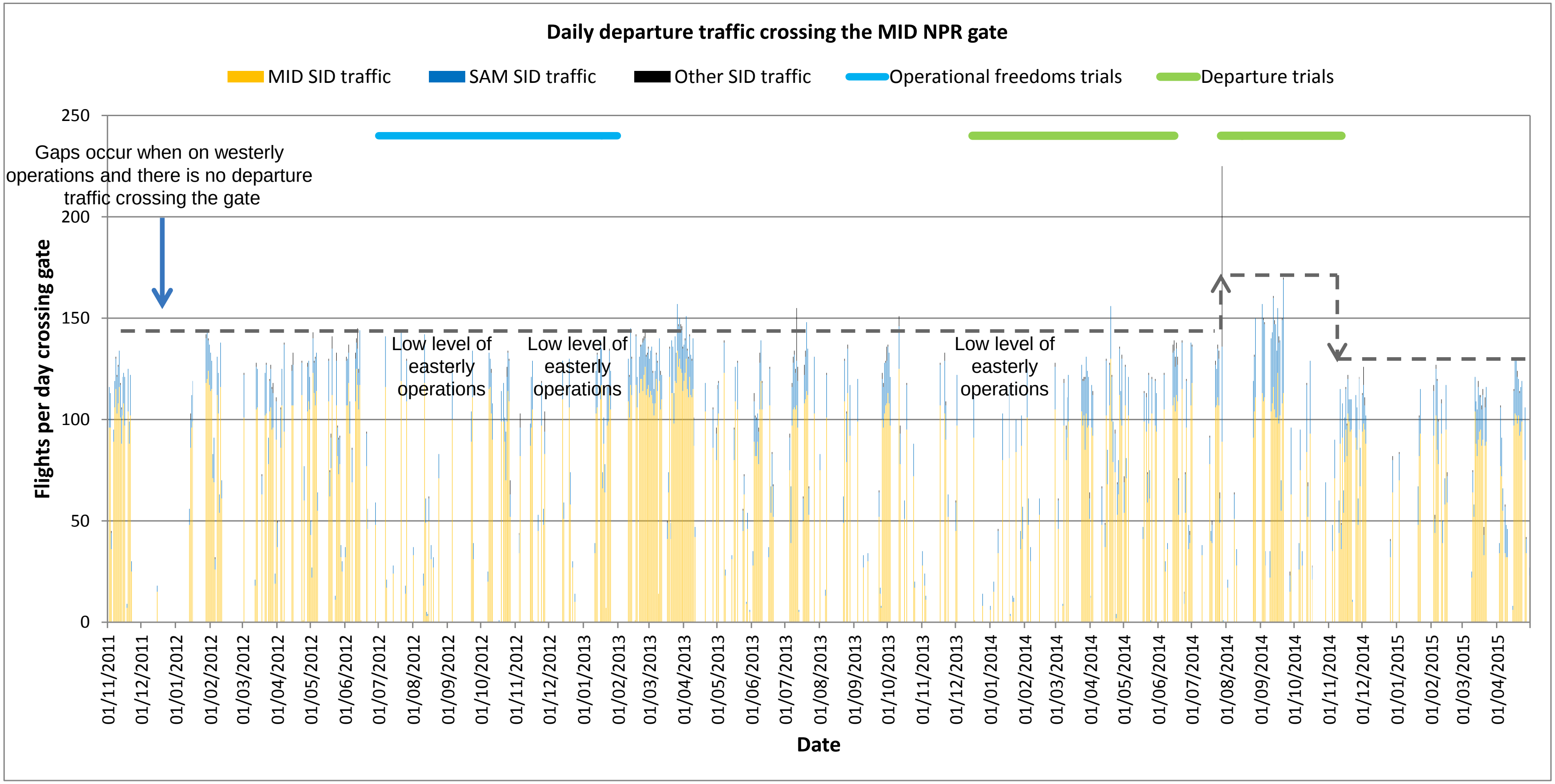


Traffic departing along the SAM SID but falling within the MID NPR

Traffic departing along the MID SID

The traffic crossing the MID gate increases during the second trial period due to a shift in the SAM SID and then appears to fall slightly below the pre-trial level

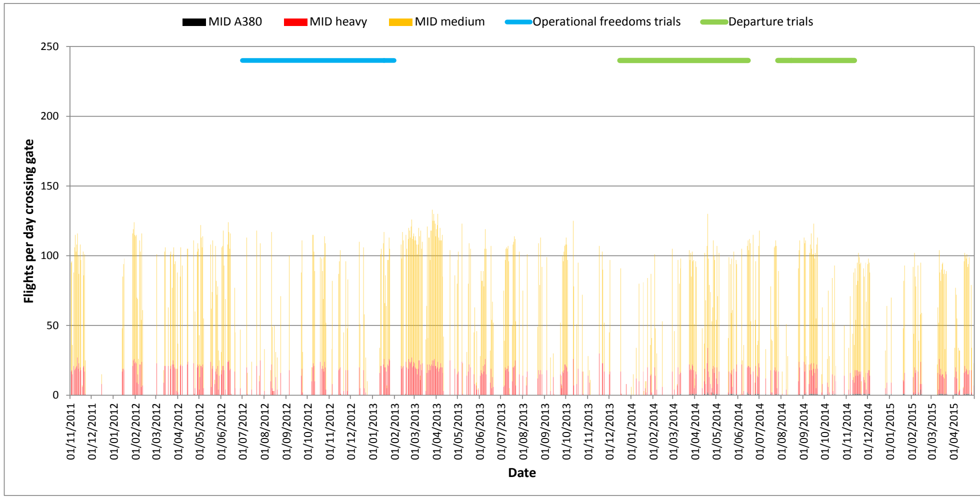
Daily departure traffic through the MID NPR gate classified by SID



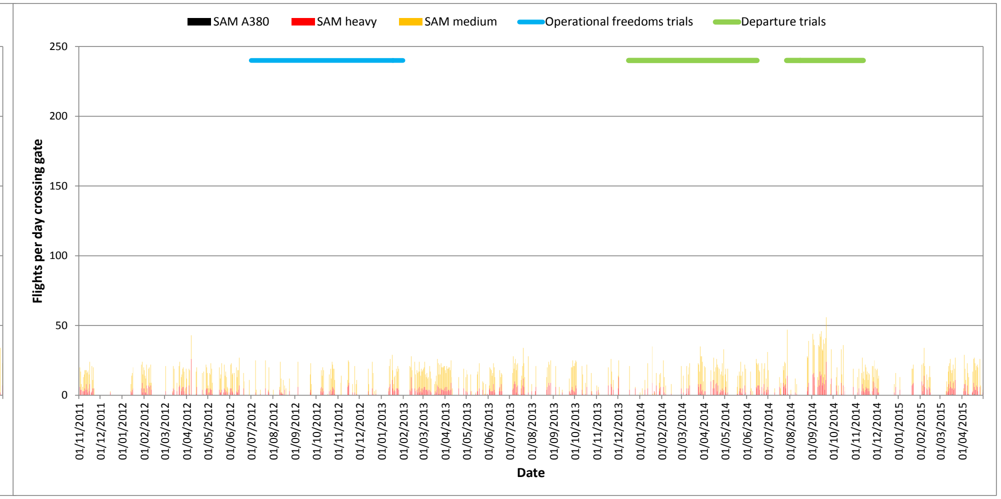
Increase in volume due to SAM traffic being shifted into the gate during the second departure trial

On average, the volume and mix of the traffic using the MID SID appears to reduce very slightly over the analysis period but with fluctuations from day-to-day

Daily MID SID traffic through the MID gate by aircraft type



Daily SAM SID traffic through the MID gate by aircraft type



Until the second departure trial period the traffic using the MID SID is at a reasonably constant level at just over 100 per day on easterly days, albeit with fluctuations above and below. This is approximately half of the traffic volume using the DVR SID. After the second trial, the traffic volume appears to decrease slightly to just below 100 per day.

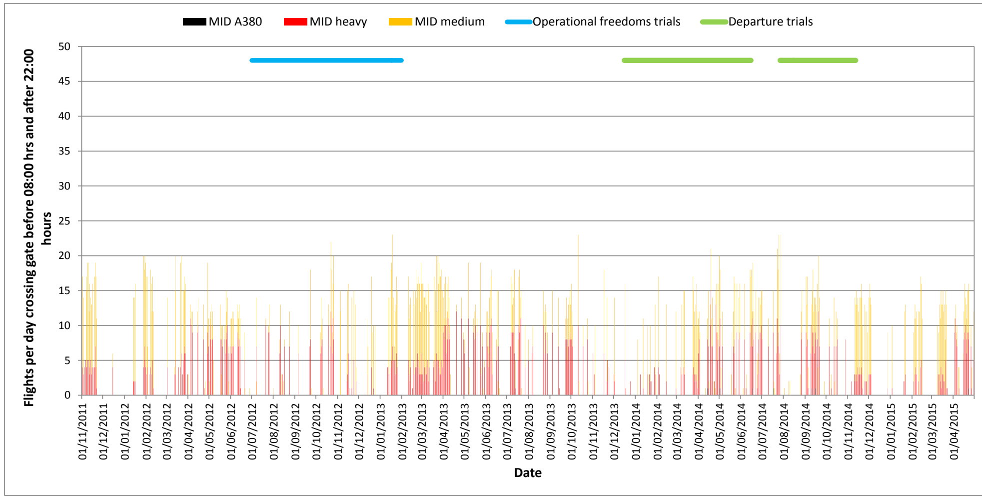
The mix of aircraft using the route has remained roughly constant over the analysis period other than a few A380s in the mix during the latter part of the analysis period. The split heavy:medium is approximately 1:4 but with daily fluctuations across the analysis period.

The traffic using the SAM SID that traverses the MID gate has an average volume of approximately 20 flights per day on easterly operations, again with fluctuations from day-to-day. The volume increases during the first part of the second departure trial and then reverts to the background level during the second half of the trial and subsequently.

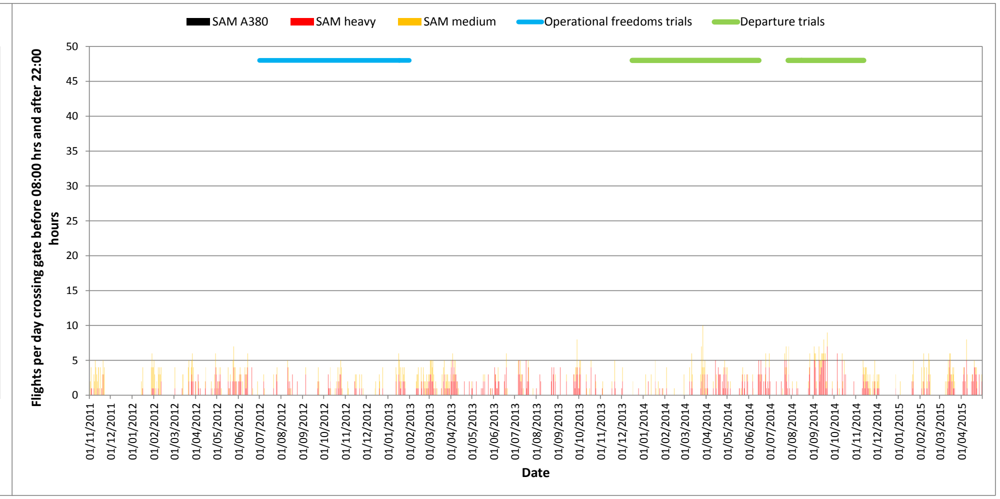
The ratio of heavy to medium aircraft is approximately 1:3. There are sometimes a few A380s in the mix.

The volume of traffic using the MID SID before eight in the morning and after eight in the evening fluctuates widely but with no apparent systematic trend

MID SID traffic traversing the MID gate before 08:00 hours and after 20:00 hours



SAM SID traffic traversing the MID gate before 08:00 hours and after 20:00 hours



The number of MID SID flights traversing the MID gate before 08:00 hours and after 20:00 hours fluctuates from approximately five to approximately 15 per day with the occasional peak at 20 flights per day. There does not appear to be any overall trend nor the seasonal cycle observed for the DVR SID.

The proportion of heavy aircraft in the mix has increased compared to the overall daily proportion, typically comprising 50% or more of the traffic. There are no A380s in the mix.

The number SAM SID flights traversing the DVR gate before 08:00 hours and after 20:00 hours is typically less than five per day, again with daily fluctuations. There is no apparent upwards or downwards trend although there is a slight increase during the second departure trial period, reverting to the background level after the trial

The majority of flights during this time period are by heavy aircraft. There are no A380s in the mix.

The gate captures the MID SID traffic, some SAM SID traffic and a number of CPT flights from the left hand side of the CPT SID

Spatial distribution of traffic crossing the MID gate classified by SID

The traffic scatter plots clearly show the effect of the first departure trial in winter 2013-2014

Distribution of traffic crossing the MID gate classified by SID for the first six analysis periods

The effect of the second departure trial period is to overlap the MID and SAM SID traffic at the left hand side of the gate

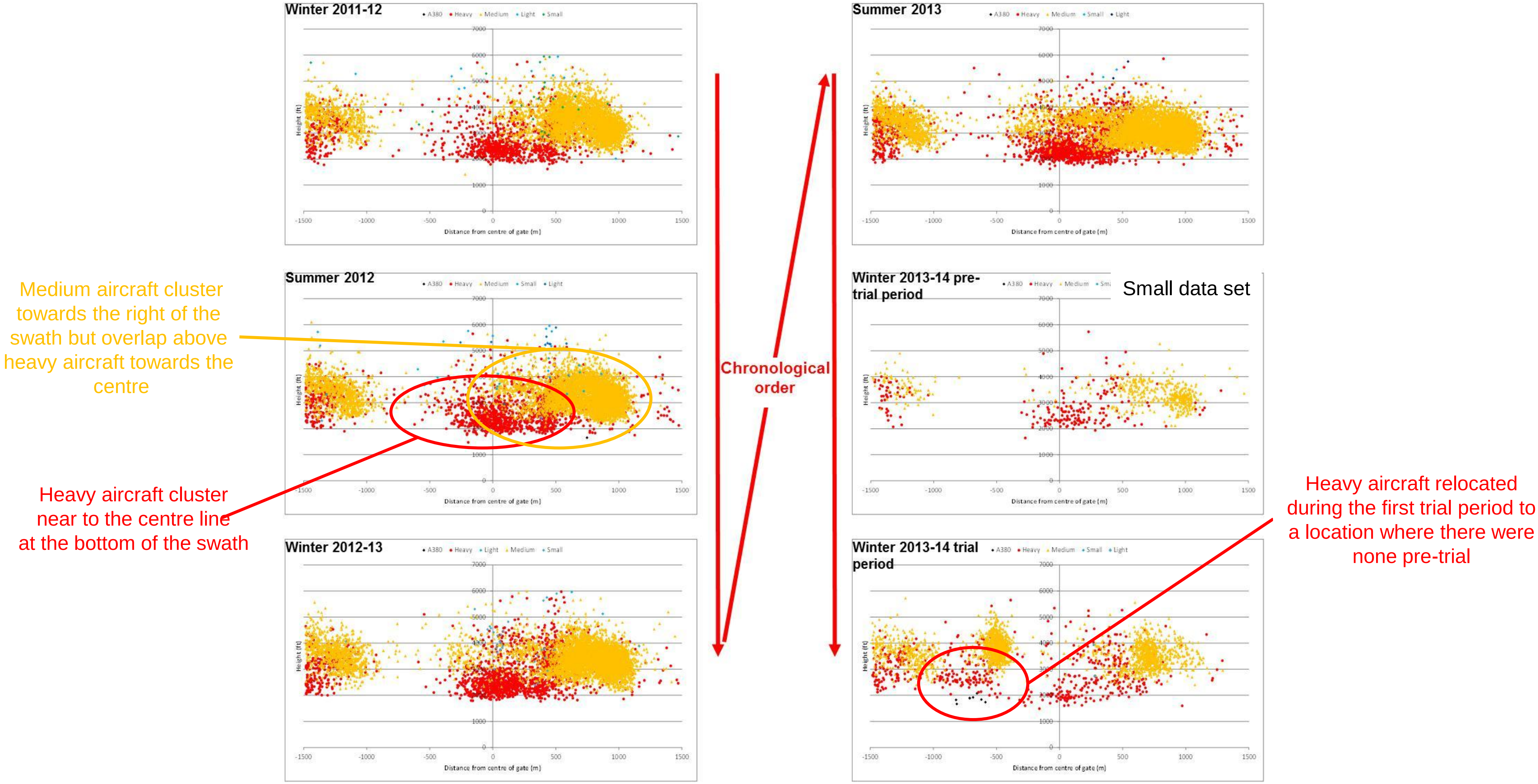
Distribution of traffic crossing the MID gate classified by SID for the final six analysis periods

Main swath reduced and second swath to the left of the centre line created due to the first departure trial

Mixing of MID and SAM traffic due to second departure trial

Heavy aircraft tend to cluster near to the NPR centre line; at the left hand edge and bottom of the MID swath

Distribution of traffic crossing the MID gate classified by aircraft type for the first six analysis periods

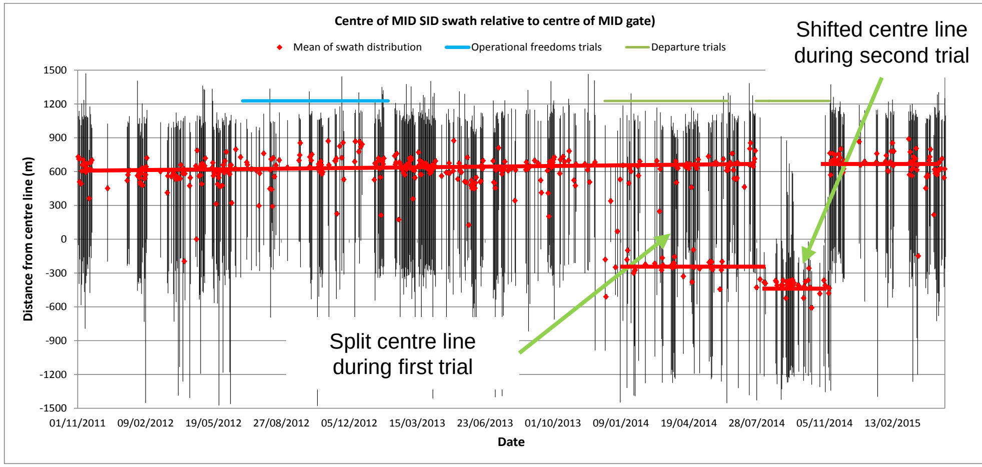


Post trials, the heavy and medium aircraft appear to be separated into two clusters in the MID swath whereas previously there was more overlap

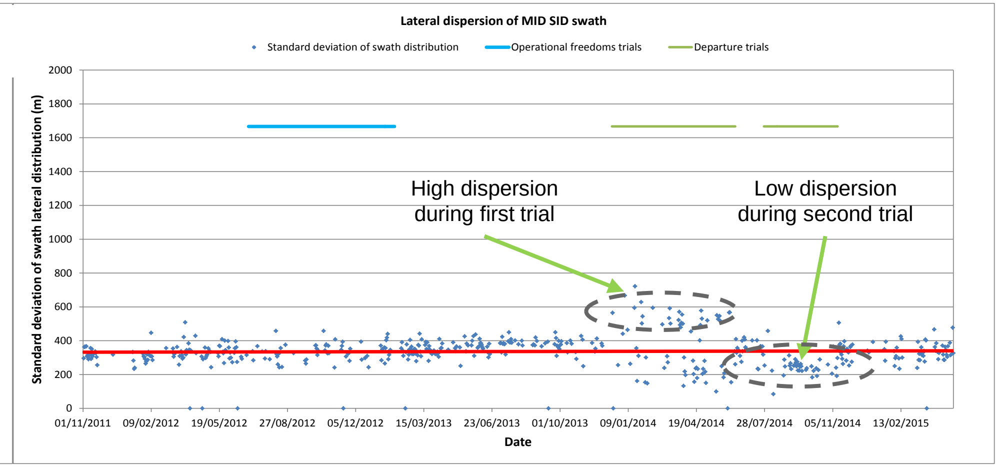
Distribution of traffic crossing the MID gate classified by aircraft type for the final six analysis periods

The splitting of the MID SID during the trial period is apparent in both the lateral centre of gravity and dispersion

Lateral centre of gravity and extent of the MID SID swath



Lateral dispersion of the MID SID swath



Prior to the departure trials the lateral centre of gravity of the MID SID swath is fairly consistent at approximately 600m to the right of the centre line. During the first departure trial the centre of gravity is split with the second swath being centred approximately 300m to the left of the centre line. During the second trial period, the centre of gravity of the swath is moved to approximately 450m to the left of the NPR centre line.

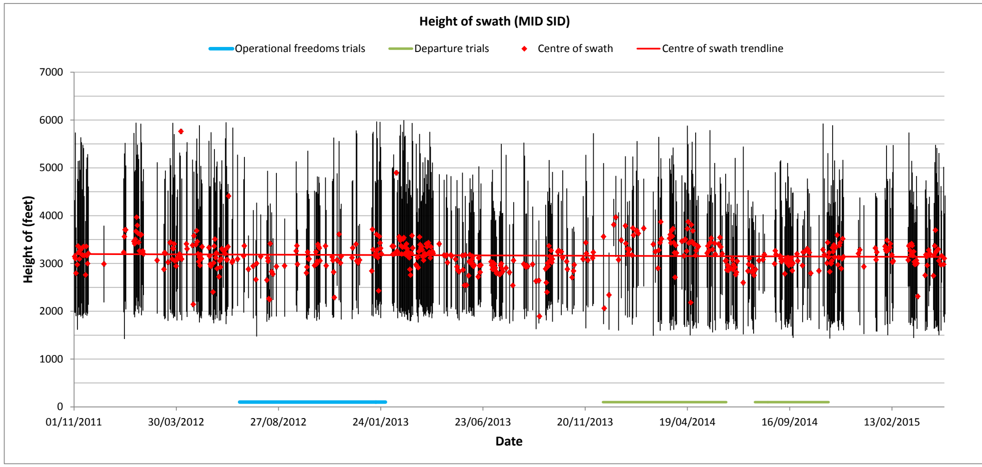
The lateral extent of the swath fluctuates but typically appears on average to be 1500m wide, typically covering half of the gate.

The lateral dispersion, defined as the standard deviation, gives a quantitative measure of the width of the swath. The chart above shows that the lateral dispersion of the swath was highest (above the red line) on some days during the first departure trial, when the SID was effectively split into two. The dispersion is also low (below the red line) on other days during this period. As each point represents a day this implies that track-keeping on one of the MID trials SIDs is good and is poor on the other MID trial SID. The dispersion is also low during the second trial period when the traffic is concentrated on the RNAV SID.

The dispersion trend line is flat implying that overall the spread of the traffic across the MID SID has remained constant.

There is a scatter on the vertical centre of gravity of the MID swath but with no clear trend; there is, however, a slight downwards trend on the lower limit of the swath

Vertical centre of gravity and extent of the MID SID swath at the MID gate

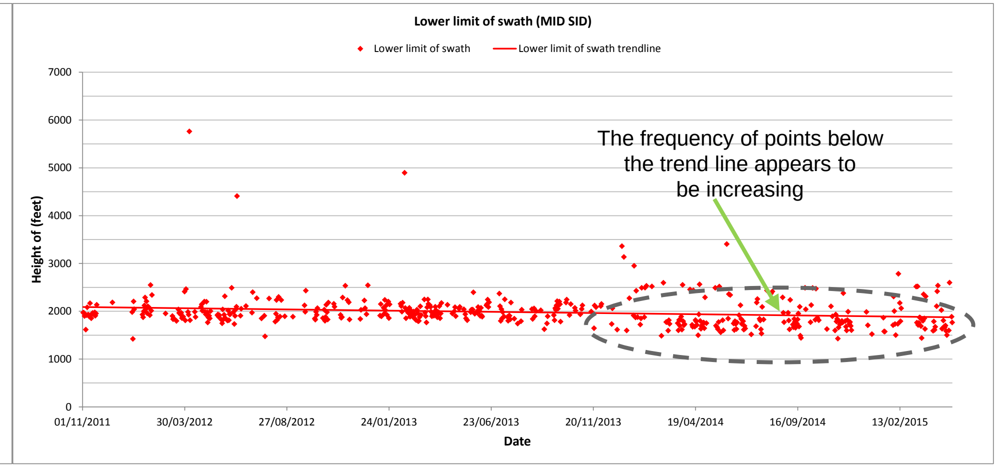


The vertical centre of gravity of the MID SID swath fluctuates around an average value of approximately 3100 feet. At the 95% level the vertical centre of gravity of the swath ranges between 2500 feet and 3700 feet.

The vertical extent of the swath extends from approximately 1500 feet to between 5000 and 6000 feet. The top of the swath appears to be getting lower.

Qualitatively the trend line of the height of the centre of gravity suggests that there has been little change over the measurement period.

Lower limit of the MID SID swath at the MID gate

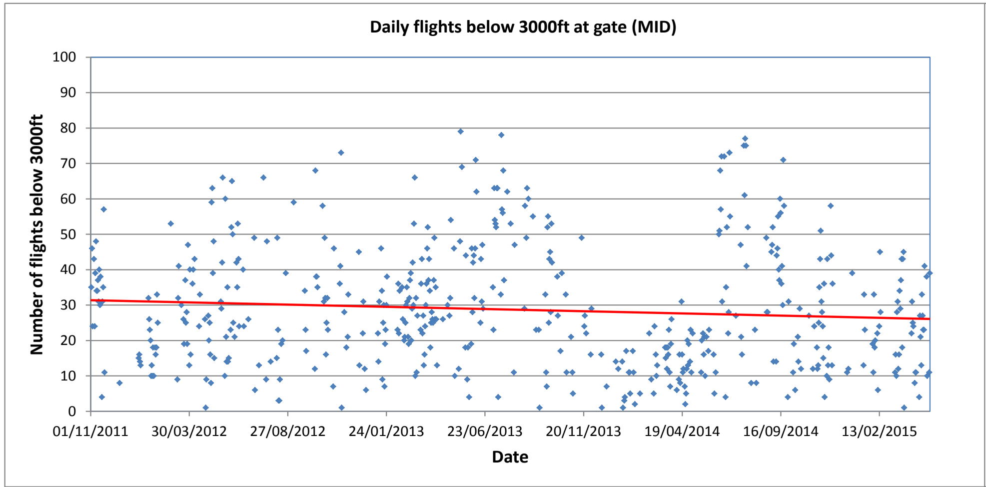


The bottom limit of the swath is defined by the lowest aircraft flying on the MID SID traversing the gate each day. On average, this height is approximately 2000 feet with a downward trend from late 2011 (slightly over 2000 feet) to present (slightly below 2000 feet).

There are daily fluctuations above and below the trend line. On 95% of days the lower limit of the swath is between 1500 feet and 2500 feet. During the measurement period, the lowest aircraft traversed the gate at a height of 1420 feet. The frequency of days with low flying aircraft is increasing.

Paradoxically there appears to be a slight trend to a decrease of flights below 3000 feet but an increase in flights below 2000 feet on the MID SID at the MID gate

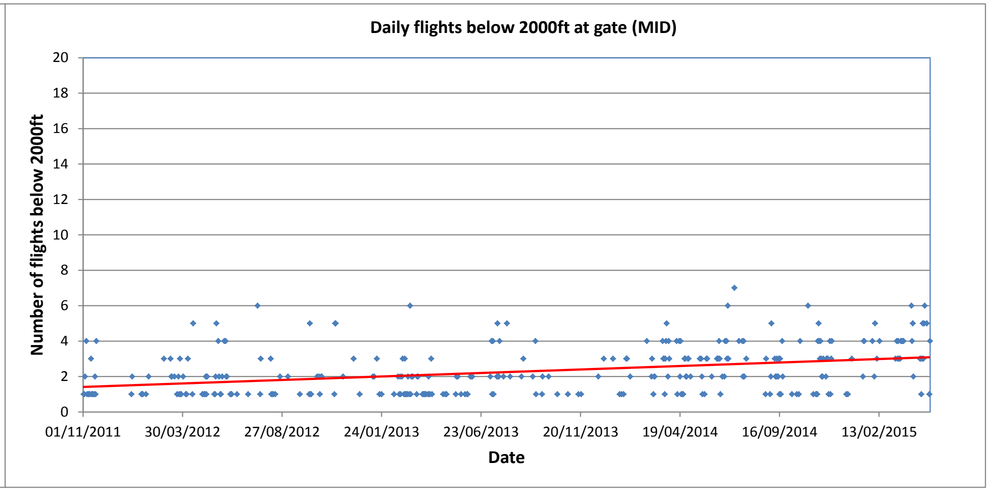
Daily number of flights along the MID SID below 3000 feet at the MID gate



The number of flights on the MID SID crossing the gate at a height of less than 3000 feet varies very widely and randomly from fewer than 10 on some days and occasionally approaching 80 per day.

The trend on the number of MID SID flights crossing the gate below 3000 feet appears to be downwards.

Daily number of flights along the MID SID below 2000 feet at the MID gate



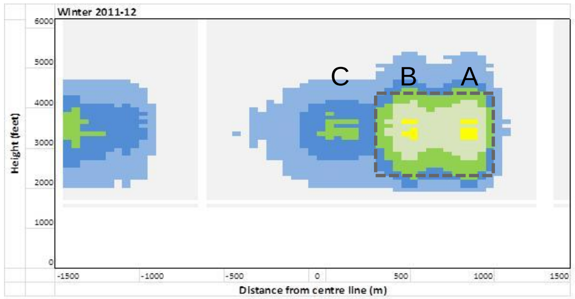
The number of MID SID flights crossing the gate at below 2000 feet varies from a minimum of one per day up to seven on a single occasion.

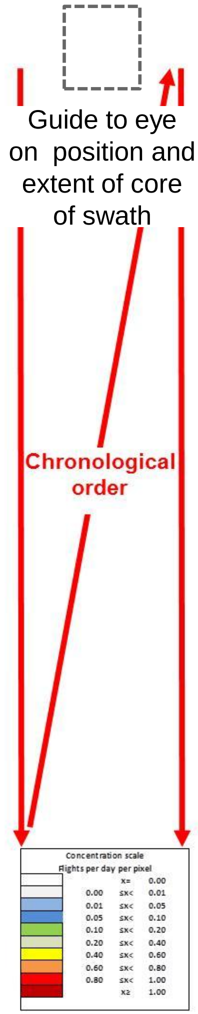
The trend on the number of flights crossing the gate at below 2000 feet appears to be slightly upwards, increasing from an average of one flight per day in late 2011 to three flights per day by April 2015.

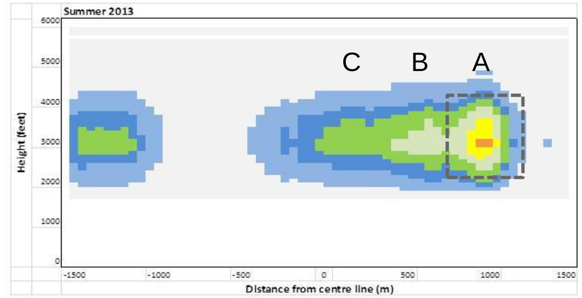
Pre-trials MID SID traffic progressively concentrates at about 1000m right of the centre line: the first trial splits the SID with another concentration at 500m to the left

Heat maps of the traffic crossing the MID gate for the first six analysis periods

There are two moderate hot spots (A&B) towards the right hand side of the MID SID. There is a cooler hot spot near the centre line (C)

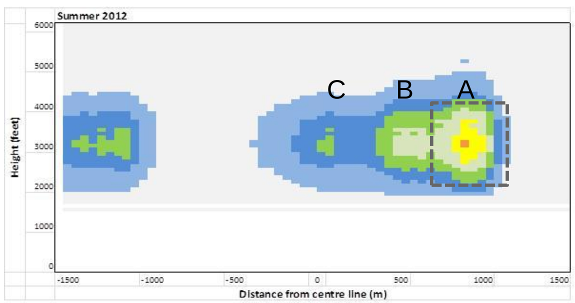


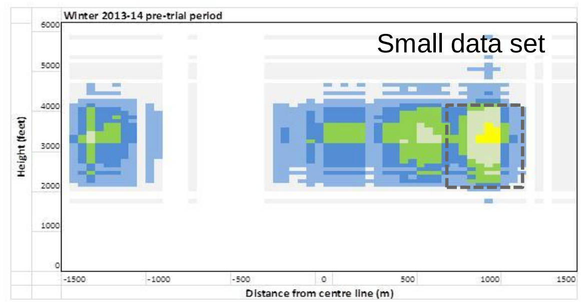




The hot spot A decreases in size and intensity. The hot spot B remains slightly more intense than C and the two start to coalesce

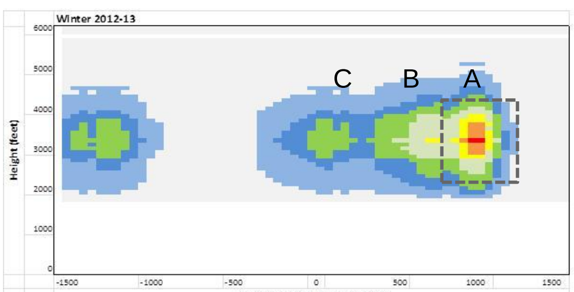
The traffic at the core of the MID SID concentrates into a single, more intense hot spot at A. The intensity of the second and third hotspots (B&C) decreases

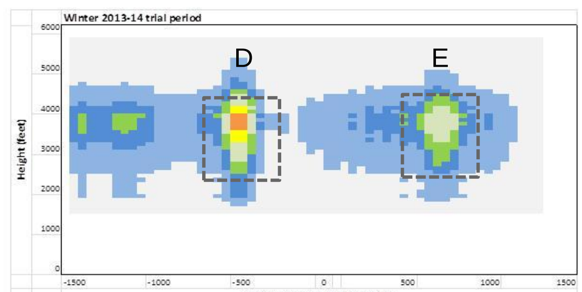




The size of the sample is too small to allow reliable interpretation

The size and intensity of the hot spot A increases. The size of the lesser hotspot C near the centre line also increases in size and becomes more distinct





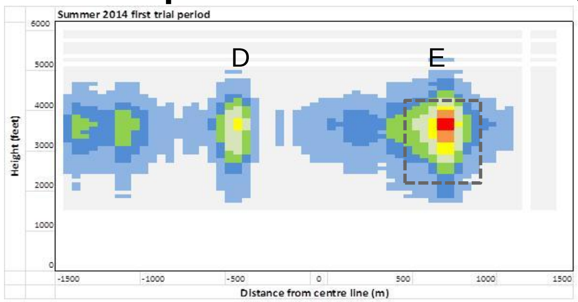
The first trial results in the creation of a hot spot D where there was low intensity traffic previously. hot spots A and B disperse and combine to create a cooler hotspot at E.

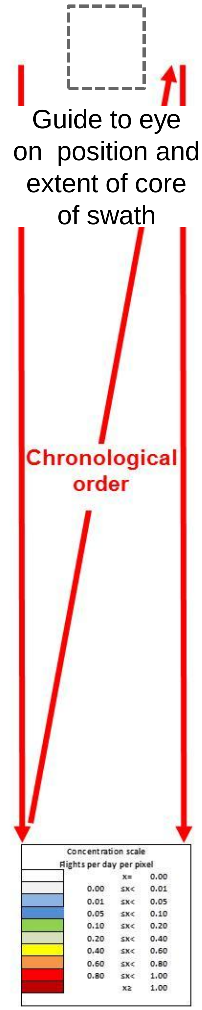
Note: the behaviour of the SAM SID is discussed in section 5

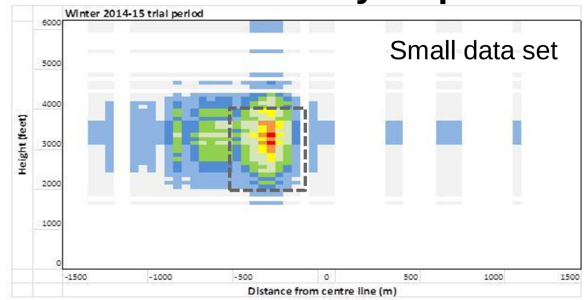
The traffic hot spots change structure and position during the trials, returning to the original pattern but with higher intensity after the trials

Heat maps of the traffic crossing the MID gate for the final six analysis periods

The hot spots D and E persist as the trial rolls into the summer schedule but their relative intensity changes with E becoming more intense than D

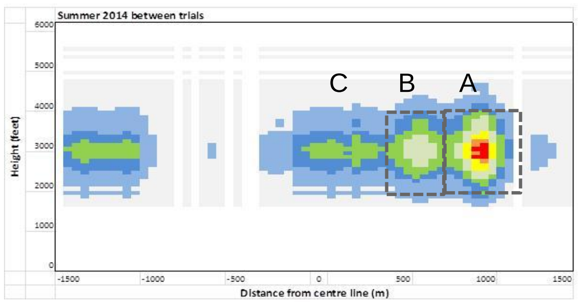


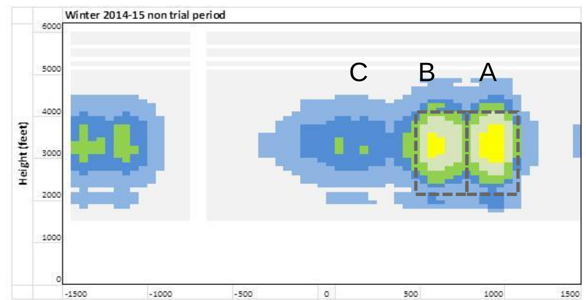




The size of the sample is too small to allow reliable interpretation

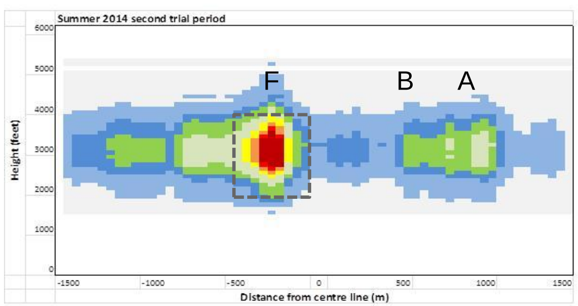
As the trial ends, the basic structure with hot spots A, B & C returns but A & B are more distinct than previously. A has become more intense

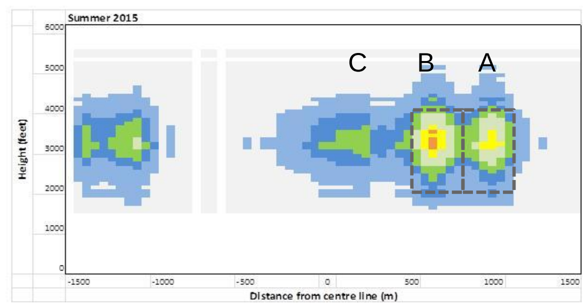




After the end of the second trial, the basic heat structure reverts to that observed pre-trial, with moderate hot spots A&B and a cooler hot spot C. A & B are more intense than previously

The second trial period results in cooling of hot spots A&B and the virtual disappearance of C. A large, intense hot spot is created at F extending to the left and coalescing with the SAM SID





In summer 2015, hot spot B increases in intensity relative to A. This is different to previous observations where A was hotter than B. C also increases in intensity.

Note: the behaviour of the SAM SID is discussed in section 5

There have been significant variations in the volume and distribution of traffic on the MID SID: these appear mainly associated with the trials rather than systematic

Conclusions concerning the MID SID at the MID gate

Traffic volume & mix

Underlying the day-to-day fluctuations in the traffic volume using the **MID SID** alone, there appears to have been a slight reduction in volume from just over 100 per day before the second trial to just under 100 per day after the second trial.

Although the pre- and post trial traffic volumes at the **MID gate** (comprising MID and SAM traffic) are similar, there is an increase during the second trial period. This is caused by SAM traffic being shifted into the MID gate.

The proportion of different sizes of aircraft in the MID SID mix has also remained roughly constant with 20% heavy aircraft and 80% medium. There are a few A380s in the mix

Lateral position

Before the trials the lateral position of the MID SID was approximately 600m to the right of the NPR centre line. There appear to be two areas of traffic concentration within the swath.

During the trials there were shifts in the swath's lateral position with areas not previously affected being overflown. During the first trial the swath's centre of gravity is split (at 300m to the left and 600m to the right of the centre line). During the second trial a single centre of gravity is shifted to approximately 450m left of the NPR centre line.

After the trials, the position and structure of the MID swath reverts to those observed pre-trial.

The first trial appears to have resulted in a spreading (increased dispersion) of the swath whereas the second trial resulted in increased concentration, albeit at a different location.

After the trials, the traffic appears slightly more intense at the cores of the swath than before the trials

Height

There appears to have been little or no systematic change in the vertical centre of gravity of the MID SID swath. However:

- there are large daily fluctuations in the height of the centre of gravity, typically in the range 2500 feet to 3700 feet
- there are large fluctuations in the lower limit of the swath, from typically 1500 feet to 2500 feet with the lowest flying aircraft being measured at 1420 feet
- there is a perceptible downward trend on the lower limit of the swath over the analysis period and the frequency of days with low flying aircraft appears to be increasing
- paradoxically there appears to be a downward trend (reduction) in the number of flights below 3000 feet but an upward trend on the flights below 2000 feet.

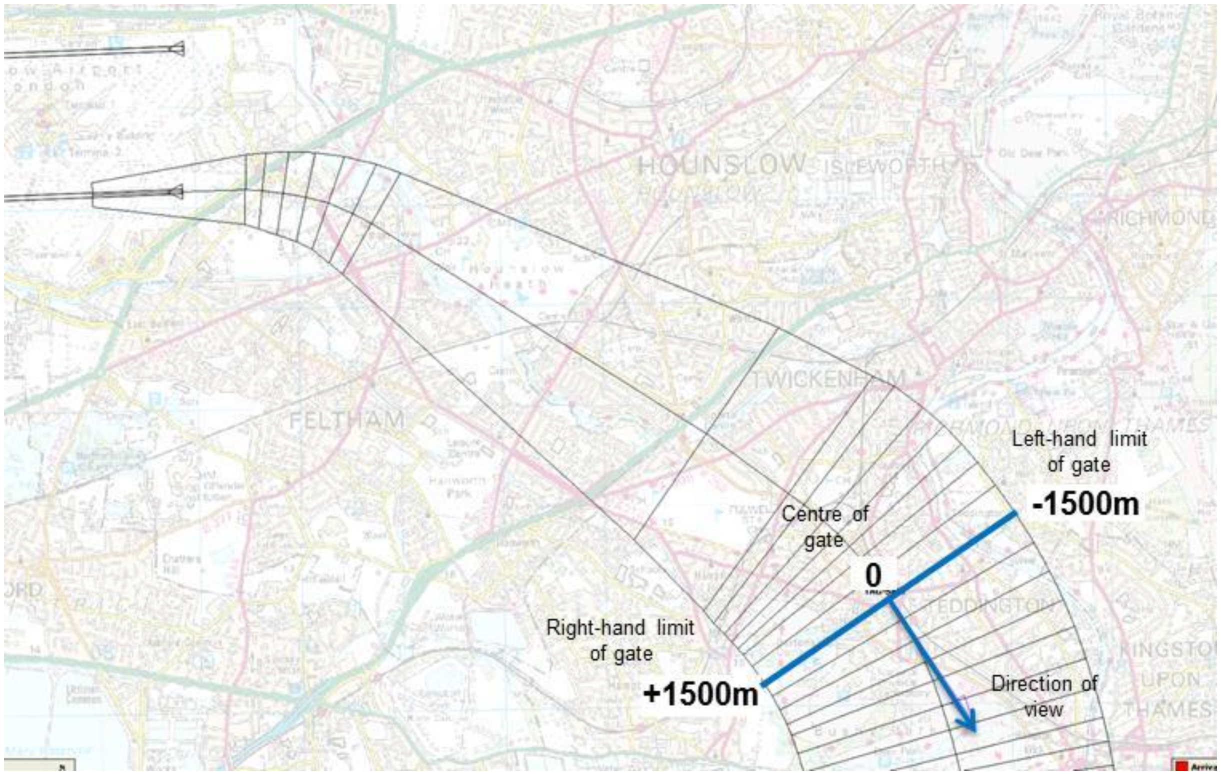
Note: Detailed conclusions concerning the SAM SID are drawn in section 5

SOUTHAMPTON NPR RESULTS

5

The SAM gate is located at the intersection of the SAM NPR centreline and Teddington High Street/ Broad Street

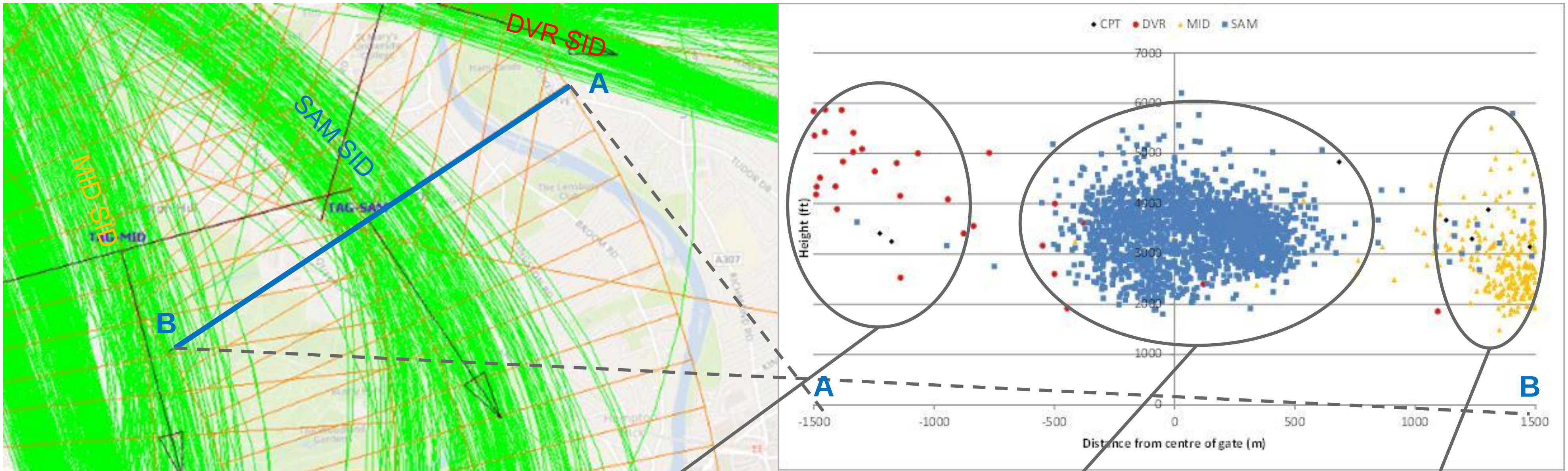
Location of the SAM NPR gate



The SAM gate captures traffic using the SAM SID around the NPR centre line, MID SID traffic at the right hand extreme and small amount of DVR traffic on the left

Position of the SAM NPR gate and associated departure flows

Typical horizontal and vertical traffic distribution at the SAM NPR gate



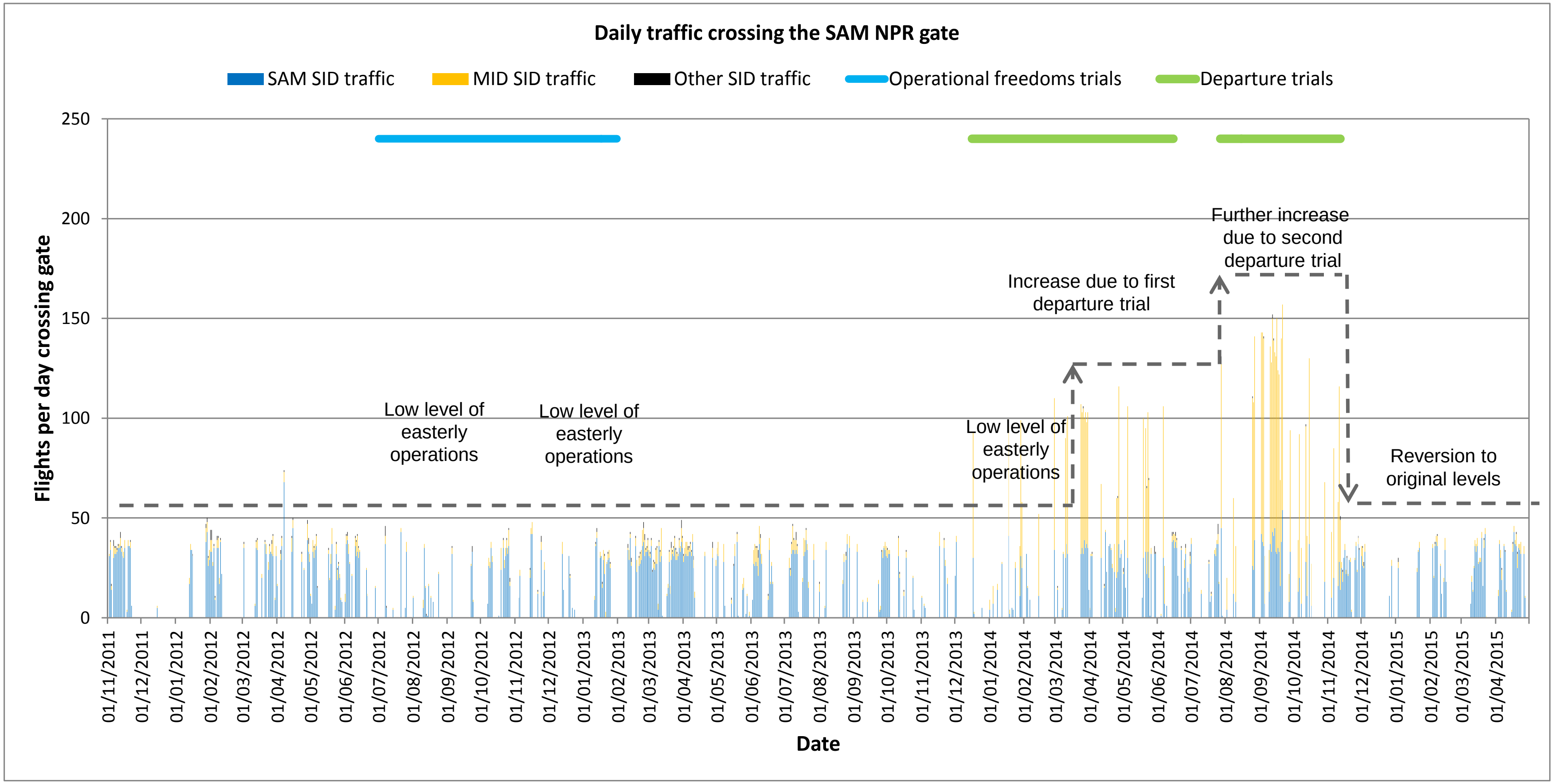
Traffic departing along the DVR SID but falling within the SAM NPR

Traffic departing along the SAM SID

Traffic departing along the MID SID but falling within the SAM NPR

The traffic volume crossing the SAM gate increases during the trials due to MID traffic shifting into the SAM gate: the volume then reverts to pre-trial levels

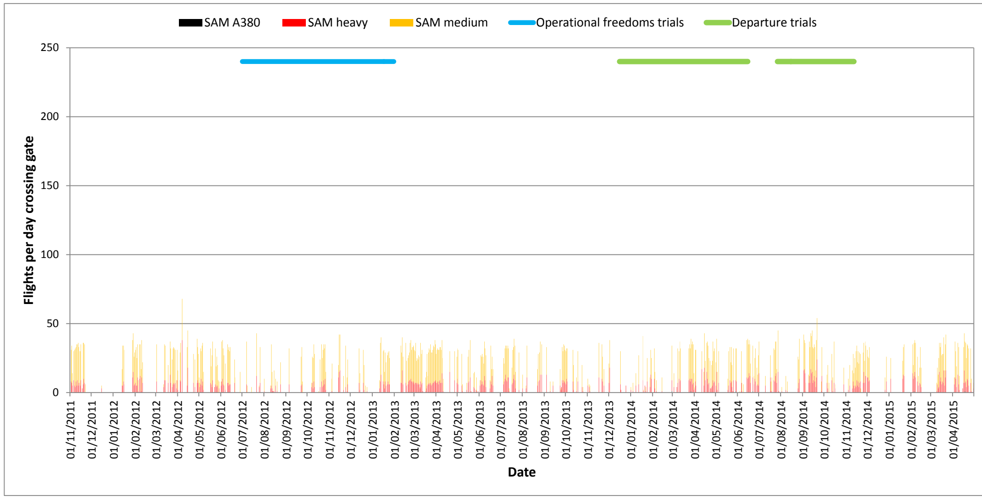
Daily departure traffic through the SAM NPR gate classified by SID



Increase in volume during the departure trial periods due to MID traffic being shifted into the SAM gate

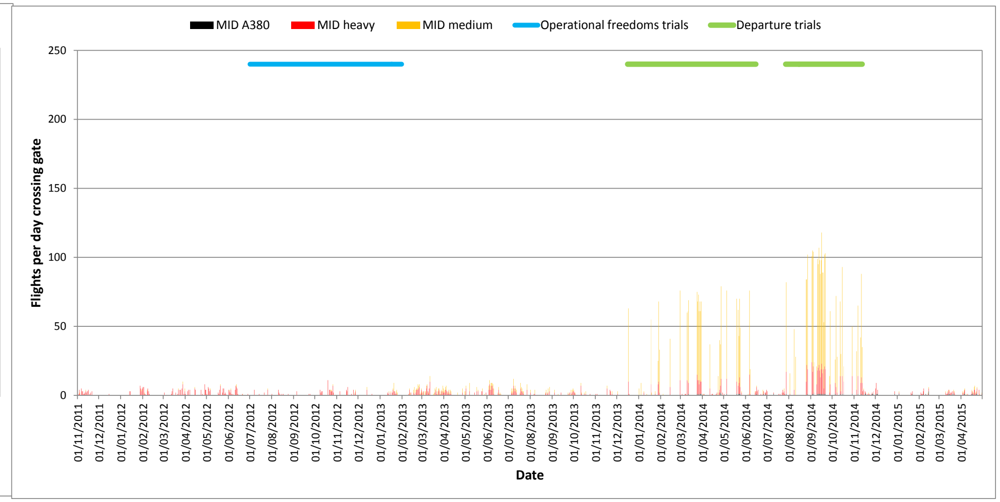
SAM traffic using the SAM gate has remained fairly constant over the analysis period but MID traffic increased during the departure trial periods

Daily SAM SID traffic through the SAM gate by aircraft type



The volume of traffic using the SAM SID is fairly consistent over the analysis period from late 2011 to Spring 2015 at between 35 and 40 flights per day (compared to 150 for DVR and 100 for MID). The traffic mix is typically 20% heavy aircraft and 80% medium aircraft. There were few A380s using the route during the analysis period

Daily MID SID traffic through the SAM gate by aircraft type

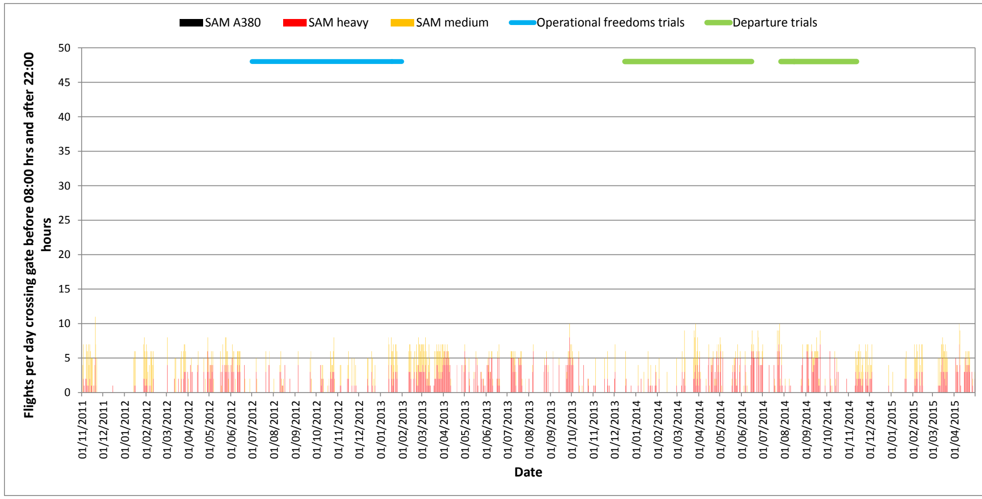


Except during the two departure trial periods, the volume of MID traffic crossing the SAM gate is small at approximately three to five flights per day. These flights are predominantly made by heavy aircraft.

During the first trial period, the volume of MID traffic using the SAM gate increases to a peak of approximately 60 flights per day. During the second trial period, the volume of MID traffic traversing the SAM gate increases further to approximately 100 flights per day. During the trail periods, the proportion of heavy aircraft using the MID route through the SAM gate is in the range 10% to 20%, the remainder being medium aircraft

There is no overall trend on the traffic SAM SID traffic volume before 08:00 hours in the morning and after 20:00 hours but MID traffic increased during the trials

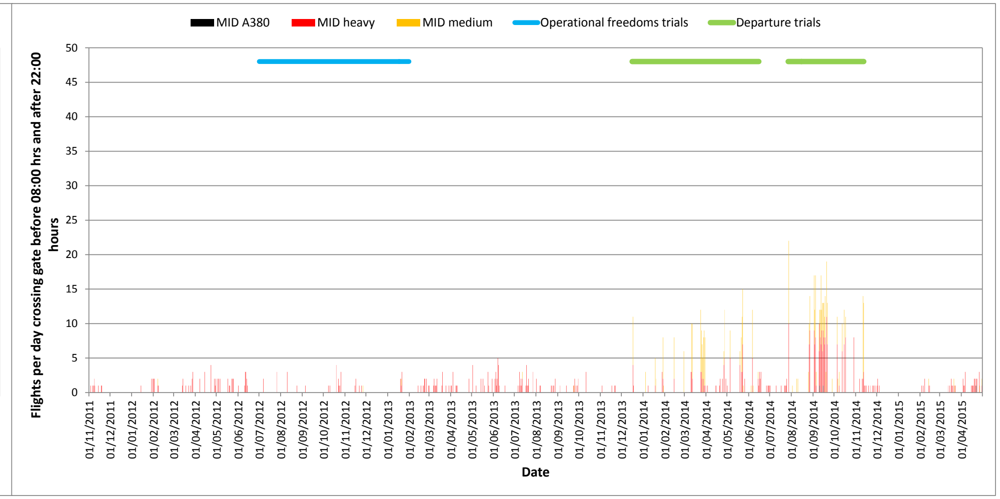
SAM SID traffic traversing the SAM gate before 08:00 hours and after 20:00 hours



The number of SAM SID flights traversing the SAM gate before 08:00 hours and after 20:00 hours ranges from five to seven or eight flights per day.

At least 50% of these flights are by large aircraft, with the proportion being higher at some times, including the first departure trial period.

MID SID traffic traversing the SAM gate before 08:00 hours and after 20:00 hours



Other than during the departure trial periods, the number of MID SID flights traversing the SAM gate before 08:00 hours and after 20:00 hours is lower than five per day.

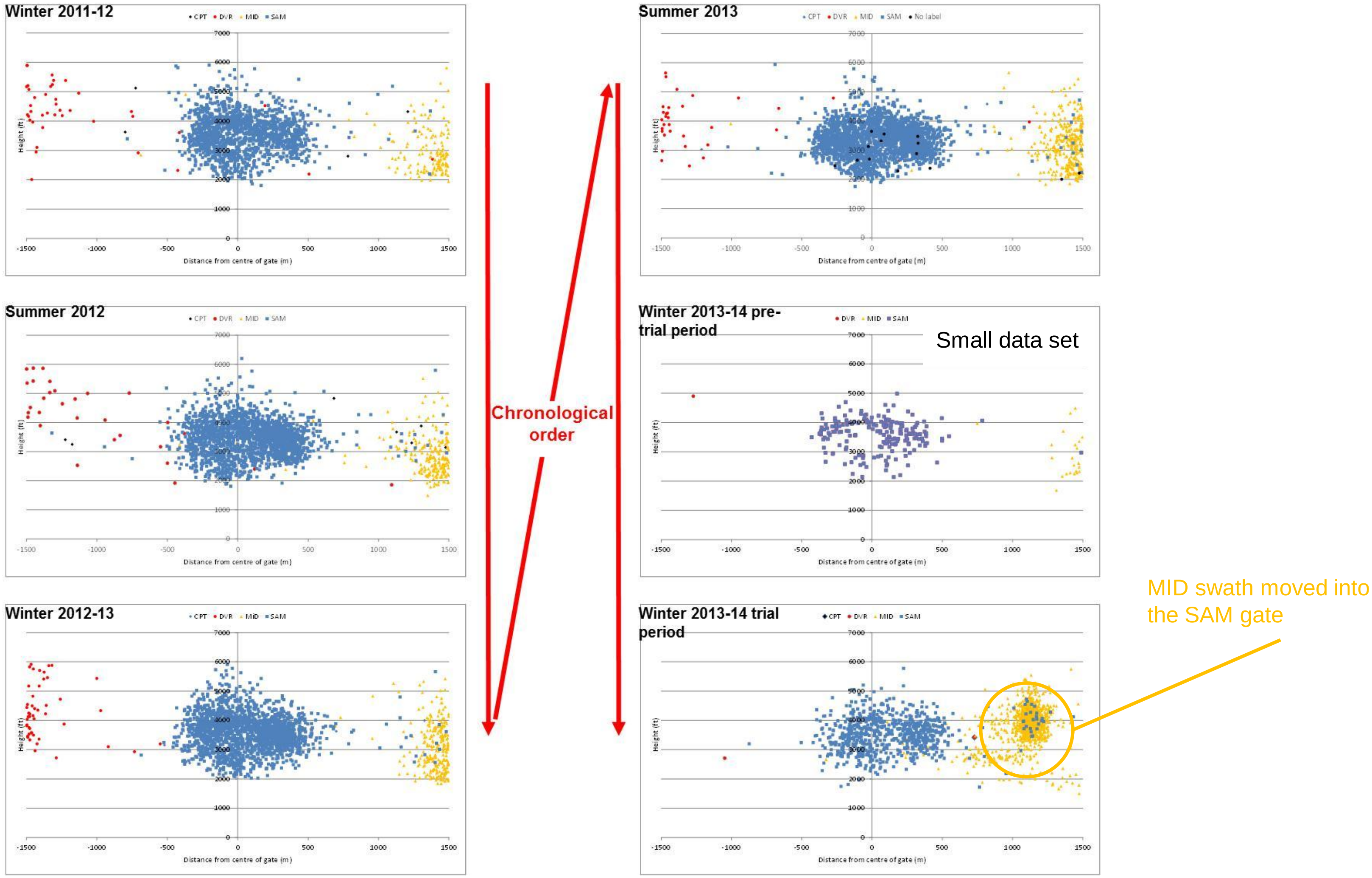
During the first trial period, this number increased to around ten per day, increasing further to approximately 15 per day during the second trial period. The proportion of heavy aircraft in the mix over both trial periods is typically 15% to 20% but with some variation

The gate captures SAM SID traffic near to the NPR centre line, as well as MID traffic at the right extreme and DVR traffic on the left extreme

Spatial distribution of traffic crossing the SAM gate classified by SID

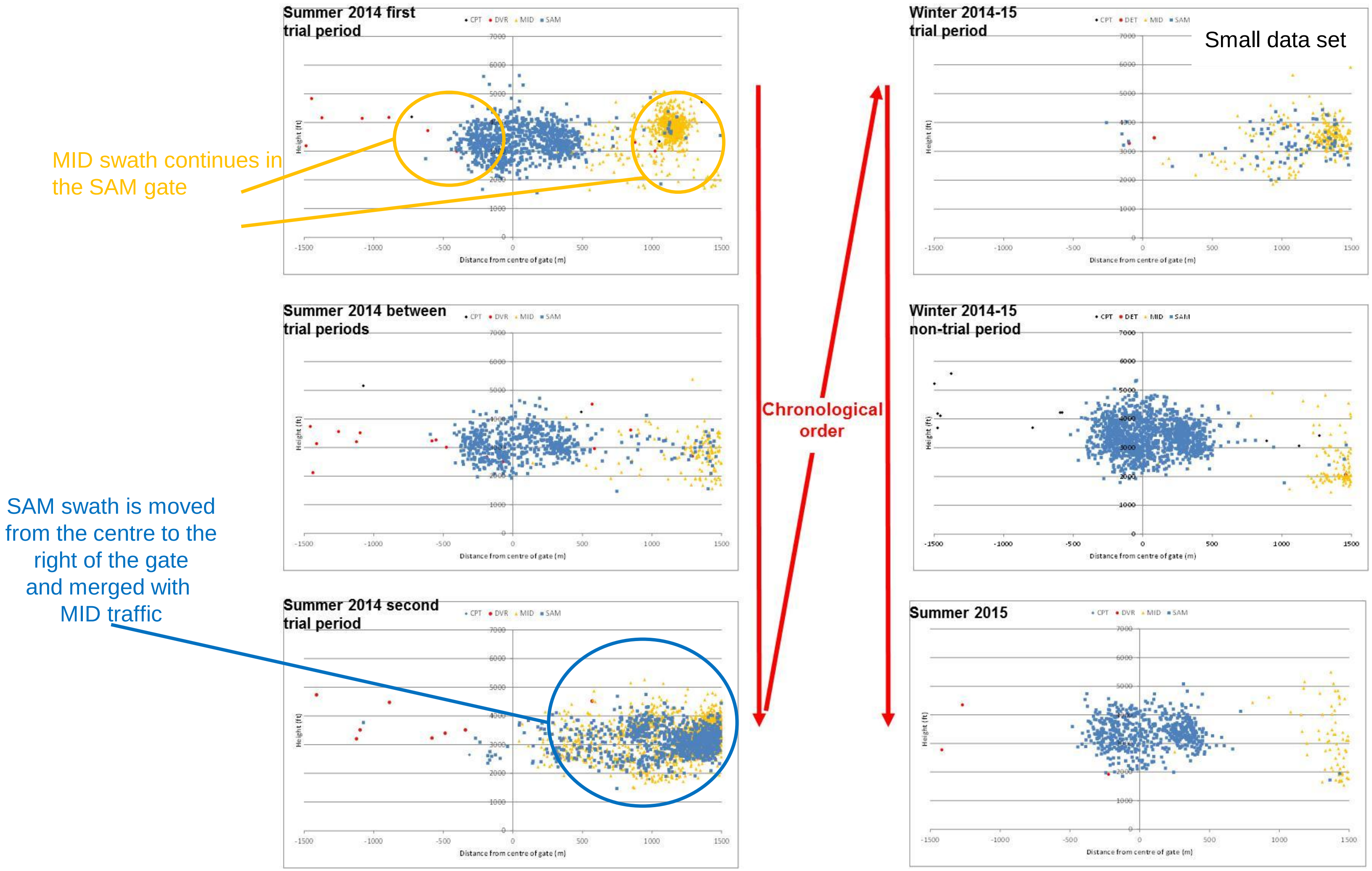
The traffic scatter plots clearly show the MID swath moving into the SAM gate during the first departure trial in winter 2013-2014

Distribution of traffic crossing the SAM gate classified by SID for the first six analysis periods



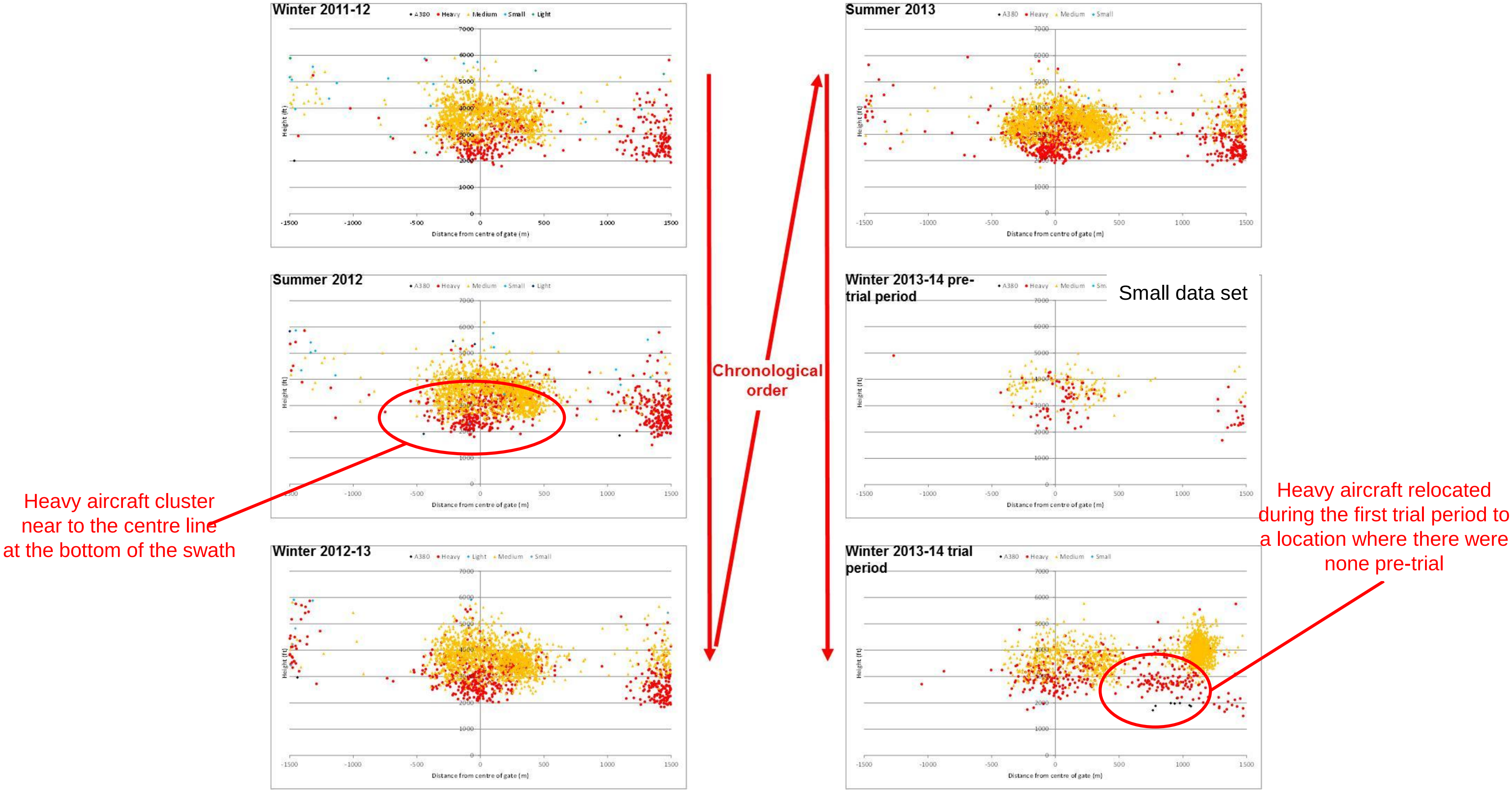
The effect of the second departure trial period is to move the SAM traffic to the right of the gate and overlap with MID SID traffic

Distribution of traffic crossing the SAM gate classified by SID for the final six analysis periods



Heavy aircraft tend to cluster at the centre line at the bottom of the SAM swath: the first trial moves low flying heavy aircraft to a previously unaffected location

Distribution of traffic crossing the SAM gate classified by aircraft type for the first six analysis periods



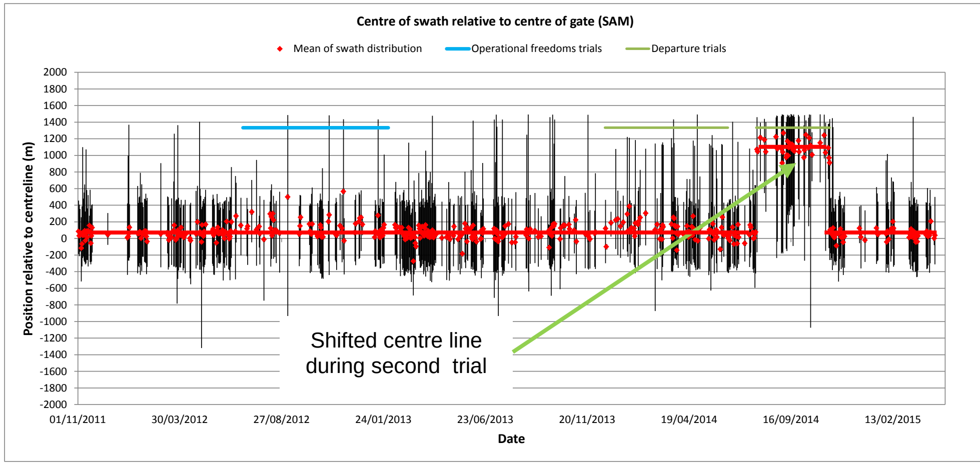
The second trial results in traffic moving to the right side of the gate and leaving the centre free: the pattern reverts to the normal pattern after the trials have finished

Distribution of traffic crossing the SAM gate classified by aircraft type for the final six analysis periods

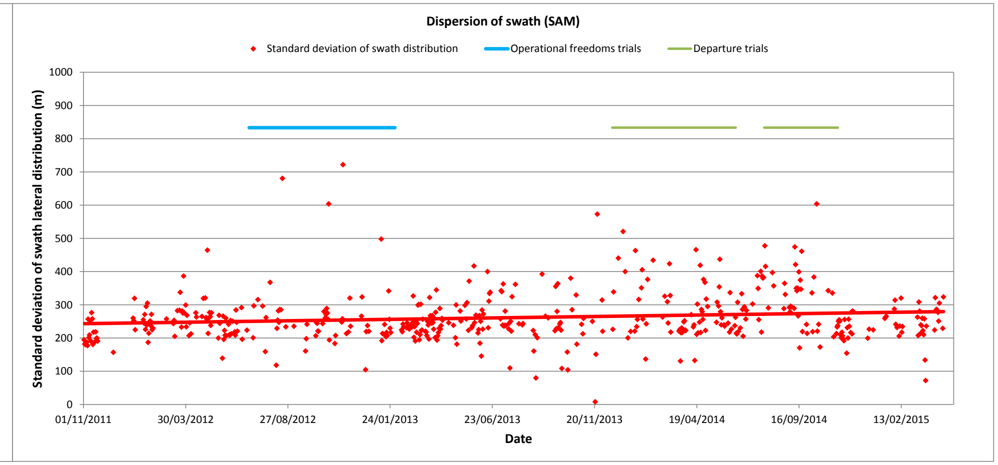
The second trial shifts traffic from the centre to the right of the gate

The shift of the centre line of the SAM SID during the second trial period is apparent in the lateral centre of gravity

Lateral centre of gravity and extent of the SAM SID swath



Lateral dispersion of the SAM SID swath



Until the onset of the second trial period, the lateral centre of gravity of the SAM SID swath is fairly consistent, near but slightly to the left of the NPR centre line. During the second trial period, the swath centre of gravity shifts to approximately 1100m to the right of the centre line. After the completion of the trials, the centre of gravity reverts to its original position near to the centre line.

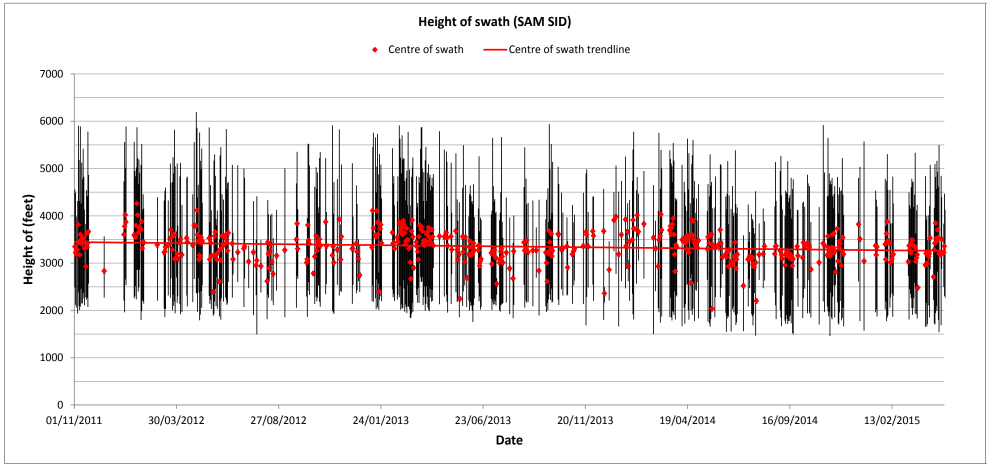
The position of the lateral centre of gravity fluctuates from day-to-day with these fluctuations generally appearing to be largest during the trial periods.

The lateral dispersion, defined as the standard deviation, gives a quantitative measure of the width of the swath. The chart above shows that the lateral dispersion of the swath was largest during all of the trial periods although operational freedoms and the first departure trials did not include the SAM SID. The overall trend in the dispersion is upwards, from approximately 250m in late 2011 to slightly below 300m in April 2015. This implies that the traffic is becoming less concentrated around the centre of gravity.

Note the points with zero dispersion in the chart are associated with days with very low traffic, i.e. predominantly westerly operations

There is to be a definite downward trend on the height of the SAM SID

Vertical centre of gravity and extent of the SAM SID swath at the SAM gate

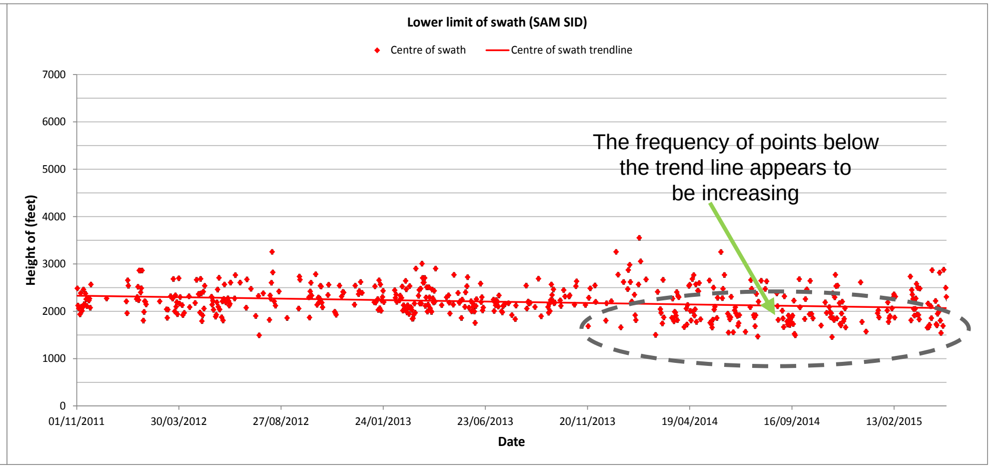


The vertical centre of gravity of the SAM SID swath fluctuates around an average value of approximately 3300 feet. At the 95% level the vertical centre of gravity of the swath ranges between 2600 feet and 3900 feet over the analysis period.

The vertical extent of the swath extends from approximately 1500 feet to between 5000 and 6000 feet. The top of the swath appears to be getting lower.

The trend line of the height of the centre of gravity suggests that there has been a gradual decrease in the height of the centre of gravity from approximately 3400 feet in late 2011 to approximately 3200 feet in April 2015

Lower limit of the SAM SID swath at the SAM gate



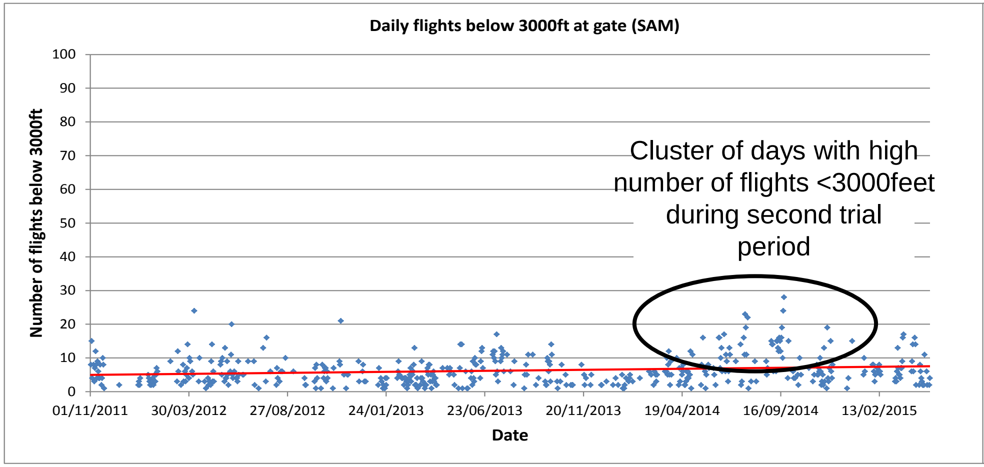
The bottom limit of the swath is defined by the lowest aircraft flying on the SAM SID traversing the gate each day. On average, this height is approximately 2200 feet with a definite downward trend from late 2011 (slightly over 2300 feet) to the present (approximately 2000 feet).

There are daily fluctuations around the average with aircraft. On 95% of days the lower limit of the swath is between 1600 feet and 2800 feet. During the measurement period, the lowest aircraft traversed the gate at a height of 1456 feet.

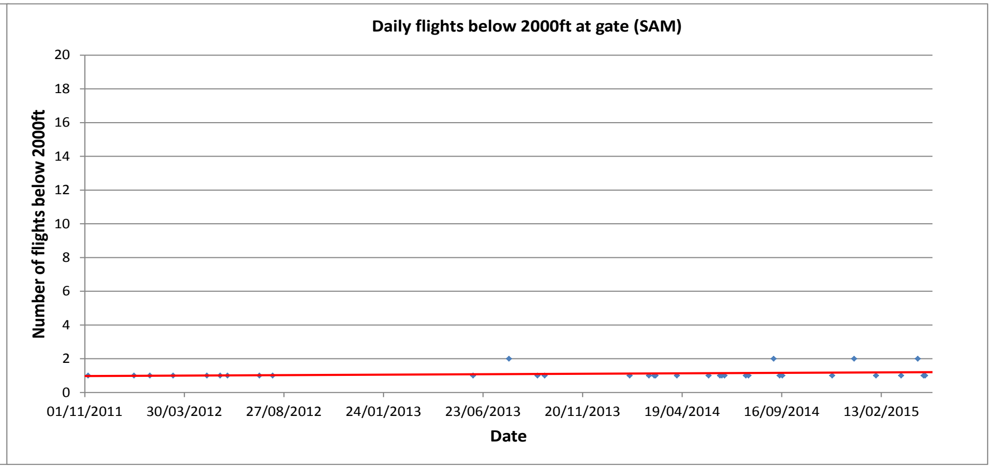
The frequency of days with low flying aircraft is increasing.

There was a large increase in the number of SAM SID flights crossing the gate below 300 feet during the second trial period

Daily number of flights along the SAM SID below 3000 feet at the SAM gate



Daily number of flights along the SAM SID below 2000 feet at the SAM gate



The number of SAM SID flights per day crossing the gate at a height below 3000 feet fluctuates but is generally between five and ten. There was a noticeable increase in the number of flights crossing the gate below 3000 feet.

The trend on the number of SAM SID flights crossing the gate below 3000 feet appears to be upwards, from around five per day in late 2011 to approximately eight per day in spring 2015

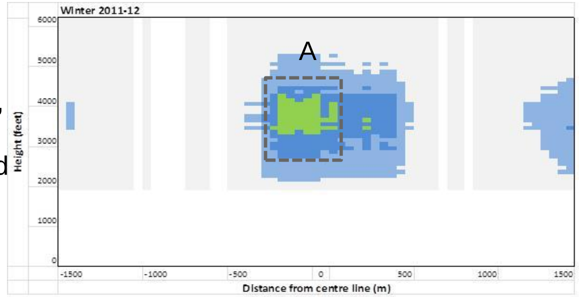
The number of SAM SID flights crossing the gate at below 2000 is either one or two per day across the analysis period.

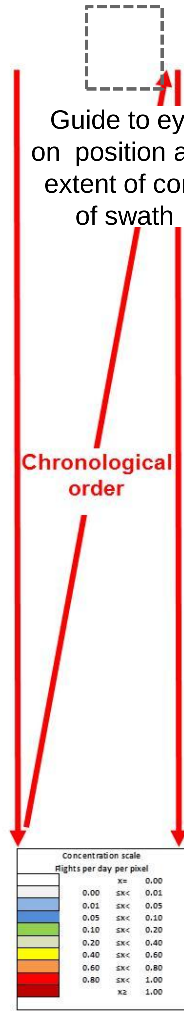
Although, there is no upward or downward trend on this statistic, the few days with two flights per day below 2000 feet at the gate occur towards the end of the analysis period

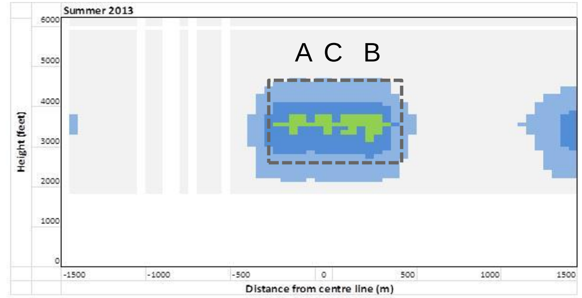
Although only of moderate intensity, the hot spots within the SAM swath change across analysis periods. The first trial creates hot spot at the right of the gate

Heat maps of the traffic crossing the SAM gate for the first six analysis periods

SAM SID traffic is concentrated to the left of the main swath, A (and is cool compared to DVR and MID)

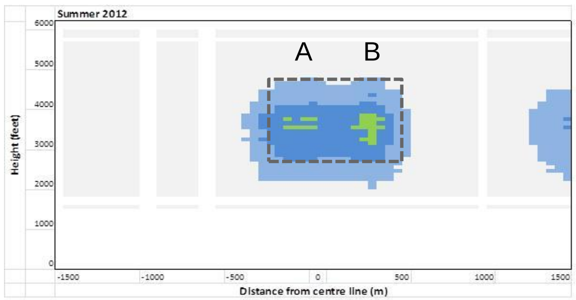


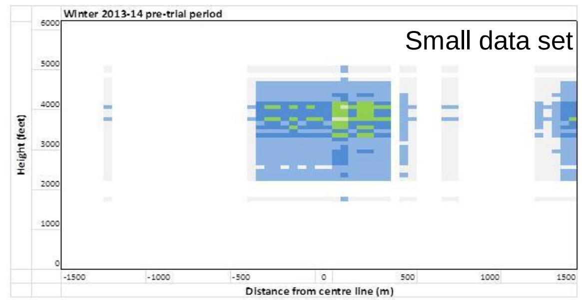




The two hot spots in the core of the swath split into three, A, B&C

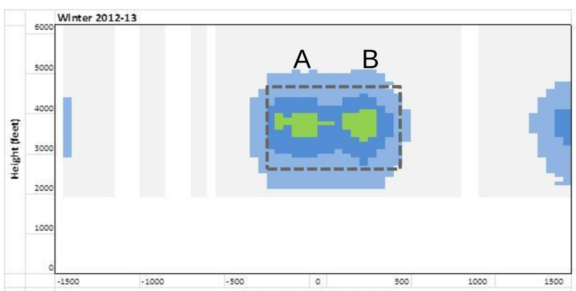
The concentration of the traffic within the swath shifts to result in two moderate hot spots, A&B

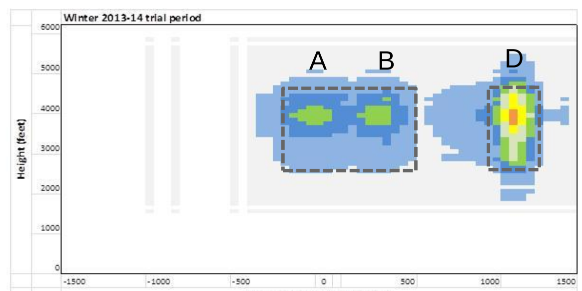




The size of the sample is too small to allow reliable interpretation

The two hotspots, A&B, become more distinct and larger although not increasing in intensity



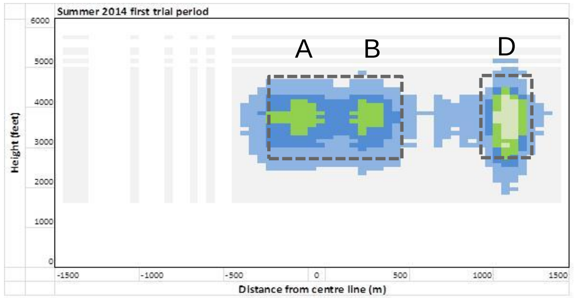


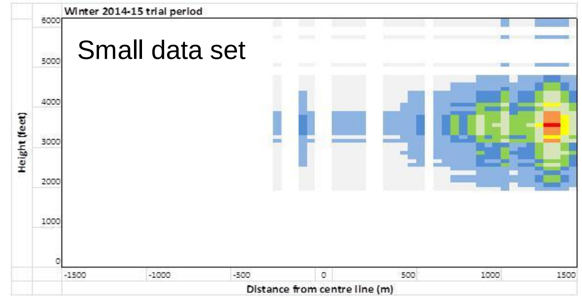
The three hot spots at the core of the SAM swath coalesce back into two, A & B. The first trial creates a more intense hot spot to the right of the gate, D.

The second trial moves and increases the traffic intensity to the right of the SAM gate

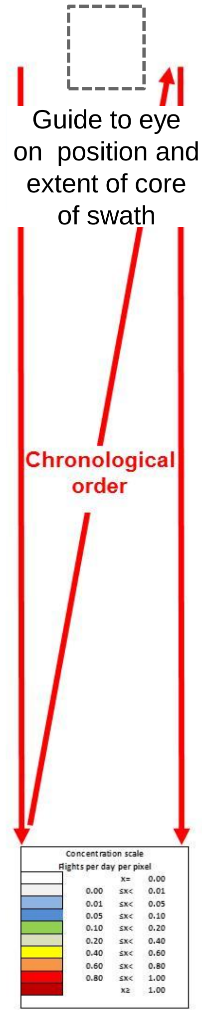
Heat maps of the traffic crossing the SAM gate for the final six analysis periods

The SAM swath hotspots remain at A&B while the MID trial hotspot at D becomes slightly less intense

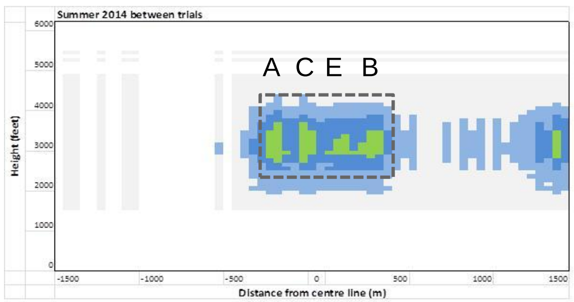


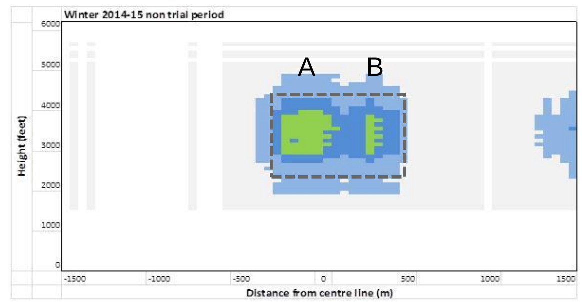


The size of the sample is too small to allow reliable interpretation but qualitatively the pattern appears similar to the summer trial period



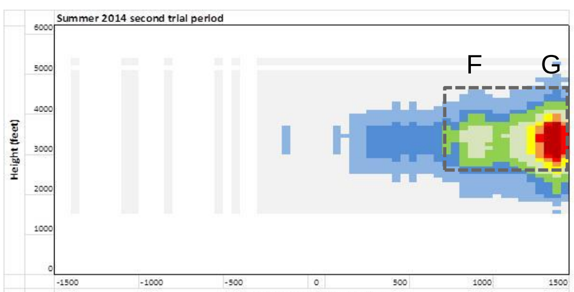
As the trial ends, hot spots in the SAM swath split into four peaks, A, B, C & E

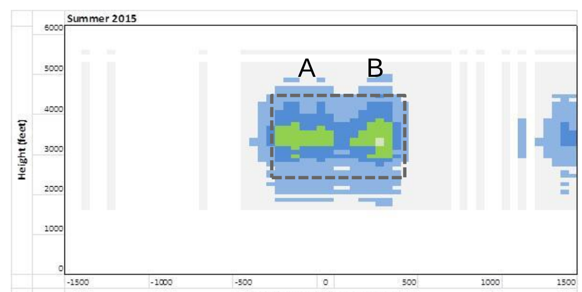




After the end of the second trial, the basic structure reverts to that observed pre-trial in winter 2011-12l, with moderate hot spots A&B at the core of the SAM swath

The second trial period results in the creation of a very intense hot spot, G, at the extreme right of the gate & a less intense hot spot, F, the to the left of G





In summer 2015, the hot spot A becomes broader and the core of hot spot B becomes more intense.

The second trial had a major impact on the SAM SID but, in addition, there appear to be ongoing underlying changes in the traffic pattern

Conclusions concerning the SAM SID at the SAM gate

Traffic volume & mix

Although the pre- and post trial traffic volumes at the **SAM gate** (comprising SAM and MID traffic) are similar, there is a large increase during the first trial period followed by a further increase during the second trial period. This is caused by MID traffic being shifted into the SAM gate.

After the trials, volumes revert to pre trial levels.

The volume of **SAM SID** traffic does not change appreciably and is fairly consistent at 35 to 40 flights per day on easterly days.

The proportion of different sizes of aircraft in the SAM SID mix has also remained roughly constant with 20% heavy aircraft and 80% medium. There are a few A380s in the mix.

Lateral position

Before the trials the lateral position of the SAM SID was just to the left of the NPR centre line. The second trial resulted in a large shift in lateral position with the swath's centre of gravity shifting to approximately 1100m to the right of the centre line.

The concentration pattern of the traffic within the SAM SID swath varies across analysis periods . Shifting of the MID SID also introduces additional hot spots within the gate. During the second trial, there is a significant traffic hot spot at the right edge of the gate due to the combining of the SAM and MID SIDs.

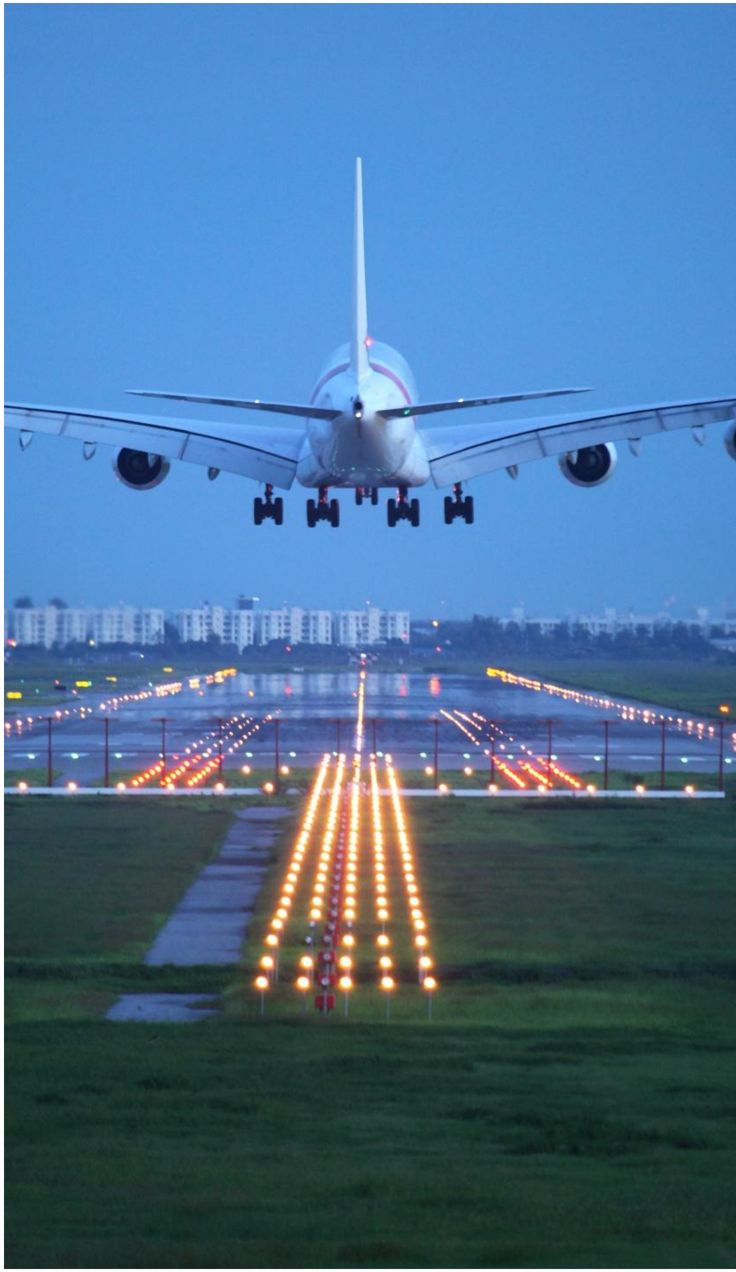
After the trials, the position and structure of the MID swath are similar to those observed pre-trial but with a slightly different and higher traffic intensity at the core of the swath. Conversely, the overall dispersion of the swath appears to be increasing, implying concentration at the core but increased spread of outliers.

Height

There are large daily fluctuations in the height of the swath's vertical centre of gravity, typically in the range 2600 feet to 3900 feet. However, there is a slight downward trend in the height of the SAM SID:

- the vertical centre of gravity moves downwards from approximately 3400 feet in late 2011 to approximately 3200 feet in spring 2015
- there is a definite downward trend on the lower limit of the swath from 2300 feet in late 2011 to approximately 2000 feet in April 2015 (the lowest observed aircraft over the analysis period was at 1456 feet)
- the frequency of days with low flying aircraft has increased
- paradoxically (other than during the trial periods) there is no perceptible trend in the number of aircraft flying below 3000 feet and 2000 feet at the gate.

Note: Detailed conclusions concerning the MID SID are drawn in section 4



CONCLUSIONS

6

At the request of the Teddington Action Group flight path analysis has been undertaken on Heathrow easterly departures at three locations of interest

A general observation that for all three SIDs is that there are, sometimes large, fluctuations from day-to-day in the characteristics of and traffic volume using the SIDs. The analysis has attempted to identify any systematic trends underlying these fluctuations.

A second general observation is that the trials resulted in major changes to the distribution of the traffic crossing the gates while the trials were being performed. After the trials the traffic distributions reverted, qualitatively, to very similar structures those observed pre-trial. However, there are underlying trends in the characteristics of the traffic which were observed before the trials and continued after the trials had ended. It is reasonable to conclude, therefore, that these trends are not due to the trials but are more general in nature

Of the three, the **DVR SID** has the highest overall traffic volume, at around 180 per day when the airport is operating to the East. DVR carries the vast majority of the Airport's A380 easterly departures. Both overall traffic volume and the number of heavy aircraft and A380s using the DVR route have increased. Departures before 08:00 and after 20:00 have increased in line with the underlying increase in traffic volume. However, the volume of these night departures appears to be cyclical: higher in summer than in winter.

The DVR route itself was unaffected by the departure trials, but was affected by the earlier operational freedoms trials from mid-2012 and to early 2013. The SAM traffic crossing the DVR gate was shifted out of the gate during the second trial period. It subsequently returned at the same position and volume after then end of the trial.

The concentration of flights at the core of the DVR traffic swath has increased. The data also indicates that the height of the DVR swath is decreasing both in terms of average height from approximately 3400 feet to 3100 feet, and the lowest flying aircraft. The number of low flying aircraft has increases. On 95% of easterly days the lowest DVR flight crossed the gate at heights between 1600 feet and 2600 feet, with the lowest flight at 1423 feet.

MID and SAM SIDs were affected significantly by the trials

In terms of volume, the **MID SID** ranks next after DVR. On easterly operations, prior to the second trial period there were just over 100 flights per day using the MID SID. After the second trial this appears to have reduced slightly, to just under 100 flights per day. The route is dominated by medium aircraft at 80% of the total. The remainder of the traffic comprises mainly heavy aircraft with a few A380s.

The position and intensity of the MID SID was affected considerably by the trials with large shifts in the lateral centre of gravity, resulting in flights over locations not previously overflown. After the end of the trials, the MID swath returned to its pre-trial location but the concentration of flights within the swath has increased. Although the vertical position of the centre of gravity of the swath has remained consistent, there is a trend indicating that the lowest flying aircraft have got lower. The frequency of days with low flying aircraft has also increased.

SAM SID traffic is typically at a level of around 35 to 40 flights per day, comprised of approximately 20% heavy aircraft and 80% medium aircraft with a few A380s. During the trials, the MID SID traffic was shifted to within the SAM gate resulting in an increase in traffic crossing the gate. The changes to both the SAM and MID SID locations during the trial resulted in a redistribution of traffic across the SAM gate. After the trials, the SAM traffic patterns reverted to their pre-trial structures but exhibit slightly higher concentration than before the trials. There is a downward underlying trend in the height of the SAM SID swath, both in terms of the centre of gravity, reducing from 3400 feet to 3200 feet, and the lowest flights, reducing from 2300 feet to 2000 feet. The frequency of the number of days with low flying aircraft has also increased.