LONDON GATWICK'S REDUCED NIGHT NOISE TRIAL

TRIAL REPORT

October 2024

LONDON GATWICK

POWERED BY VINCI AIRPORTS | GLOBAL INFRASTRUCTURE PARTNERS

Glossary

Acronym	Description
ATC	Air Traffic Control
CAA	Civil Aviation Authority
FAF	Final Approach Fix
FASI S	Future Airspace Strategy Implementation South
FLOPSC	Flight Operations Performance and Safety Committee
FMS	Flight Management System
ILS	Instrument Landing System
LGW	London Gatwick Airport
MET	Meteorological / Meteorology
MSL	Mean Sea Level
NaTMAG	Noise and Track Monitoring Advisory Group

Acronym	Description
NATS	(formerly) National Air Traffic Services
NM	Nautical Mile
NMB	Noise Management Board
NMT	Noise Monitor Terminal
NTK	Noise and Track Keeping
PBN	Performance Based Navigation
RF	Radius to Fix
RNN	Reduced Night Noise trial
RNP	Required Navigation Performance
RWY	Runway

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1. Introduction

Overview of the trial report

London Gatwick Airport has undertaken a trial to assess the extent to which PBN (Performance Based Navigation) can deliver noise benefits to local stakeholders by changing flight-path management of arriving aircraft during the night.

This document is the trial report and provides the results of the trial, as well as key observations and next steps. The document is supported by Reduced Night Noise (RNN) route statistics, which provide an overview of key data for each across all routes (Annex A). This document will be published on the CAA (Civil Aviation Authority) Airspace Change Portal and Gatwick website where it will be accessible to all stakeholders.

The trial was undertaken in accordance with guidance provided in CAA document CAP 1616[1] for airspace trials.

[1] *CAP 1616 Airspace Change Process (Fourth edition published March 2021)*

2. Background

How the trial was established through the NMB

Setting the scene, how the RNN trial came about and what it aims to achieve

In April 2017, Gatwick Airport's Noise Management Board (NMB) agreed that opportunities for night noise respite should be explored to reduce the impact of, and the number of people disturbed by, night-time arrivals.

PBN is a means of modern aircraft navigation that allows the lateral and vertical profile of arriving aircraft to be controlled in a more accurate manner, enabling efficient use of airspace through route placement, thus resulting in improved fuel efficiency and reduced noise generated by an aircraft.

In 2018, LGW commissioned an independent study[2] which investigated the relationship between the height of an aircraft and the perception of its noise. The study identified that 'outlier' noise events, defined as aircraft that are significantly lower or noisier than the mean average, are responsible for a disproportionate impact on communities.

The trial focussed on using PBN to improve the vertical profile of arriving aircraft with the aim of reducing outliers. The following aim was agreed and included in the trial Submission Pack (which was submitted to and approved by the CAA):

Trial Aim

"The trial will assess the extent to which PBN technology can deliver noise benefits for arriving aircraft during the night period, by reducing the number of noisy 'outliers' that are significantly lower or noisier than most aircraft."

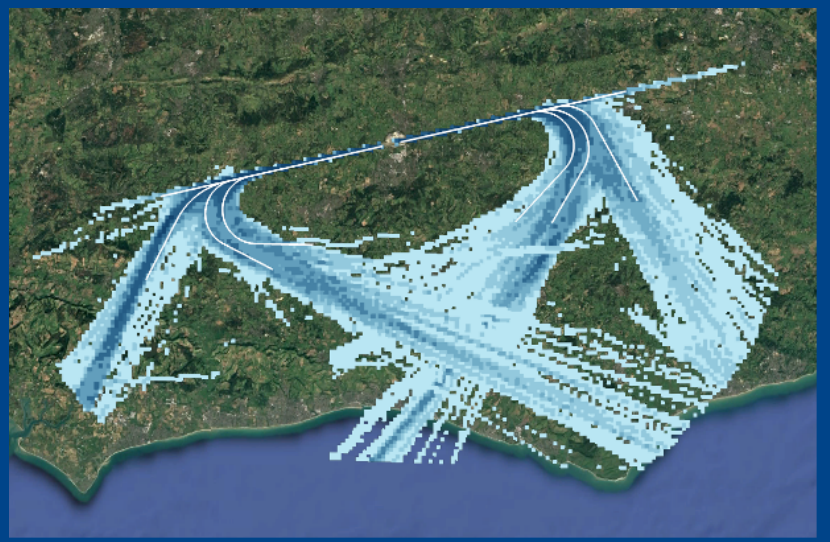
[2] *Gatwick Airport Arrivals Review: Perception of Aircraft Height and Noise, University of Sussex, March 2018.*

Community agreed trial principles and PBN route design

A number of trial principles were agreed with communities at the start of the planning phase and were used in the trial design.

The trial will:	The trial will not:
Compare environmental performance of 'with PBN' and 'without PBN' scenarios by placing the new procedures in the existing airport night-time arrivals swathe.	Identify routes for use in future airspace design.
Identify and address the planning, implementation and operational challenges associated with multiple PBN arrival transitions to inform future planning.	Overfly people currently outside of the night-time arrivals swathe.
Gather data on PBN operational performance and noise impacts.	Move the minimum night-time ILS joining point from the existing 10NM.
Further develop the NMB's understanding of PBN for arrivals.	Optimise routes for capacity improvements or efficiency.
Evaluate new community engagement initiatives and processes.	Evaluate future mechanisms for higher-density sequencing, Fair and Equitable Distribution (FED), respite or other concepts.
	Introduce a permanent airspace change without consultation.

The PBN procedures comply with ICAO procedure design standards and were designed to both runway ends. Pilots were directed by ATC to the PBN transition closest to their normal direction of arrival, thus avoiding extra track miles. The image below shows the trial routes (white), placed within the existing night-time arrivals swathe (blue heatmap). The routes were placed in the arrivals swathe to avoid overflying new people and to enable before ('without PBN') and after ('with PBN' comparison.



In total, eight PBN routes were designed that were distributed across the swathe to spread the traffic and alleviate the concentration of arrivals. The trial commenced in the winter to facilitate maximum participation and help minimise the impact on communities (since windows are more likely to be closed).

3. Trial Overview

Details of the trial and objectives, including route design and an explanation of how the trial was measured with associated limitations

Trial details, objectives and the definition of outliers

Length and time: the trial ran for a period of 6 months, from 11 January to 11 July 2024, between 01:30-05:00 local time.

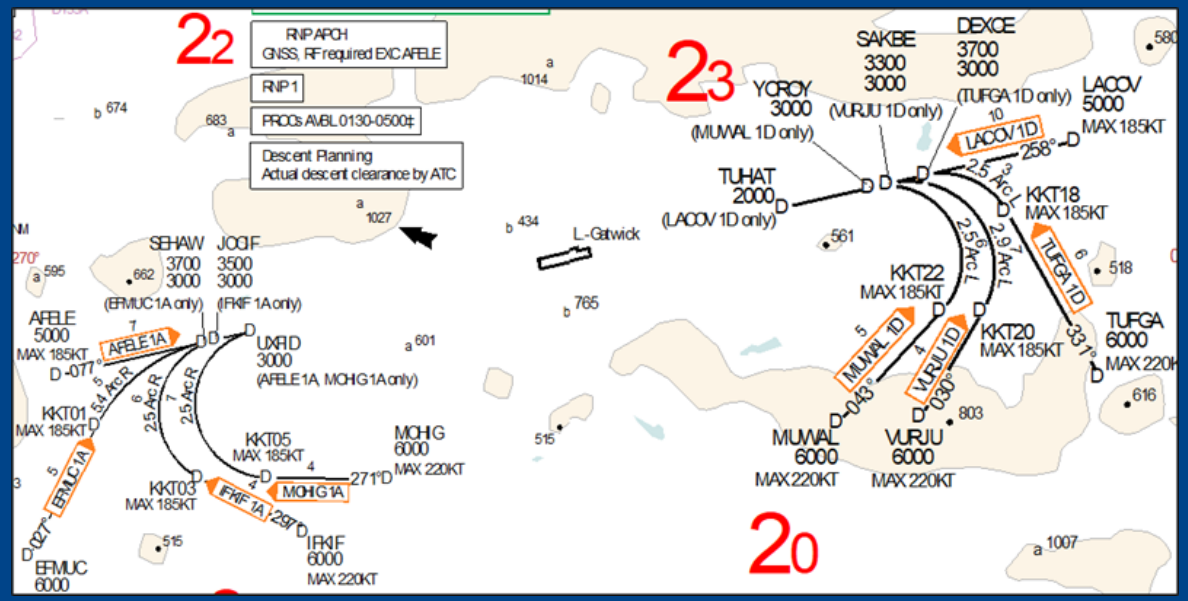
PBN routes: the routes were RNP 1 with radius-to-fix (RF) legs. The image opposite illustrates the PBN procedures (note: Easterly and Westerly procedures are presented in one image for ease).

Runway: the PBN transitions intercept the ILS on runway 26L and 08R.

Participation: the PBN procedures were flown by suitably equipped aircraft, with others being vectored as per normal operation.

Suspension: the trial was suspended on nights, or for part of a night, when operational concerns were raised, such as poor weather conditions or high levels of traffic.

NMTs and data capture: nine Noise Monitoring Terminals (NMT) were used to capture the baseline and trial data environments under three of the trial routes. Track and vertical profile data was recorded for all trial aircraft.



Quantitative objectives: the agreed trial objectives are below:

- Objective 1: Reduce the number of noise outliers by 90%
- Objective 2: Reduce the number of altitude outliers by 90%

Definition of outliers: to determine which flights qualify as an outlier, baseline data was collected from the NMTs for up to a year before the trial began. Outliers were defined as exceeding a threshold defined by the "worst-performing" 5% of flights in this baseline data, either the loudest 5% (noise) or the lowest 5% (altitude). Using this information, outlier thresholds were set at each NMT. Once the trial started, flight data was compared against these pre-determined thresholds where it was expected that the proportion of outliers would be less than 0.5% of trial aircraft.

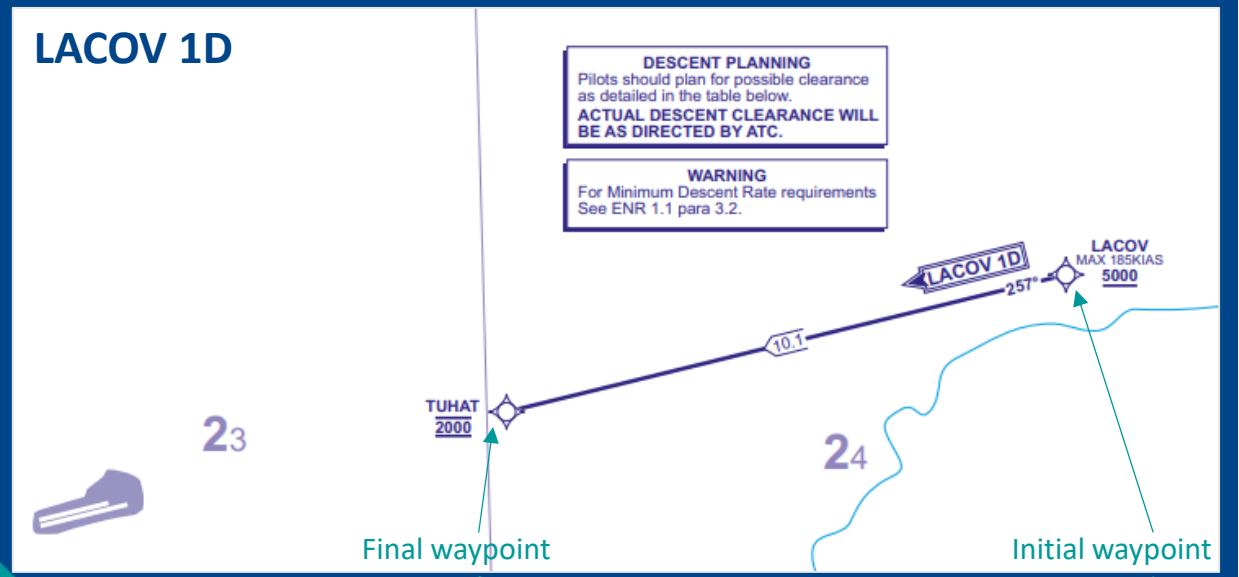
Information on the PBN route design

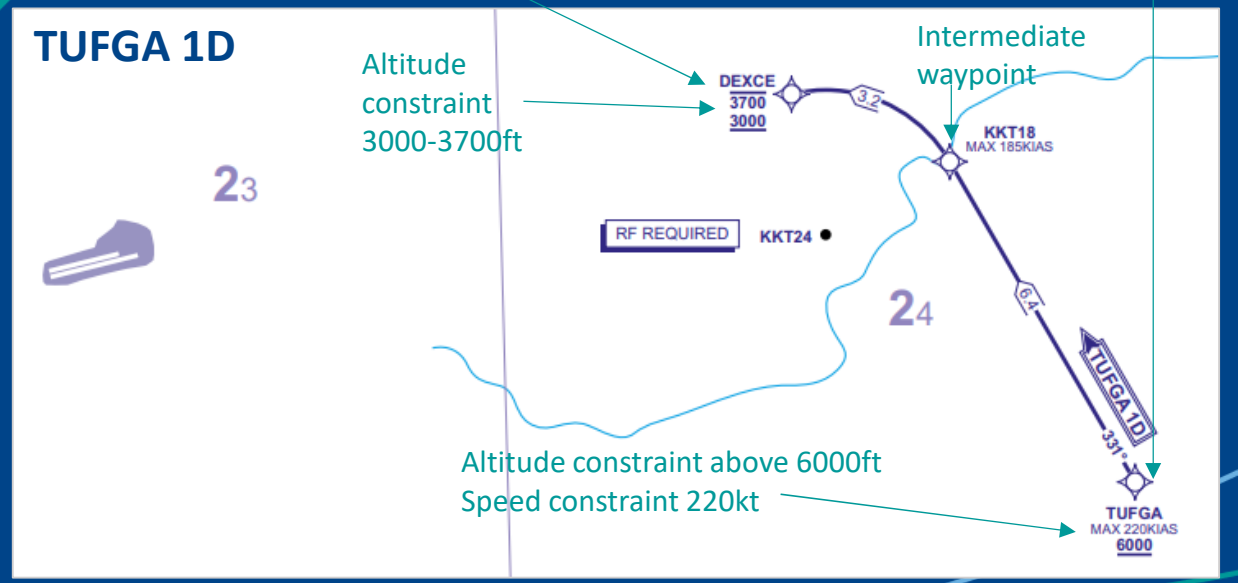
The PBN trial routes were defined by a series of waypoints with associated constraints, either altitude, speed, or both. The routes were also designated by an ICAO five letter name-code e.g. LACOV 1D, and comprised of the following:

- 2 waypoints for the straight in routes (example picture top right: LACOV 1D route)
- 3 waypoints for the curved routes (example picture bottom right: TUFGA 1D route)
- The curved routes have RF legs which are a constant radius circular path
- There are altitude constraints on the first and final waypoints
- There are speed constraints on the first waypoint and middle waypoint for the curved routes

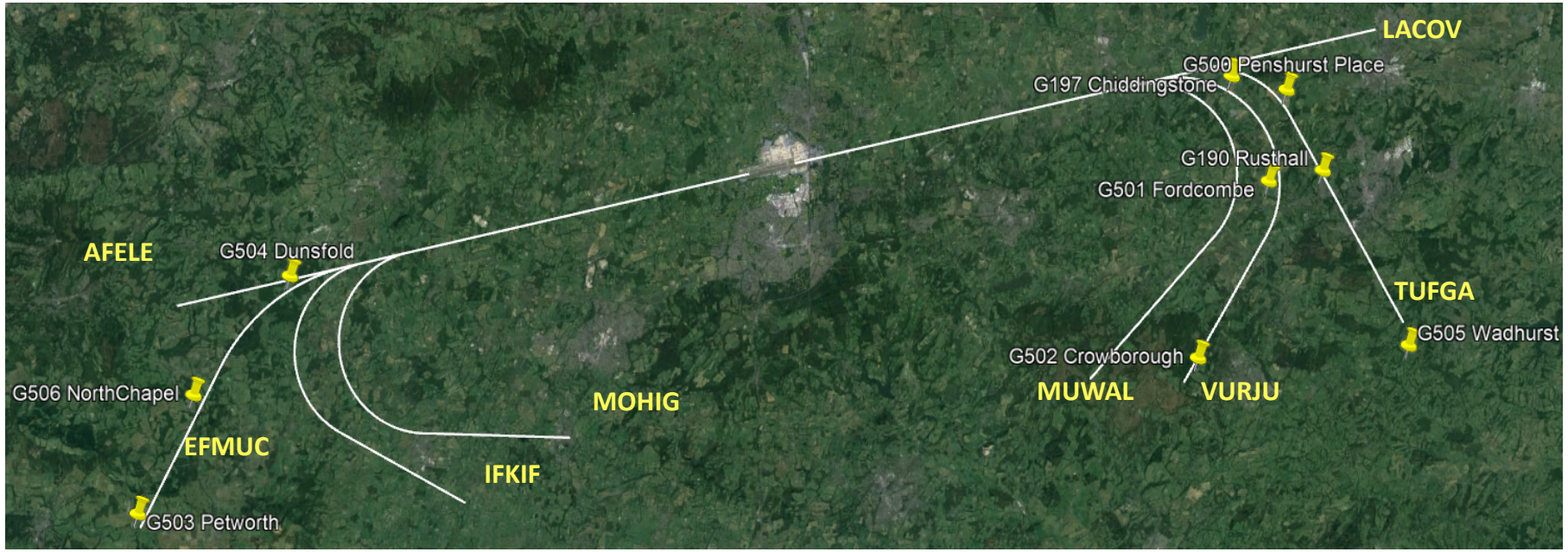
Altitude restrictions are defined by being either:

- **At** (example: TUHAT)
- **At or above** (example: TUFGA, LACOV)
- **Between a range** (example: DEXCE)





Noise Monitor Terminals (NMTs) were used to measure noise from aircraft participating in the trial



NMT distance to runway threshold

Wadhurst – 22.2NM

Rusthall – 17.3NM

Penshurst Place – 14.0NM

Crowborough – 21.6NM

Fordcombe – 16.7NM

Chiddingstone – 13.0NM

Petworth – 21.6NM

North Chapel – 17.8NM

Dunsfold – 13.5NM

Based on pre-trial analysis, the NMTs were positioned along the routes expected to be most used during the trial. Arrivals at London Gatwick are predominantly Westerly (70% Westerly vs 30% Easterly) and therefore two Westerly routes were monitored vs one Easterly route. In total, nine NMTs were located under three trial routes (TUFGA, VURJU and EFMUC).

Noise readings from the monitors were adjusted according to the aircraft's altitude and lateral distance from the point directly above the monitor to ensure the readings are comparable across the flights. This is standard practice when analysing noise data.

Any unusual noise events were assessed on a case-by-case basis and discarded if the source was found to be non-aviation.

Making noise measurements

There were three Noise Monitor Terminals (NMTs) on each monitored route (pictured right).

An aircraft could exceed these thresholds on none, one or multiple monitors along its route.

Other factors affecting data capture were:

- **Missing data:** caused by capture rate of the temporary monitors and the accuracy of correlation to flights. Consequently, not all flights have noise readings on all the monitors along their route. Occasionally, flights could have been too quiet to be captured by the monitors, which have a noise minimum of 50dB. Altitude data is not captured by individual monitors but is computed from trajectory data.
- **MET conditions[4]:** there is inherent variation that exists in the measured noise due to the external environment and this may cause individual readings to vary by a significant amount. The variations are due to meteorological (MET) conditions on the day (temperature, humidity, wind speed, direction, and atmospheric pressure) impacting sound propagation.

[4]*Impact of meteorological conditions on noise monitoring https://www.aca-acoustics.co.uk/uncategorized/how-weather-conditions-affect-noise-survey-results/*

Monthly reporting and engagement throughout the trial

Throughout the trial, London Gatwick engaged with stakeholders to share updates on trial progress and to understand if there were any concerns regarding the procedures. Monthly reports were produced by the project team which summarised performance in the defined reporting period, including general statistics and details of any outliers. The reports were submitted to the CAA and uploaded to London Gatwick's RNN website page[3] for local communities to access.

Engagement with airlines was key to understanding how different airlines, aircraft types and pilots managed the PBN procedure. The team organised airline workshops, bilateral meetings, and attended Airline Base Captain meetings to present the trial findings and gather feedback. Updates were also provided through formal channels such as the airport's Flight Operations Performance and Safety Committee (FLOPSC).

The project team attended the London Gatwick's Noise and Track Monitoring Advisory Group (NaTMAG) and Airport Consultative Committee (GATCOM) to share updates on trial progress with local councils and communities. The NMB was transitioning to its third term through the duration of the trial. Whilst there were no formal NMB meetings, the monthly reports were shared with members and uploaded on the website. Feedback was provided by communities via the existing NMB processes.

In addition to the above, the project team held bi-weekly meetings which included representatives from London Gatwick, NATS (the air traffic control service provider) and Egis. During these meetings, the team discussed trial progress, ATC feedback, safety concerns, Noise Monitor Terminal (NMT) data and performance, and any noise complaints received during trial hours.

[3] *London Gatwick Airport Website: www.gatwickairport.com/company/reduced-noise-night-trial/rnn-trial.html*

4. Trial Results

Statistics showing an overall view of the outcomes of the trial, a deeper analysis of results and outlier outcomes

Overall trial results

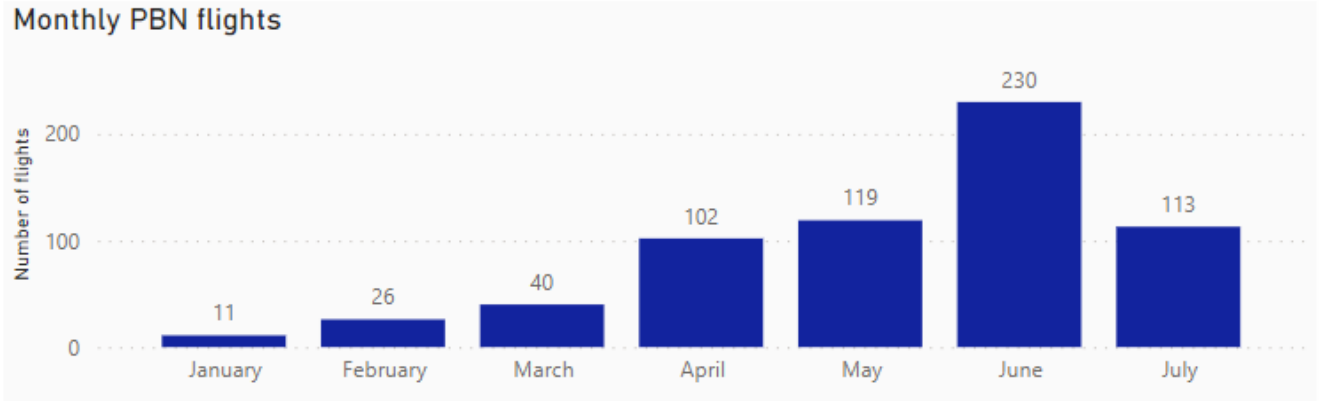
At the start of the trial the number of trial flights that flew the PBN procedure was relatively low due to low traffic numbers in the winter. They began trending upwards in April, due to Easter, and continued growing as summer approached.

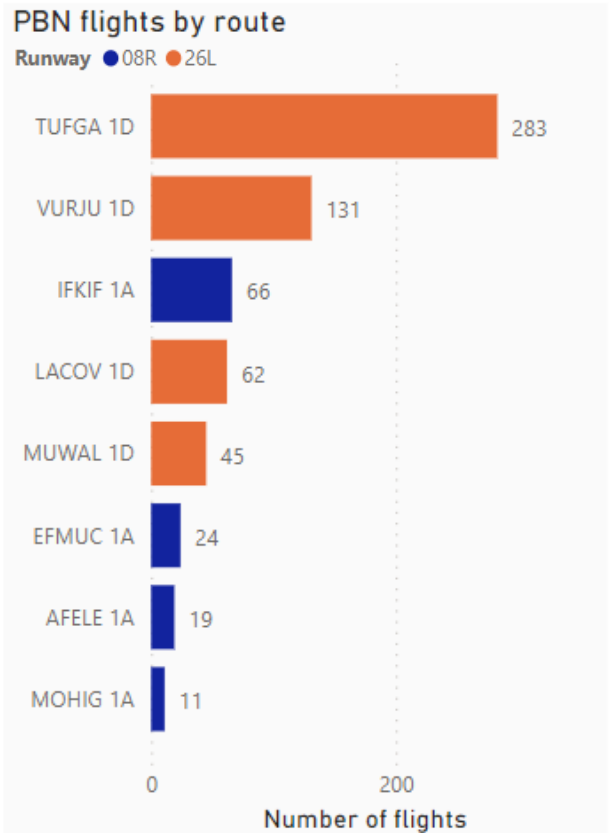
There were **641 PBN flights**, and in keeping with routine operations, Westerly routes were the most utilised: 521 flights landed in a Westerly direction (RWY 26L) while 120 flights were Easterly (RWY 08R).

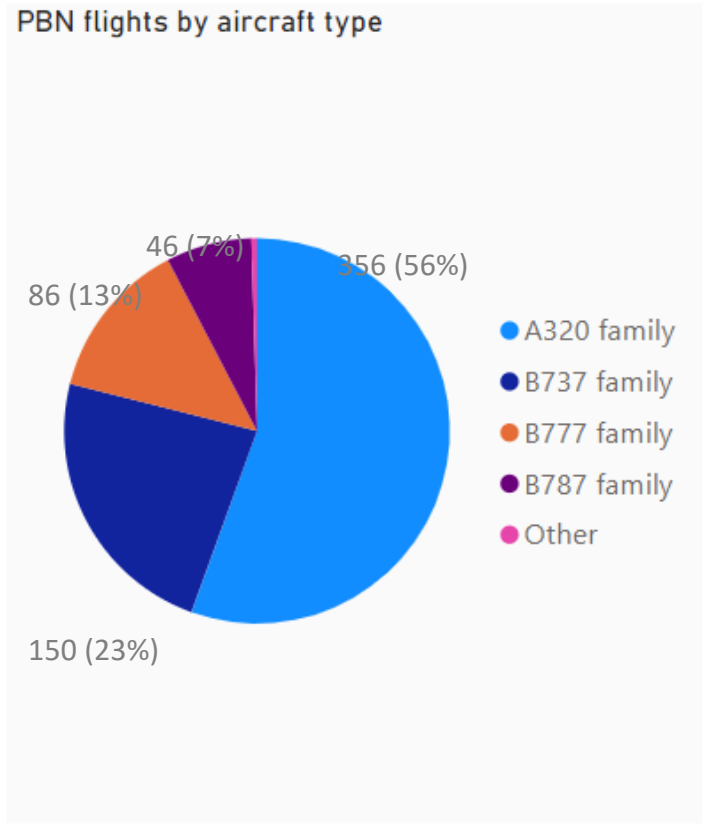
On the monitored routes the total number of flights was 438, accounting for 68% of all PBN flights. The majority of PBN flights were on the TUFGA 1D route.

Aircraft from the A320 family were the most frequent aircraft type in the trial (56%), followed by the B737 family (23%).

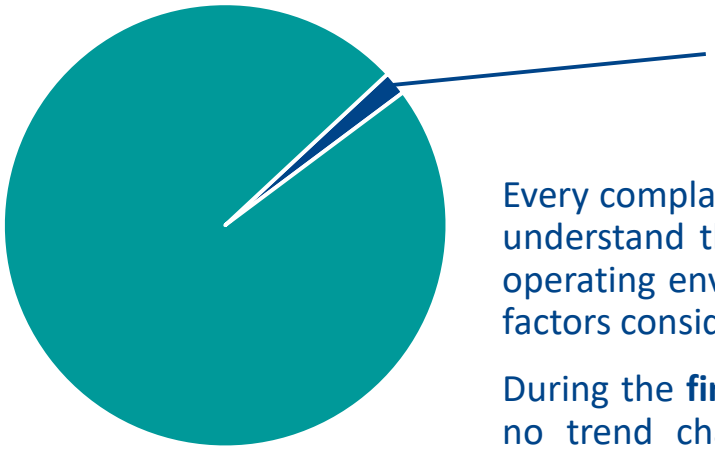
Note: The trial started on 11 January and ended on 11 July, so data does not cover a full month for each of these. In addition, 2 nights (22 January and 7 April) were excluded from analysis due to stormy weather.







There were few noise complaints during the trial



There were a total of 11 complaints that were coincident with trial aircraft out of a total of 641 PBN flights. This is equivalent to 1 complaint every 58 flights or 1.8 complaints every month for the trial period.

Every complaint coincident with a trial aircraft was investigated (as set out in the original trial documentation) to understand the contributing factors and to ensure the trial caused no adverse noise compared to the normal operating environment. Outlier comparison, weather factors and other operational constraints were among the factors considered when analysing each complaint.

During the **first third of the trial there were no complaints** made in reference to any PBN flights and there was no trend change identified. This indicates there was no significant impact to local communities at the introduction of the trial.

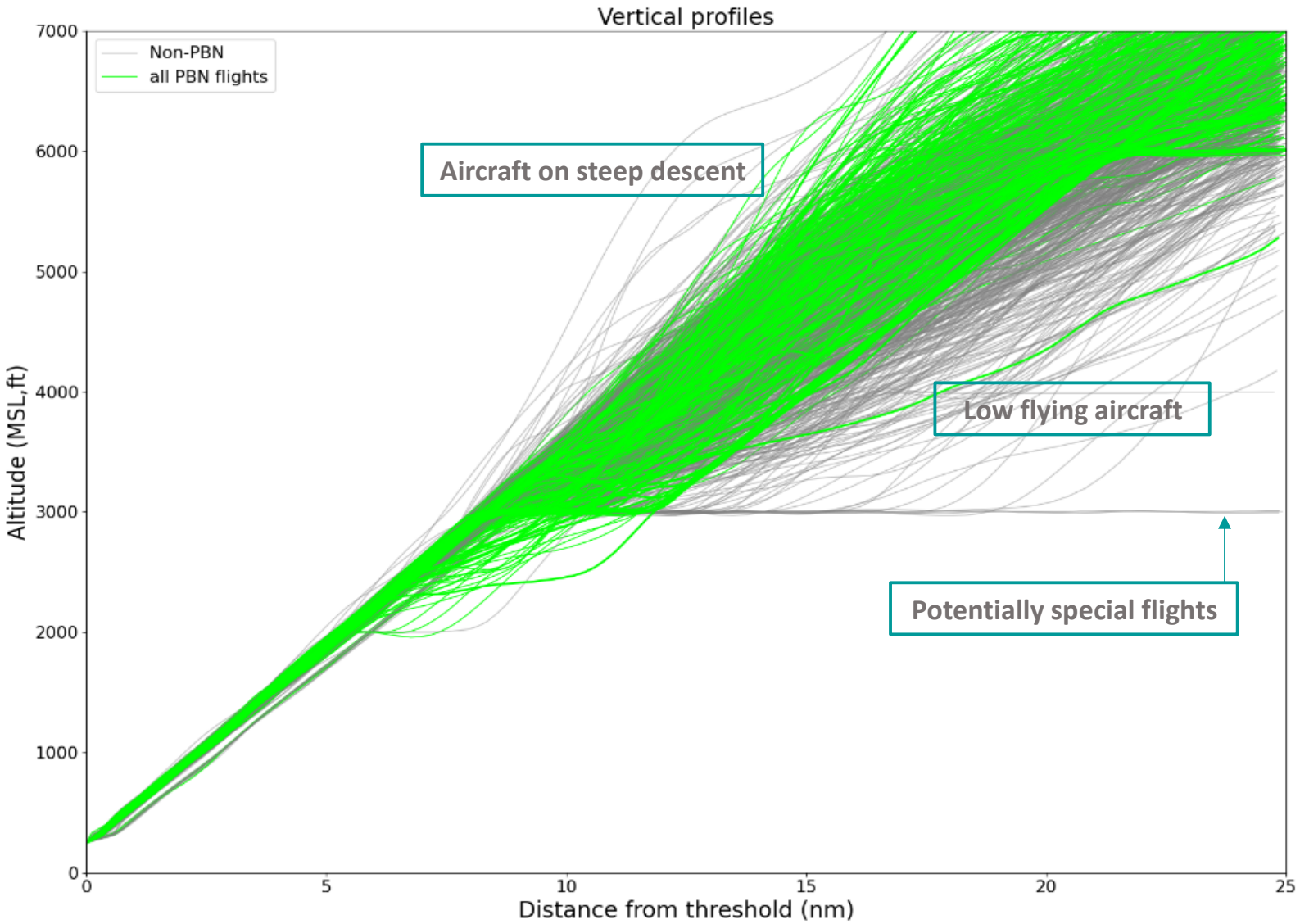
Most complaints were made in the second half of the trial which is aligned with the seasonal increase in traffic, and therefore PBN flights towards the summer. This is also aligned with the complaints trend observed for non-trial aircraft and so from this perspective is not unexpected.

Information for trial aircraft with complaints[8]

- 7 aircraft were not outlier events.
- 2 aircraft were not on routes with NMTs and therefore no comment can be made on them in relation to noise measurement as part of the trial.
- 1 was removed from outlier analysis due to storm conditions adversely impacting operations.
- At no stage during the trial did any individual complaints or total complaints numbers raise the need to suspend or terminate the trial.

[8]One aircraft had two complaints which accounts for the total of 11 it was not an outlier

The trial delivered improvements in vertical accuracy



PBN technology enables aircraft to follow more precise vertical flight paths. When flown to the altitude constraints along these routes, aircraft fly within a narrower range of altitudes.

The graph on the left illustrates the difference between trial aircraft (green) and non-trial aircraft (grey) throughout the trial period.

Trial Finding

The trial succeeded in:

- **reducing low-altitude flights**
- **eliminating excessive level segments**
- **removing steep descent approaches**

The main trial aim was to increase the altitude of aircraft, but note that overly steep descent approaches can also result in higher noise levels. This is due to changes in aircraft configuration such as increased use of flaps, slats, or speed brakes.

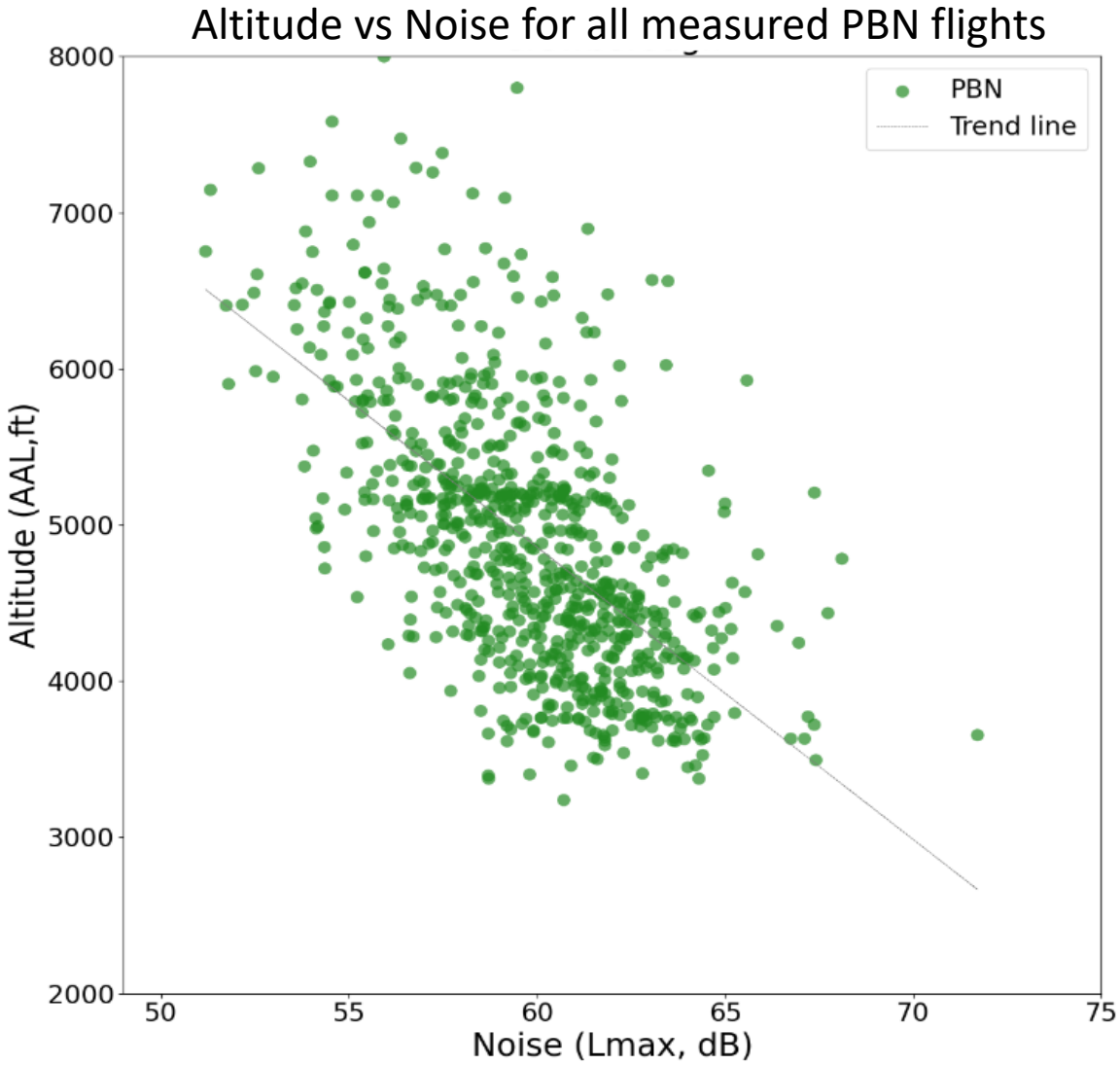
Trial aircraft altitude and noise interdependencies and key factors to address noise reduction in arrivals

As explained on previous slides the relationship between altitude and noise on the ground is inverse – higher aircraft typically result in lower noise on the ground. Overall, the noise results from the trial agree with this, as depicted in the scatter plot (right) of all noise measurements from trial aircraft showing a downward trending line. The variation around this trend is due to other aspects that impact this relationship, the most important ones are:

- Aircraft type
- Aircraft configuration and descent management
- Meteorological conditions
- Terrain absorption

When addressing noise reduction in arrivals, the key factors to consider are aircraft altitude and configuration, which is related to descent management. These aspects will be discussed further in section 6.

Individual scatter plots for each monitor separately can be found in Annex B of this report.



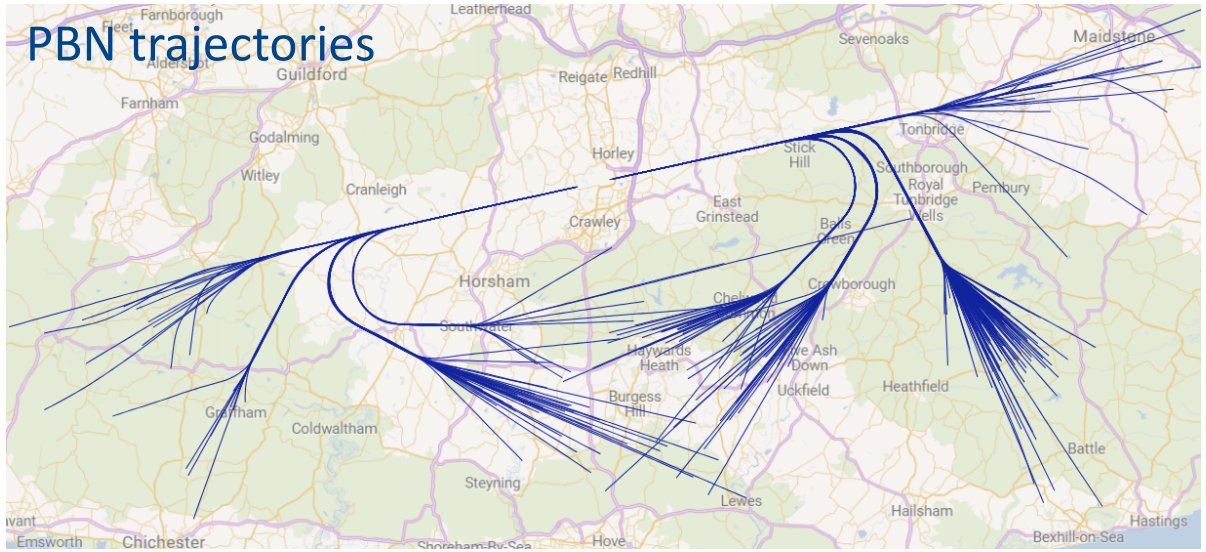
Lateral Accuracy within the trial was improved compared to routine operations

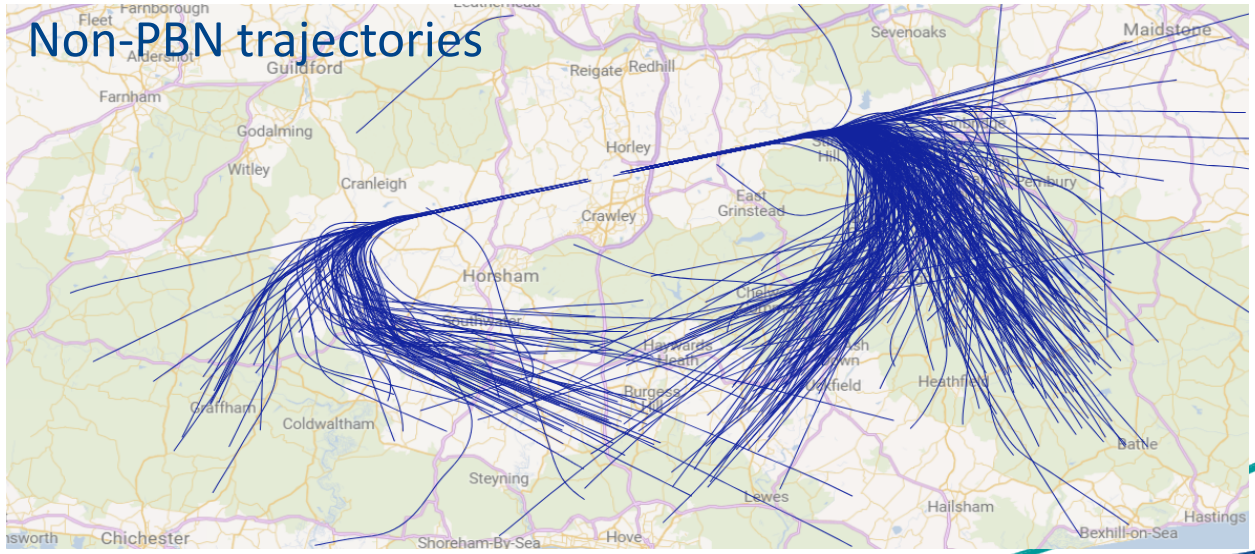
Trial Finding

PBN flights followed highly precise lateral navigation including during the turns.

Non-PBN trajectories were widely dispersed across larger areas, whilst PBN trajectories tracked precisely on predefined routes and maintained this alignment down to the runway. This is evidence that the trial improved lateral accuracy building on what is known about PBN, which is that it uses precisely defined routes and satellite-based systems rather than ground-based navigation aids.

Note: The trajectories shown below are shown from 0-7,000 feet.





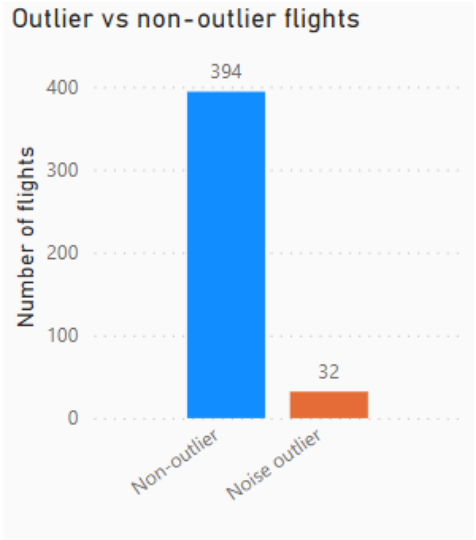
Outlier statistics

Noise and altitude measurements are presented for the three monitored routes: TUFGA 1D, VURJU 1D and EFMUC 1A.

Noise

The total number of PBN flights with at least one valid noise reading was 426. Of these, there were 32 aircraft that exceeded the noise threshold on at least one noise monitor. Some aircraft exceeded the threshold on multiple monitors. There were 42 outlier readings in total, where 21 of these exceeded the threshold by less than 1dB, 13 readings were between 1dB-3dB above the threshold and 8 readings were above 3dB louder than the threshold.

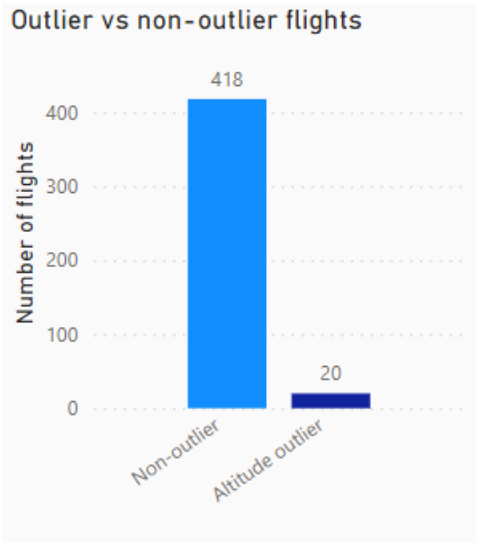
The quantitative objective of the trial the aim was to have less than 0.5% of outliers. The proportion of noise outliers on the monitored routes was 7.5% so the objective was not met.



Altitude

The total number of PBN flights on the monitored routes was 438. Of these there were 20 aircraft that infringed the altitude threshold. 1 flight exceed the threshold on 2 monitors. 17 aircraft were less than 100ft below the threshold. 4 recordings (3 aircraft) were between 100ft-307ft lower than the threshold.

The quantitative objective of the trial the aim was to have less than 0.5% of outliers. The proportion of altitude outliers on the monitored routes was 4.6% so the objective was not met.



There were nine outlier flights that infringed both noise and altitude thresholds, and these are included in both noise and altitude outlier statistics.

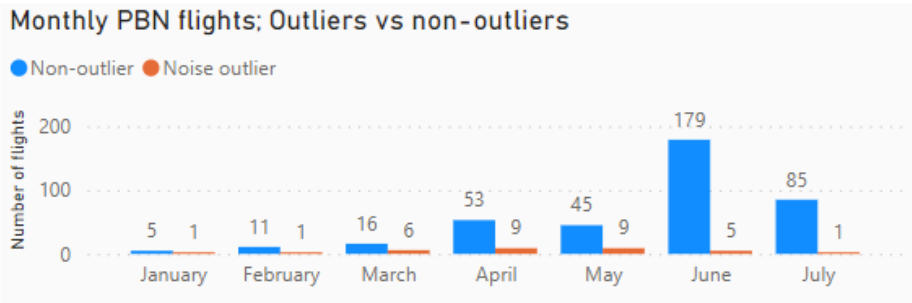
- Total number of noise outliers: 32 flights (23 noise outliers + 9 noise & altitude)
- Total number of altitude outliers: 20 flights (11 altitude outliers + 9 noise & altitude)
- Total number of individual outliers: 43 flights

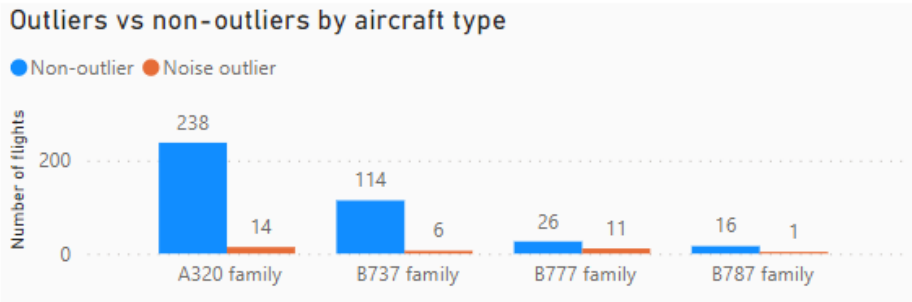
Trends in trial outliers by month, aircraft type and PBN route

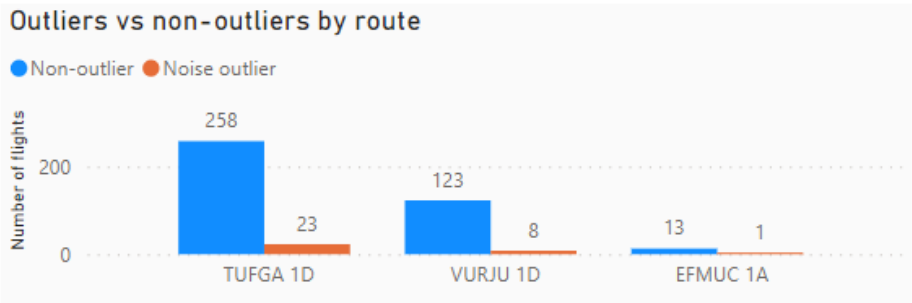
As shown below, the number of trial flights increased with the seasonal increase in traffic. The proportion of outliers significantly reduced though June and July, probably due to increasing pilot familiarity with the trial. The most common aircraft types in the trial were the A320 family, however the Boeing 777 family had the highest rate of infringements compared to the number of movements.

There is no significant difference in performance between routes when it comes to noise outliers, as there are more outliers for routes with higher participation. For altitude outliers, VURJU 1D had no infringements in contrast to the two other routes.

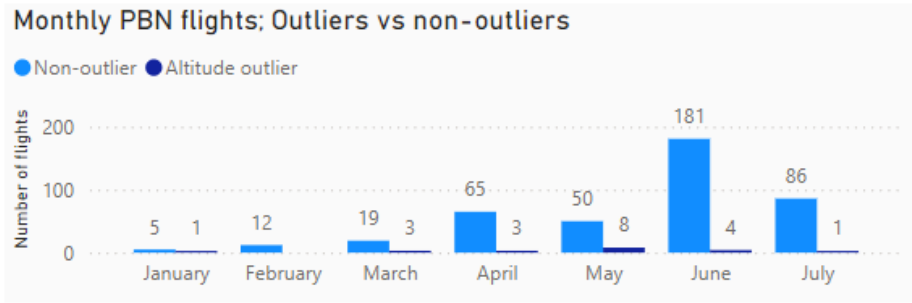
Noise

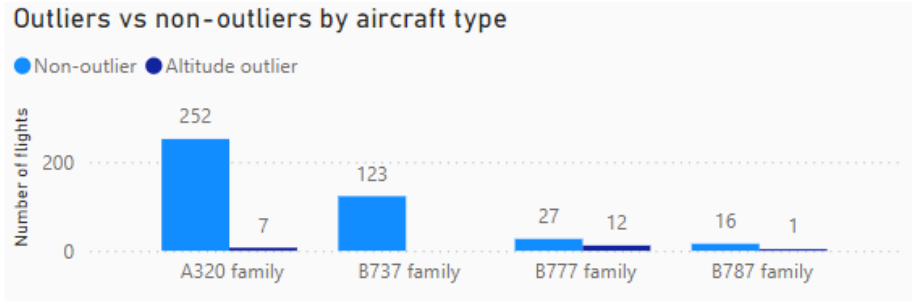


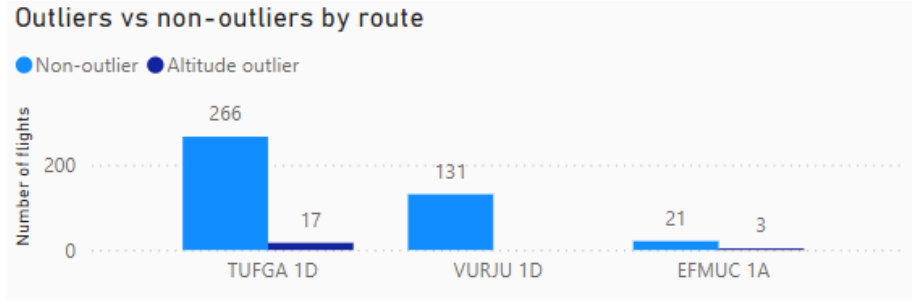




Altitude



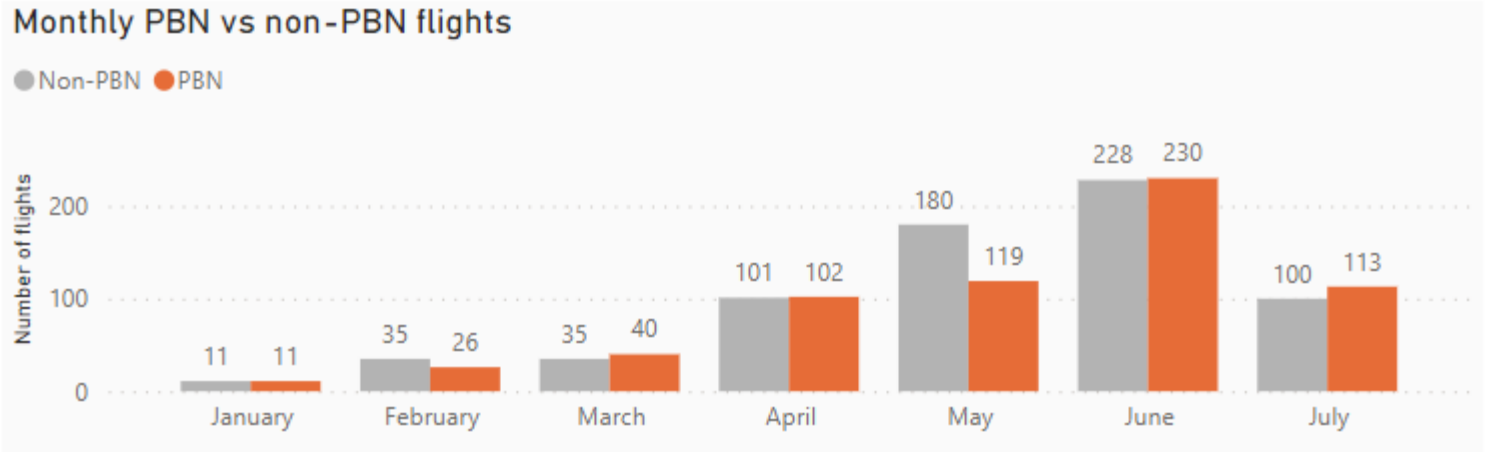


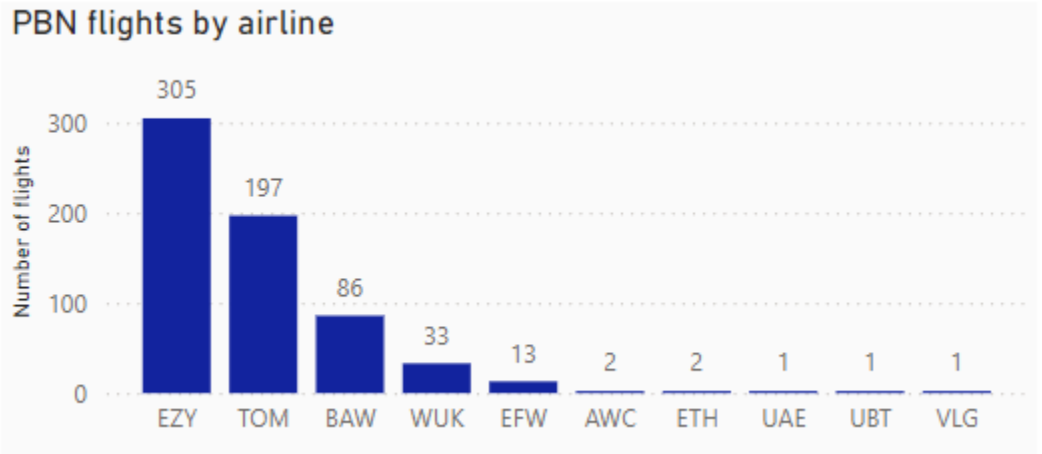


Trial participation and factors contributing to uptake

In total there were 1331 flights during trial hours and 641 flew the trial, which corresponds to 48% participation rate.

There are a few factors that limited trial participation which would not apply with a permanent airspace change. For example, flight planning procedures were different for trial flights and this could have reduced participation. London Gatwick organised various engagement sessions to raise awareness and encourage participation in the trial.





Factors affecting participation:

- Not all aircraft were equipped to fly this type of PBN procedure (RNP 1 with RF leg).
- Air Traffic Controllers suspended the trial in the event of high traffic or other operational reasons.
- Pilots could decline a trial clearance at their discretion. As this was a temporary trial and the first of its kind in the UK, familiarity with the procedure influenced participation.
- Only one aircraft was permitted on a trial route at any given time.

5. Stakeholder Feedback and Other Insights

Trial insights from operational stakeholders. And well as other factors for consideration when assessing the results

Feedback from aircrew and NATS: Part 1

In addition to the engagement outlined in Slide 7 various other engagement activities were undertaken to seek stakeholder feedback on factors such as instrument flight procedure design, interaction with ATC and airline procedures. The engagement provided feedback on how the trial procedures were working in a real-world environment and how to improve them for future noise improvements.

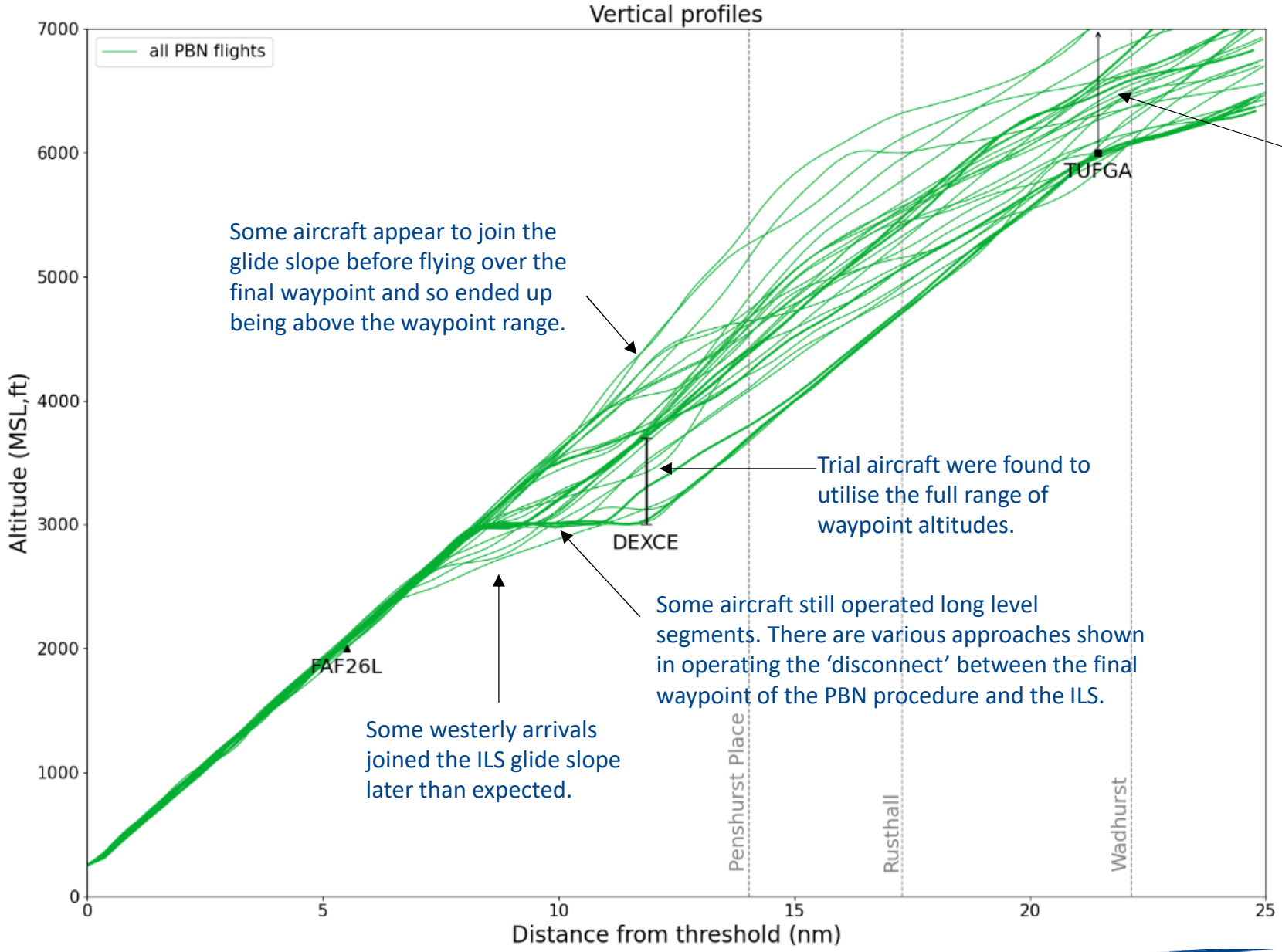
The insights came through trial feedback reports from pilots, meetings and workshops from operational staff with the following companies:

Trial feedback category	Comment
Participation	Trial participation was influenced by familiarity with the trial, the time of night and its temporary nature. Internal fleet notices were found to be an effective means of messaging the wider network of pilots, as well as including a note on the trial in the Gatwick ATIS. This type of approach transition needs to be included and briefed in the flight plan phase so that pilots are better prepared.
Role of ATC	There was a suggested amendment to the phraseology to allow more descent distance ahead of the first transition waypoint. Also, if the clearance could be given earlier this would allow better descent planning and consequently improved profiles. The procedures of air traffic controllers in the wider area had an impact on some aircraft commencing the procedures.

Feedback from aircrew and NATS: Part 2

Trial feedback category	Comment
Airline operating procedures	Airline culture and operating procedures encourage flying with maximum automation and with CDA, it was felt that the transition procedures offered conflicting information with the inclusion of level-segments.
Crew experience	Operational factors like training flights and different line pilots impacted the way the procedures were planned and flown e.g. operating more conservatively with increased use of control surfaces like flaps.
Workload	In some circumstances the procedures created increased workload e.g. planning the flight on vectors to ultimately fly PBN. Location of the procedures in the FMS could also impact this. It was also reported on occasion that the procedure flew fully automated as planned and expected, making a very easy approach.
Type variation	Different FMS create variation in calculated descent profile. This is influenced by the mode e.g. managed, and by the MET conditions.
Energy management	Energy management of an aircraft is directly linked to configurations, such as flaps, speed brakes etc. This can create noise and so this needs to become a primary consideration in procedure design.
Instrument flight procedure design	Waypoint ranges were open to interpretation which created differences in the way transitions were flown. It would be helpful to include track distance to landing from the final waypoints on charts. Narrower and higher altitude constraints may help to make the procedures quieter.
ILS	There was some ambiguity as to where the aircraft would be in relation to the ILS following the transition. The interaction between the final transition waypoint and the ILS needs further work.
Meteorological conditions	On some routes, aircraft could experience a tailwind approaching the first waypoint which impacts energy management to meet the the speed constraint. MET conditions also impact sound propagation.
Seasonal variation	Performance is likely to be worse during winter due to an increase in adverse weather conditions at this time of year impacting operational decisions by ATC and airline operators.

Example of other procedure observations – TUFGA 1D



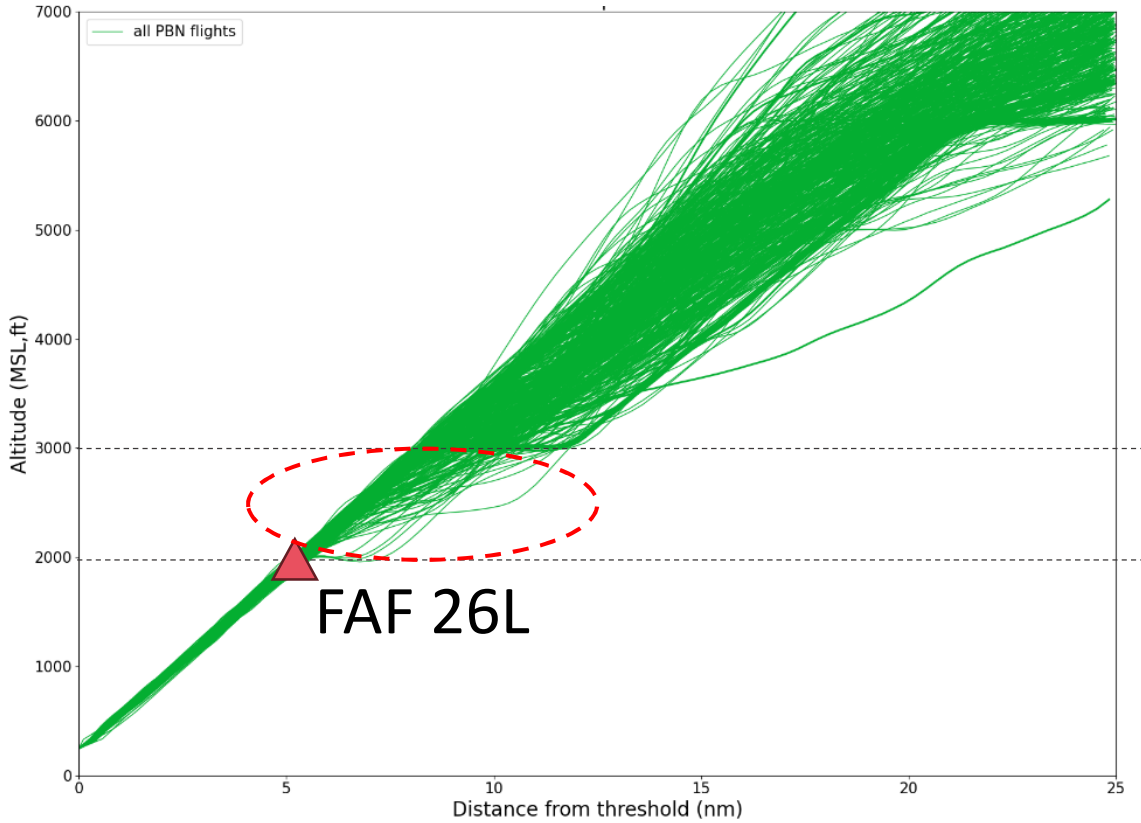
The initial waypoint has an "at or above" constraint, which means that aircraft can join the procedure at or above the waypoint altitude. The joining altitude impacts the follow-on descent gradient, and subsequent aircraft energy management and configuration.

Operational data on the interaction between the PBN transition and the ILS procedure

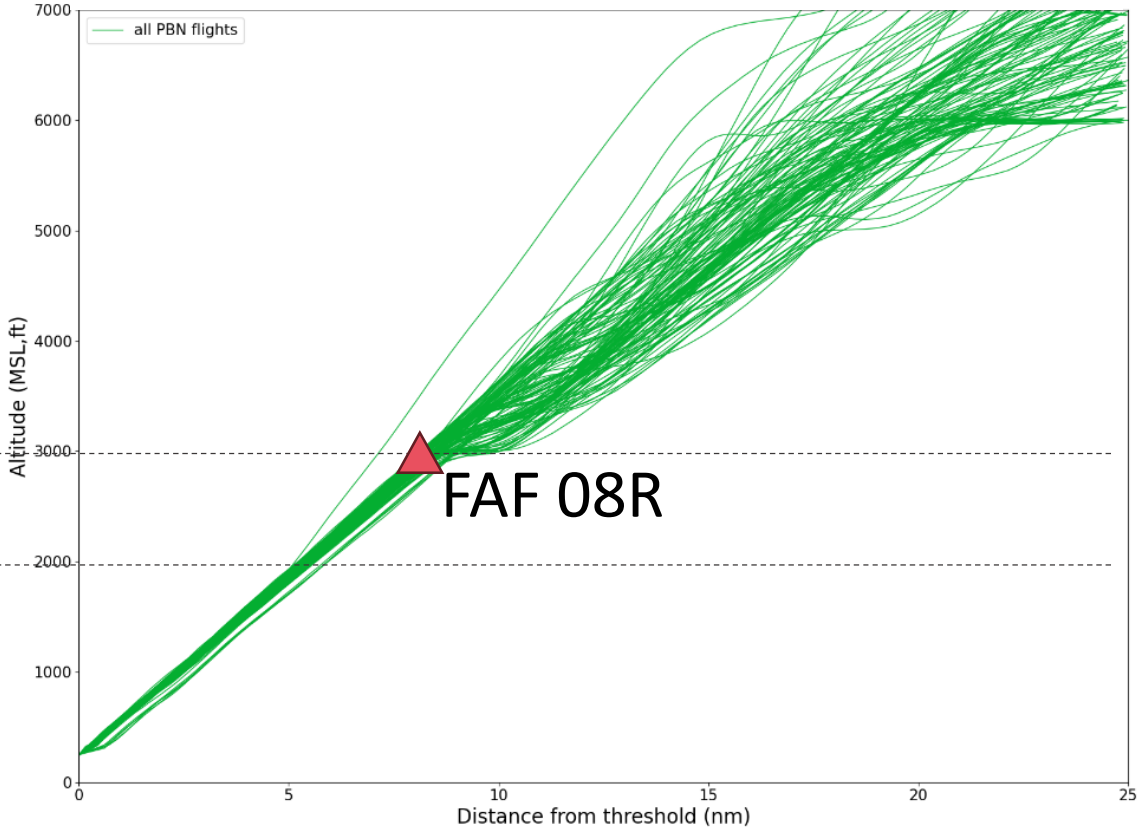
The Final Approach Fix (FAF) is a designated point in an instrument approach procedure where the final approach segment begins. This point is located at 2,000ft for westerly arrivals to runway 26L and at 3,000ft for easterly arrivals to runway 08R.

It was observed that westerly arrivals had variation in vertical profile between 2,000-3,000ft. The reason for this may be the 'disconnect' between the PBN transition, which ends at 3,000ft, and the FAF located on the instrument landing system (ILS) glide slope at 2,000ft.

Vertical Profiles for Westerly Arrivals



Vertical Profiles for Easterly Arrivals



6. Conclusions & Next Steps

What has been learnt in the RNN trial and what will come next to build on findings

Trial conclusions

The central purpose to this trial was to implement PBN arrival technology to reduce the loudest and lowest aircraft. The trial successfully delivered PBN transitions designed specifically for this purpose in a live operational environment, the first of its kind in the UK, and critically no safety concerns were raised.

A highlight of the trial was the reduction of low altitude flights, removal of excessive level segments and removal of the steepest descents, all of which contribute to the progression towards quieter skies. Additionally, the procedures demonstrated had high lateral precision. The trial generated minimal noise complaints, showing no increase compared to normal operations.

Engagement in this trial was extremely valuable for understanding the context around the recorded noise and altitude data, and to learn of other factors influencing the outcomes of the trial. London Gatwick is an airport that already has good management of arrival noise, and it is now clear that to further improve noise is a complex task. The process must consider several elements holistically and balance their respective contribution to noise, rather than simply thinking that higher aircraft reduce noise. One of the most important elements is appropriate Instrument Flight Procedure design to facilitate optimal aircraft configuration for energy management.

Key points summary & next steps following the trial

- **PBN transitions for arrivals have been successfully demonstrated in real-world operations with no reported safety concerns.**
- **PBN technology offers advantages through highly precise lateral track keeping and maintaining aircraft within an optimal altitude range during descent.**
- **No adverse impacts on the community were observed, as evidenced by the absence of any increase in noise complaints during the trial.**
- **Several factors affect the extent to which PBN technology can provide noise benefits for arriving aircraft.**
- **Although the reduction in low altitude flights, removal of excessive level segments and removal of the steepest descents provided clear benefits, the trial did not achieve its initial objective of reducing the number of outliers by 90%.**

Next steps

The trial has provided a leap forwards in improving understanding of PBN as a tool for noise management. It is a starting point for a follow-on PBN study focused on utilising more ground-based simulation to optimise route design for noise reduction, and to inform the wider Future Airspace Strategy Implementation - South (FASI-S) programme.

Annexes

Annex A: Trial Statistics by Route

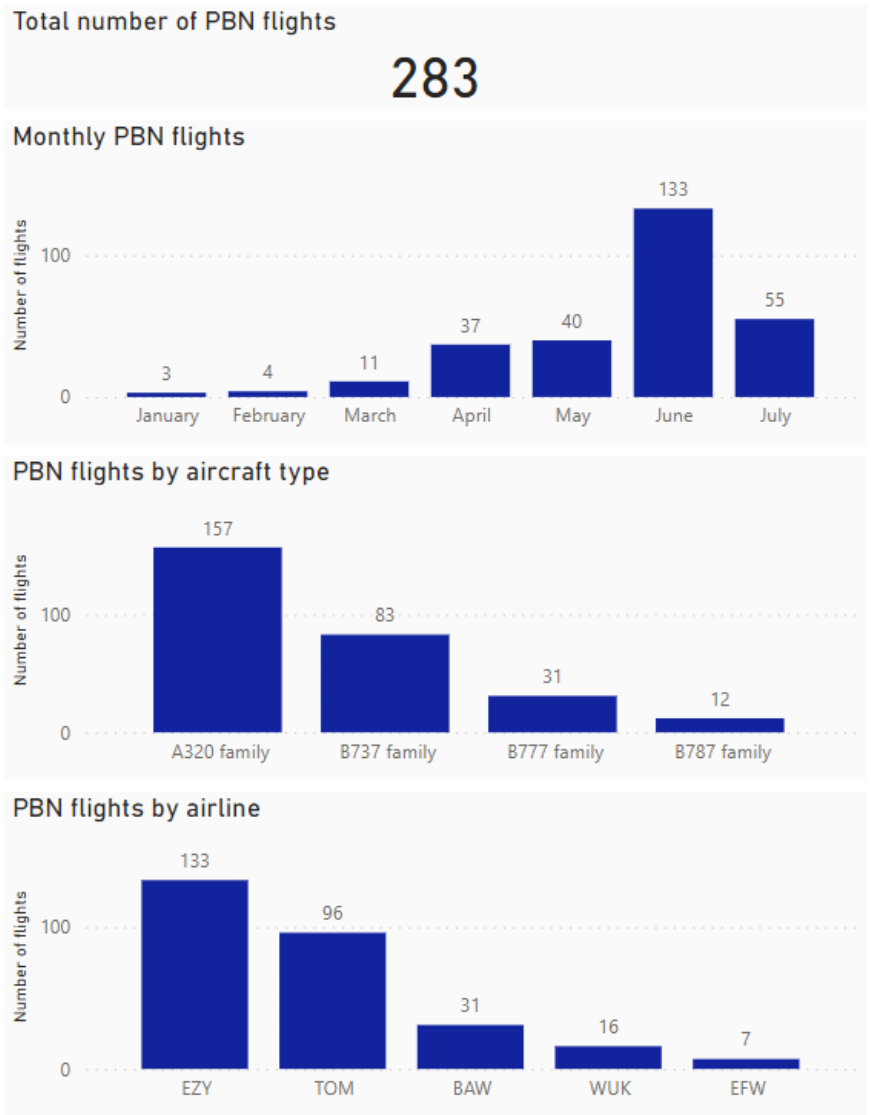
Further detail of trial statistics per route

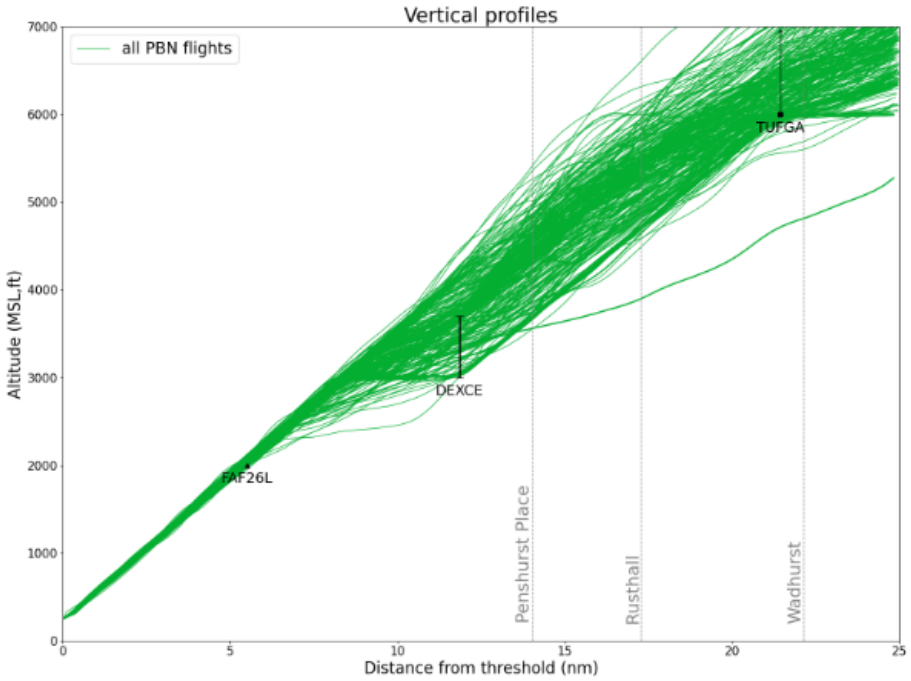
Overview of TUFGA 1D westerly PBN approach to RWY 26L

TUFGA 1D is one of the three routes fitted with noise monitors.

There were 283 PBN flights during the trial period and it was the most frequently used route in the trial.

The route has two waypoints with altitude restrictions – TUFGA and DEXCE. The TUFGA waypoint has an altitude constraint to keep aircraft above 6000ft. DEXCE has a range of altitudes between 3000ft-3700ft. After passing DEXCE, aircraft aim for the final approach fix (FAF) on the ILS.



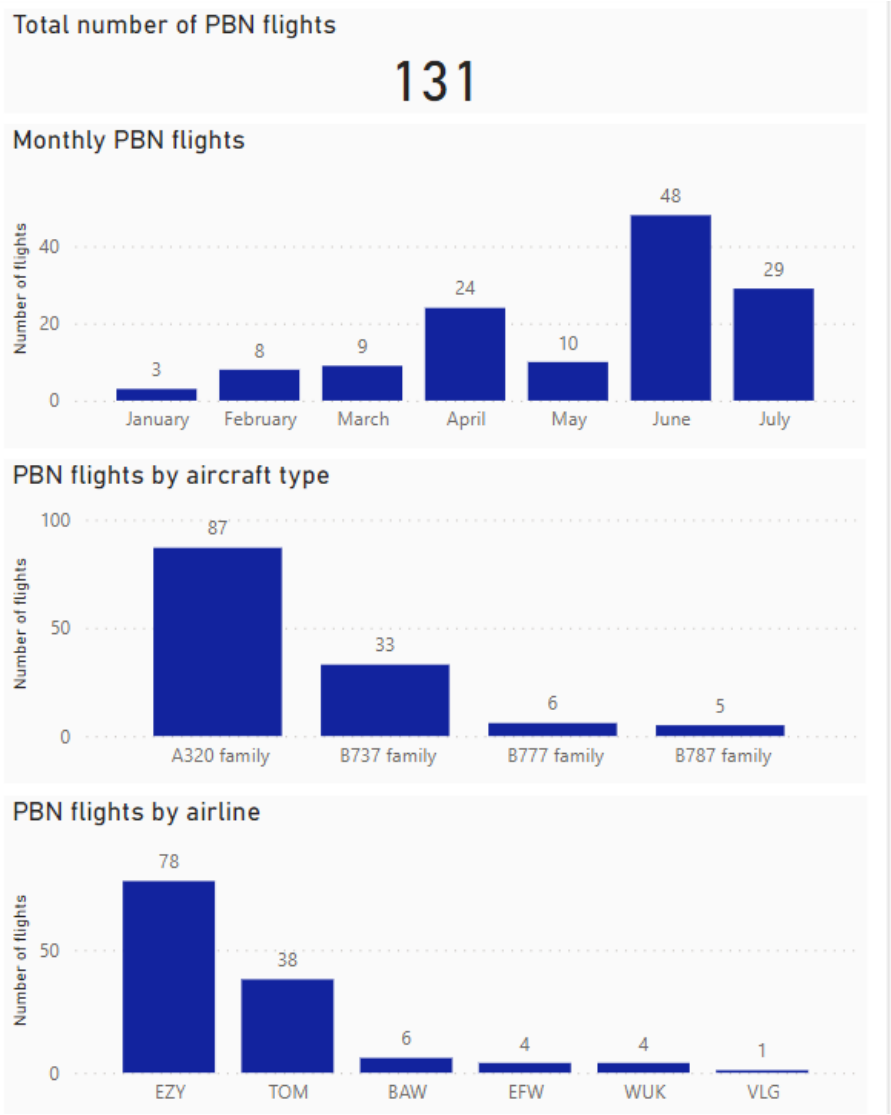


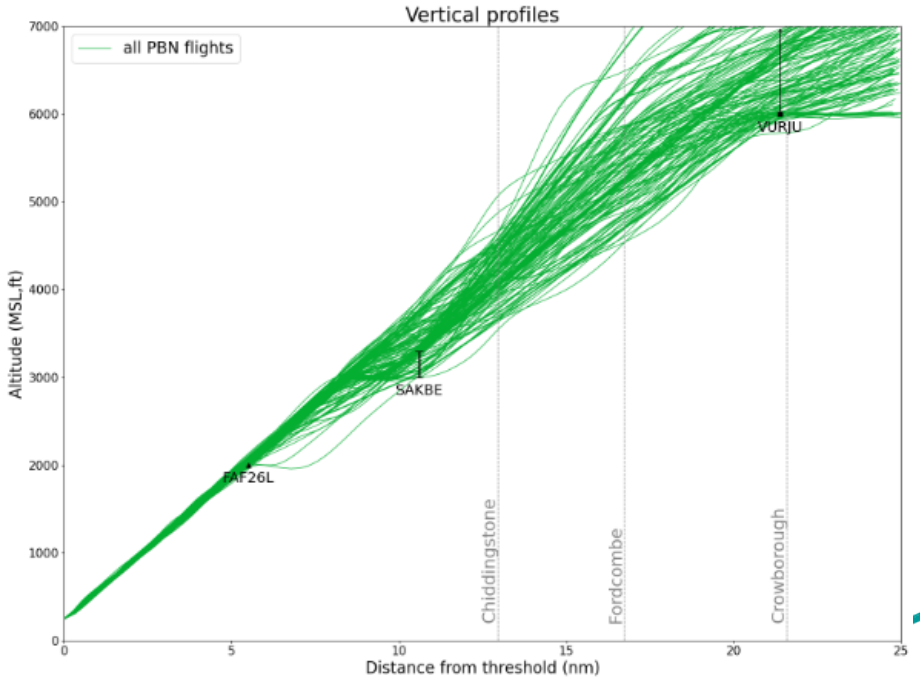
Overview of VURJU 1D westerly PBN approach to RWY 26L

VURJU 1D is one of the three routes fitted with noise monitors.

There were 131 PBN flights during the trial period and it was the second most flown route in the trial.

The route has two waypoints with altitude restrictions – VURJU and SAKBE. The VURJU waypoint has an altitude constraint to keep aircraft above 6000ft. SAKBE has a range of altitudes between 3000ft-3300ft. After passing SAKBE, aircraft aim for the final approach fix (FAF) on the ILS.





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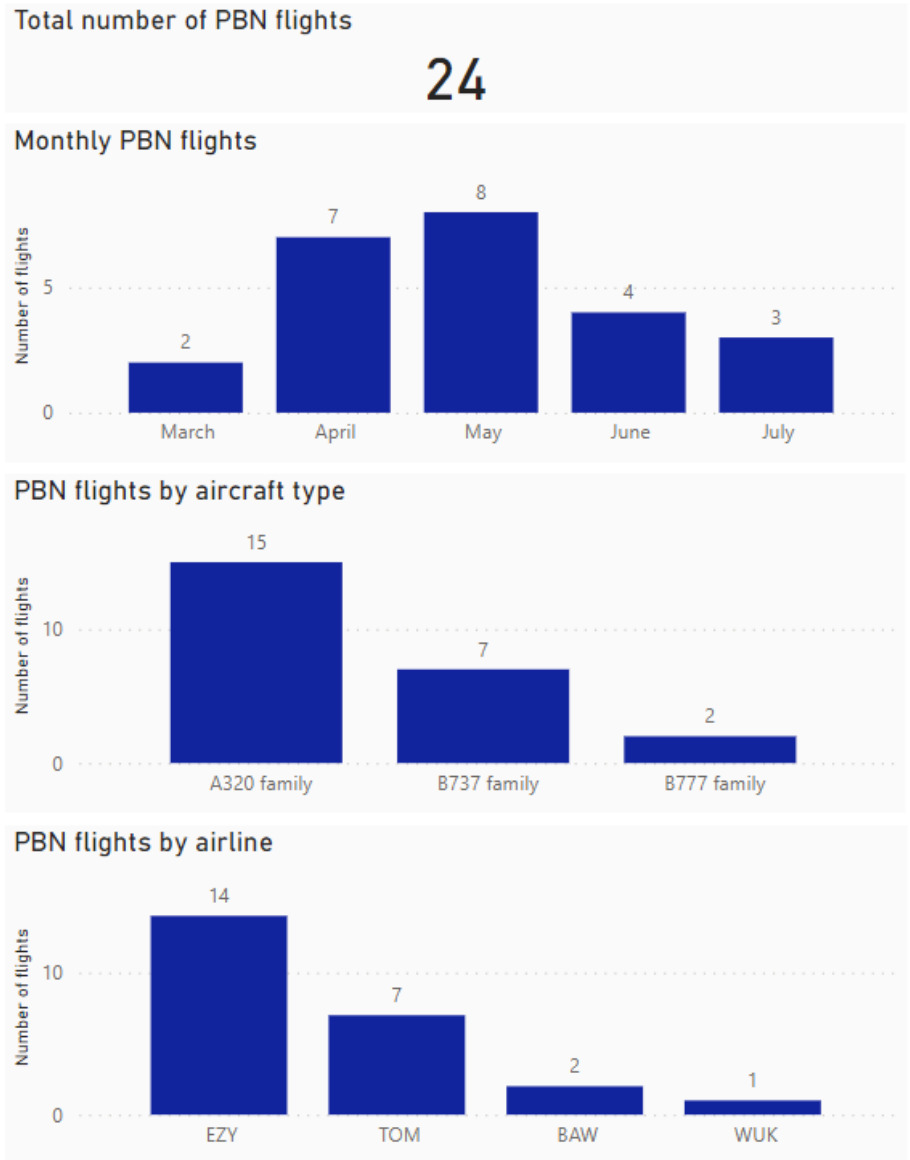
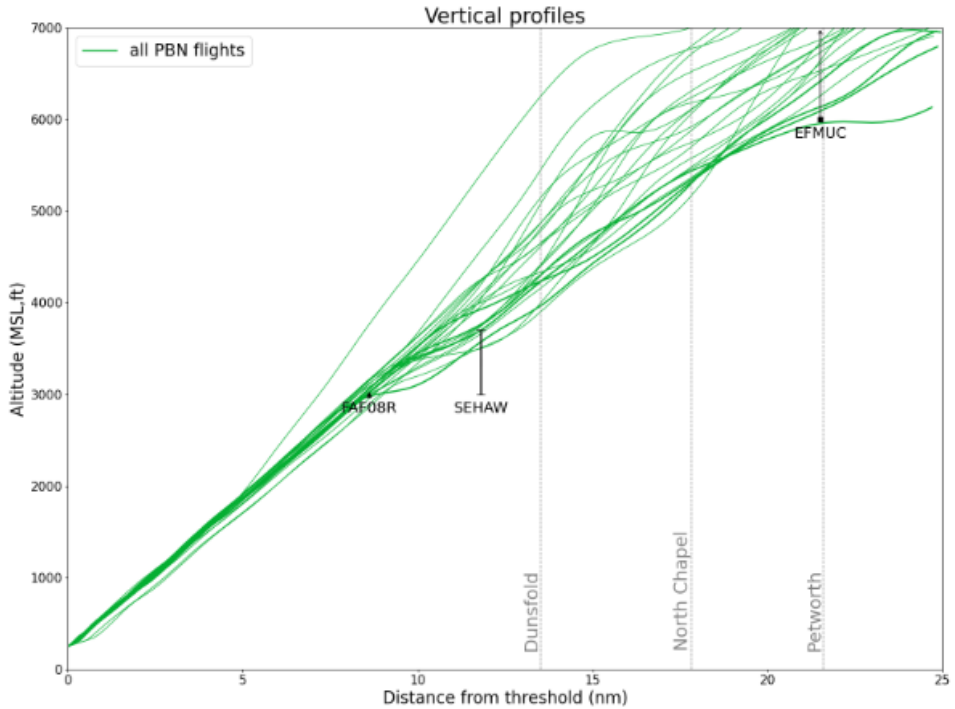
Overview of EFMUC 1A easterly PBN approach to RWY 08R

EFMUC 1A is one of the three routes fitted with noise monitors.

There were 24 PBN flights during the trial period.

The route has two waypoints with altitude restrictions – EFMUC and SEHAW. The EFMUC waypoint has an altitude constraint to keep aircraft above 6000ft. SEHAW has a range of altitudes between 3000ft-3700ft. After passing SEHAW, aircraft aim for the final approach fix (FAF) on the ILS.





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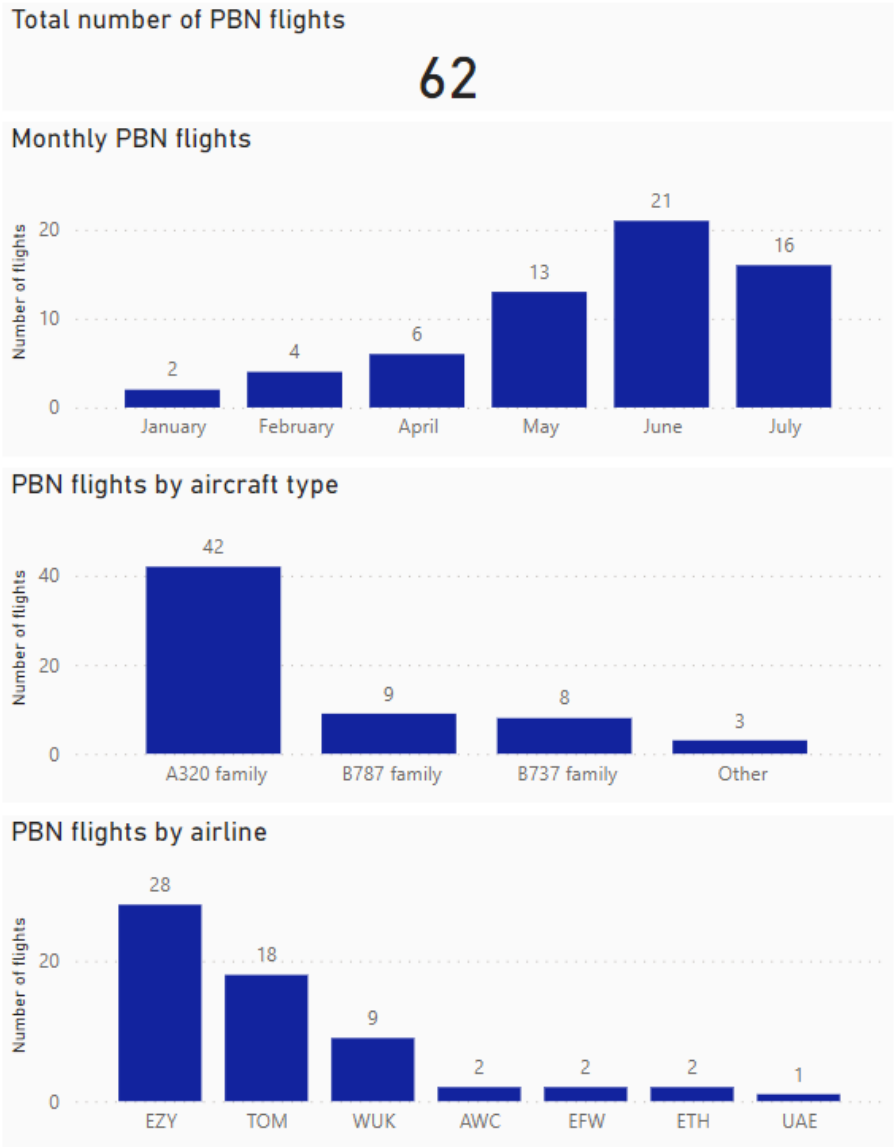
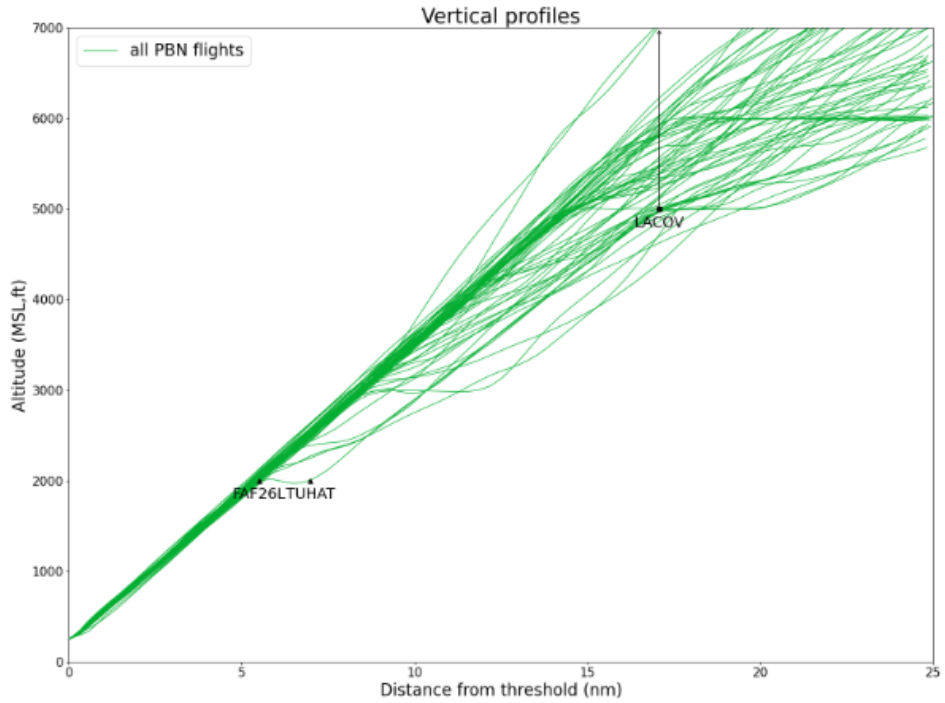
Overview of LACOV 1D westerly PBN approach to RWY 26L

LACOV 1D is one of the 5 routes not fitted with noise monitors.

There were 62 PBN flights during the trial period.

The route has two waypoints with altitude restrictions – LACOV and TUHAT. The LACOV waypoint has an altitude constraint to keep aircraft above 5000ft. TUHAT is placed at 2000ft. After passing TUHAT, aircraft aim for the final approach fix (FAF) on the ILS.





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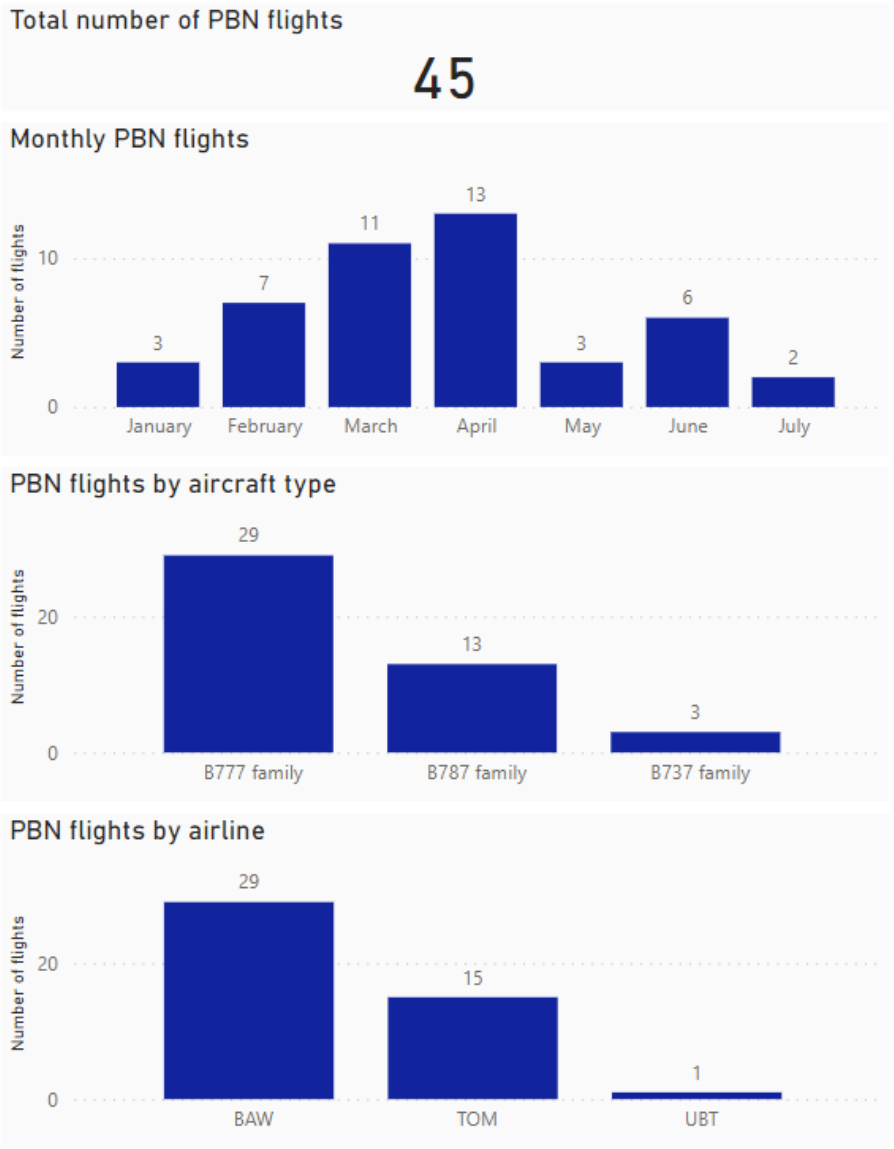
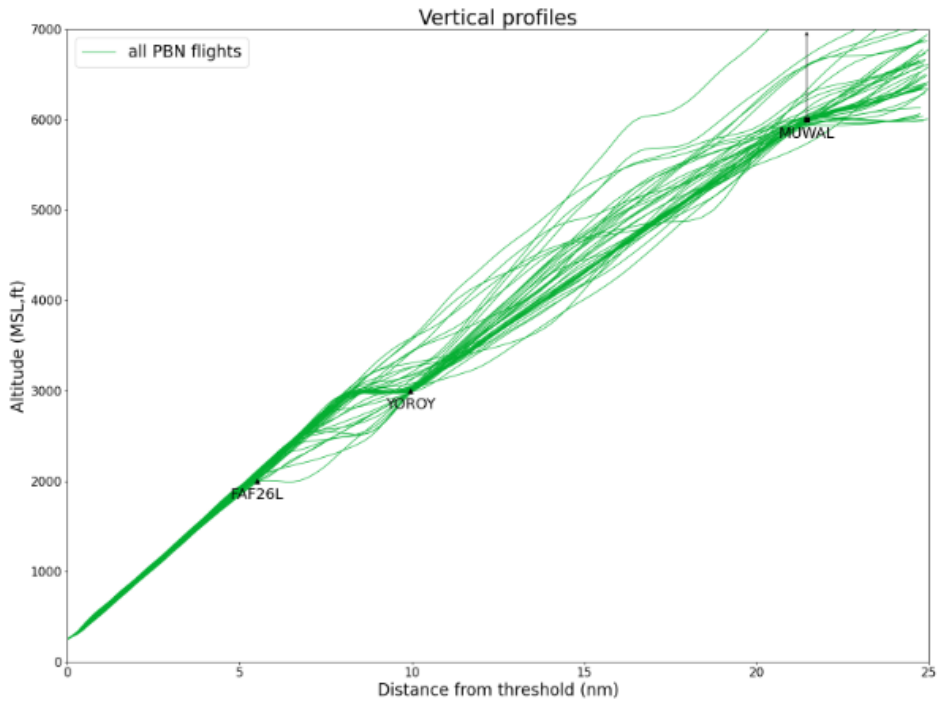
Overview of MUWAL 1D westerly PBN approach to RWY 26L

MUWAL 1D is one of the 5 routes not fitted with noise monitors.

There were 45 PBN flights during the trial period.

The route has two waypoints with altitude restrictions – MUWAL and YOROY. The MUWAL waypoint has an altitude constraint to keep aircraft above 6000ft. YOROY is placed at 3000ft. After passing YOROY, aircraft aim for the final approach fix (FAF) on the ILS.





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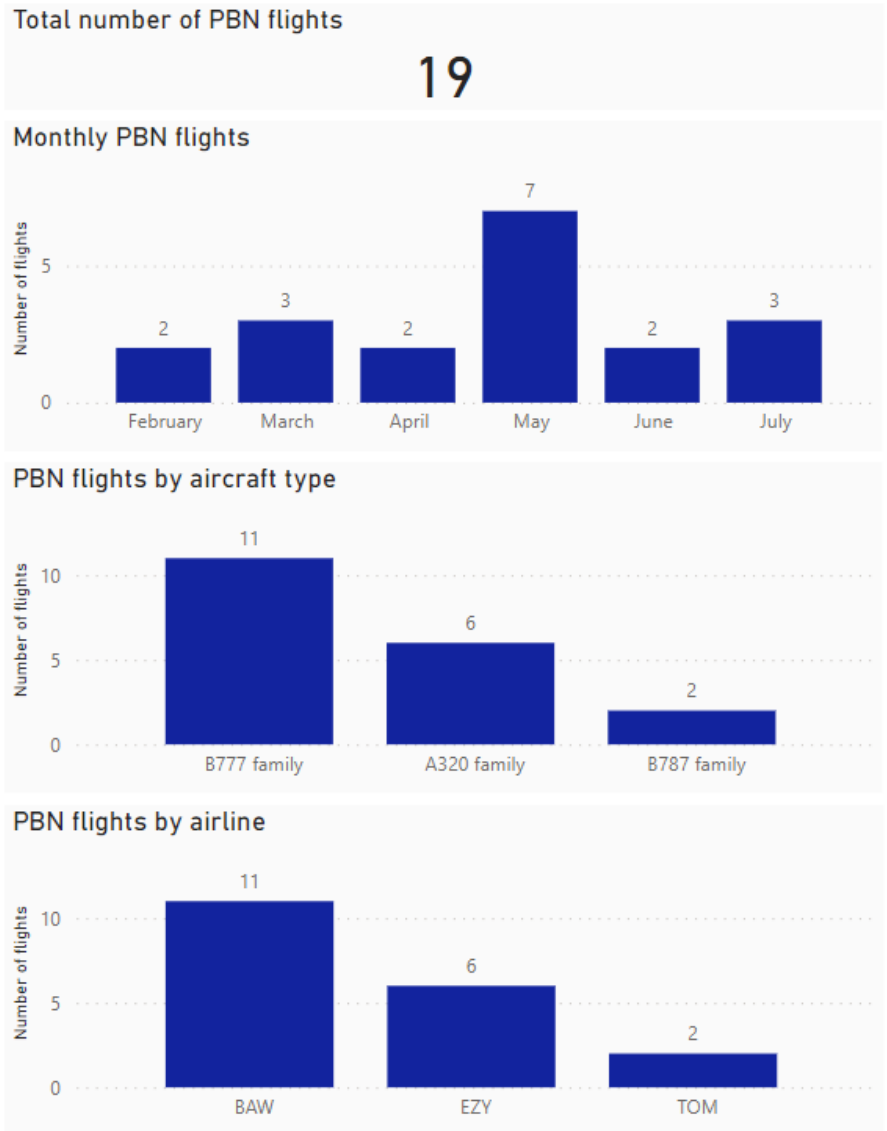
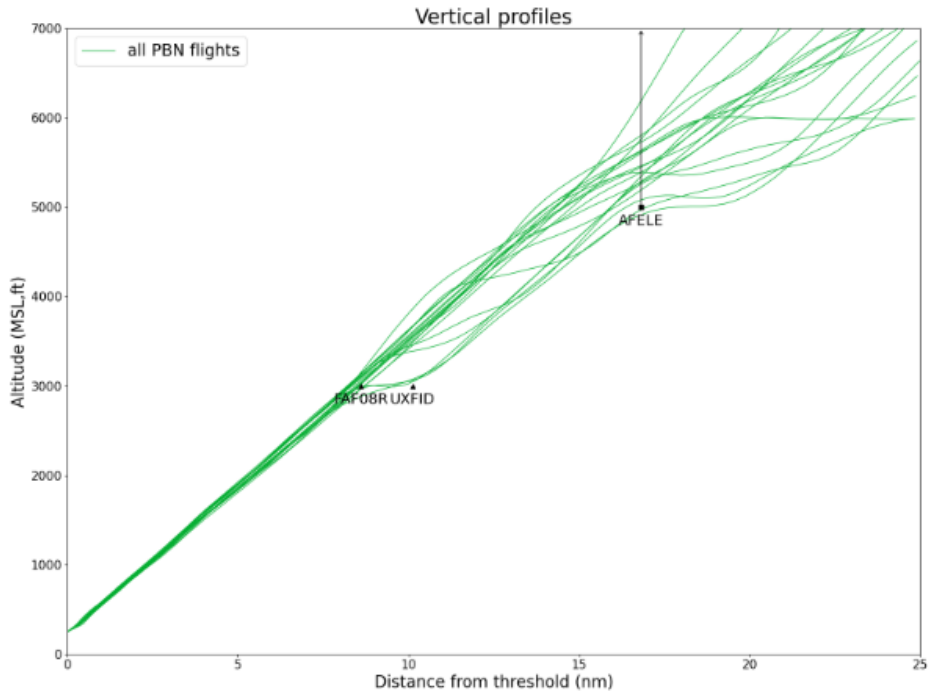
Overview of AFELE 1A easterly PBN approach to RWY 08R

AFELE 1A is one of the 5 routes not fitted with noise monitors.

There were 19 PBN flights during the trial period.

The route has two waypoints with altitude restrictions – AFELE and UXFID. The AFELE waypoint has an altitude constraint to keep aircraft above 5000ft. UXFID is placed at 3000ft. After passing UXFID, aircraft aim for the final approach fix (FAF) on the ILS.





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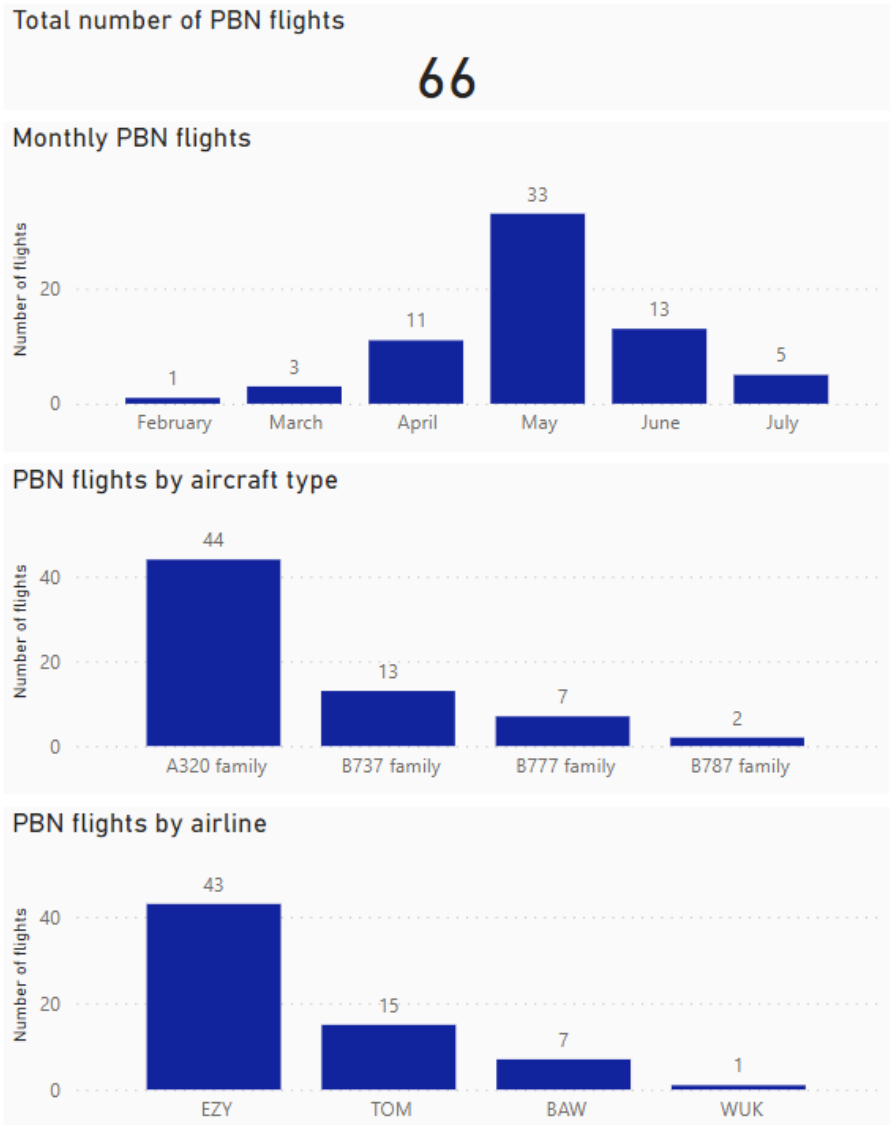
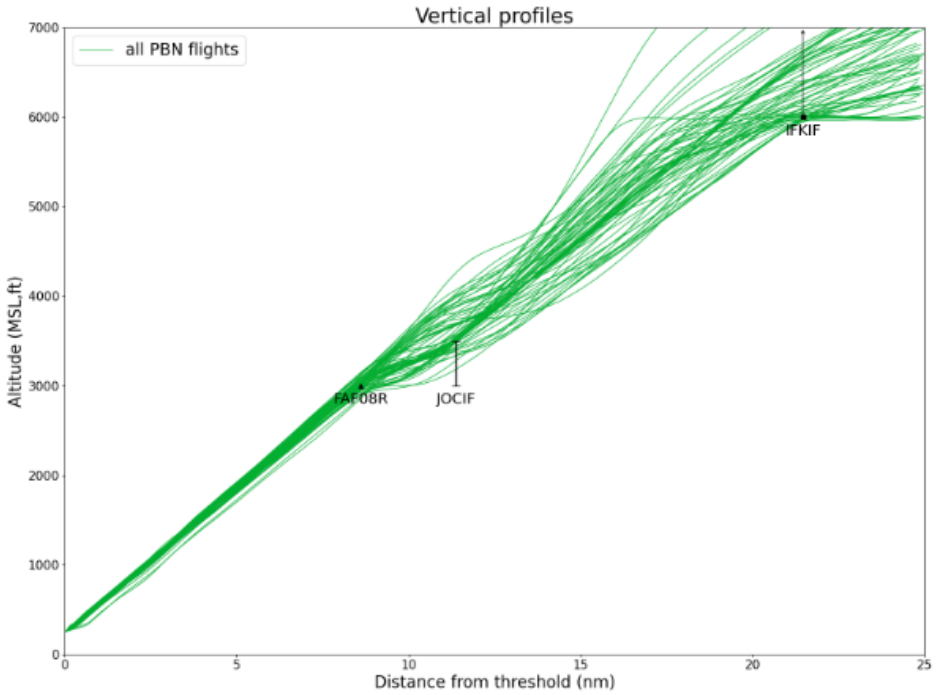
Overview of IFKIF 1A easterly PBN approach to RWY 08R

IFKIF 1A is one of the 5 routes not fitted with noise monitors.

There were 66 PBN flights during the trial period.

The route has two waypoints with altitude restrictions – IFKIF and JOCIF. The IFKIF waypoint has an altitude constraint to keep aircraft above 6000ft. JOCIF has a range of altitudes between 3000ft-3500ft. After passing JOCIF, aircraft aim for the final approach fix (FAF) on the ILS.





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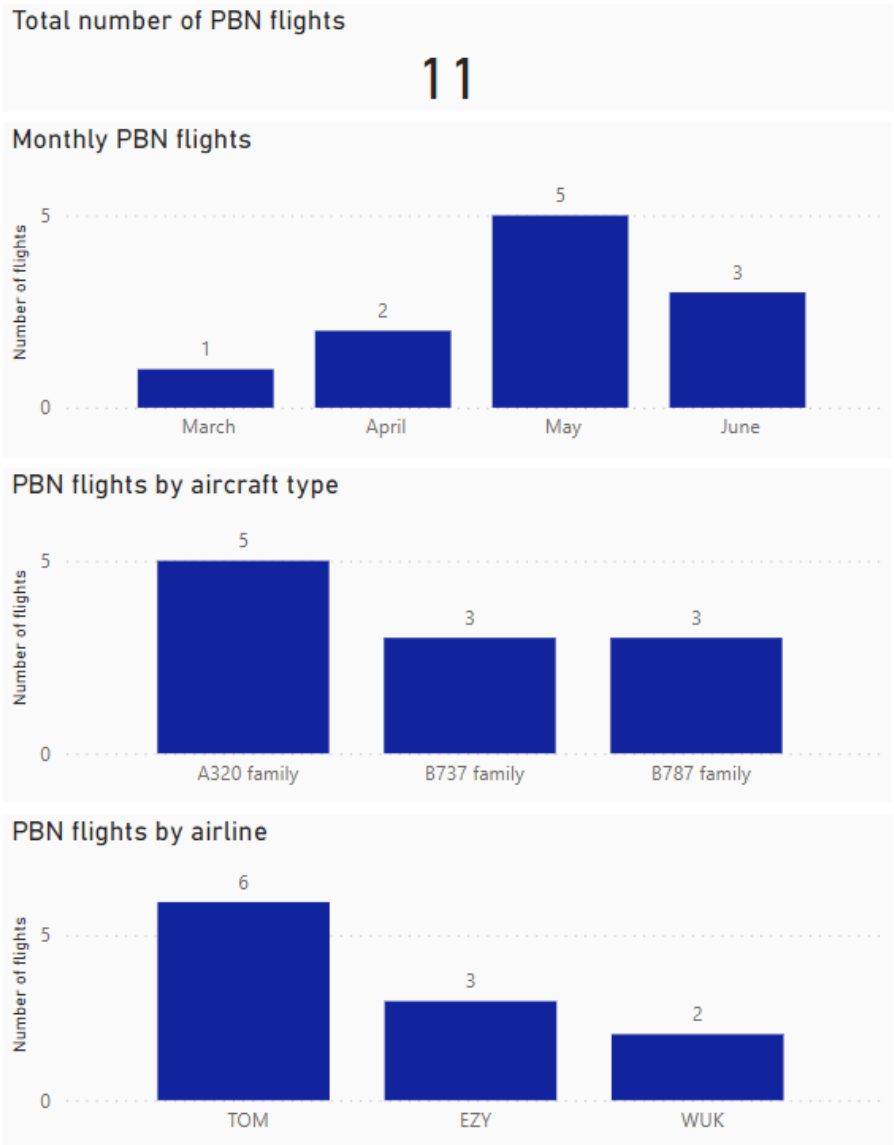
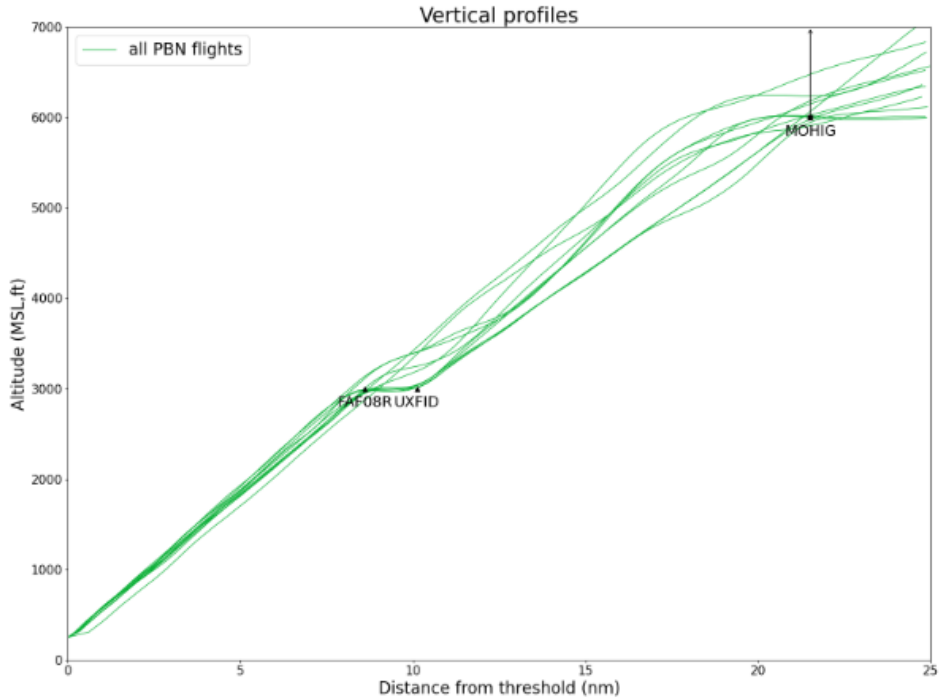
Overview of MOHIG 1A easterly PBN approach to RWY 08R

MOHIG 1A is one of the 5 routes not fitted with noise monitors.

There were 11 PBN flights during the trial period.

The route has two waypoints with altitude restrictions – MOHIG and UXFID. The MOHIG waypoint has an altitude constraint to keep aircraft above 6000ft. UXFID is placed at 3000ft. After passing UXFID, aircraft aim for the final approach fix (FAF) on the ILS.





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Annex B: Detailed Outlier Analysis

A more detailed analysis of outlier results

Scatter plot explanation

This slide describes the scatter plot graphs used in this annex.

A scatter plot is a type of graph used to display values for two variables for a set of data which is noise and altitude in this trial. Each point on the graph represents an observation where the position on the x-axis corresponds to recorded noise above a monitor and the position on the y-axis corresponds to the altitude above the monitor.

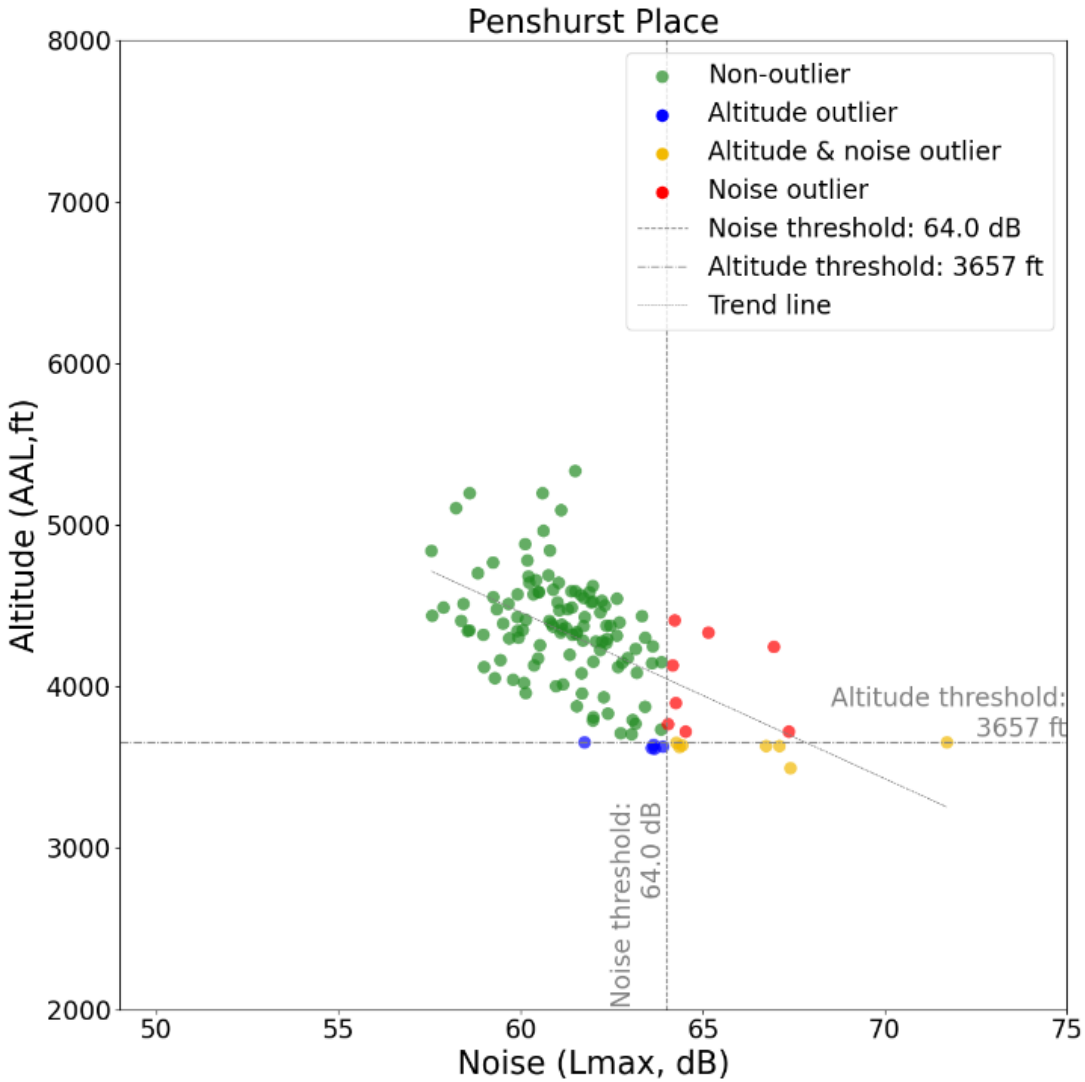
Each graph shows values for one noise monitor. Each route is therefore represented by three graphs.

In this graph, flights are categorised into four quadrants (four categories):

- **Non-outliers** (green) are PBN flights that did not infringe any of the thresholds
- **Altitude outliers** (blue) are PBN flights that were below the altitude threshold when they were overflying the monitor
- **Noise outliers** (red) are PBN flights that were louder than the noise threshold when they were overflying the monitor
- **Altitude & noise outliers** (yellow) are PBN flights that were both below the altitude threshold and louder than the noise threshold

Please note that these are snapshots of noise and altitude when an aircraft was overflying the monitor. If an aircraft is categorised as an outlier on this graph, it does not mean it was low and/or noisy throughout full descent.

Flights with missing noise recordings are not shown on these graphs but are still included in the statistics.

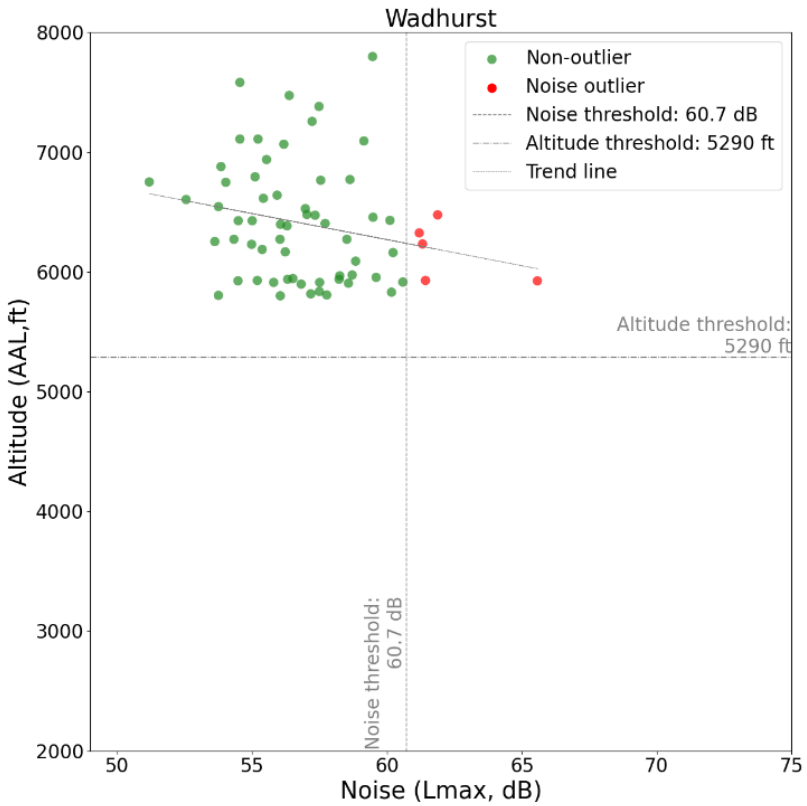


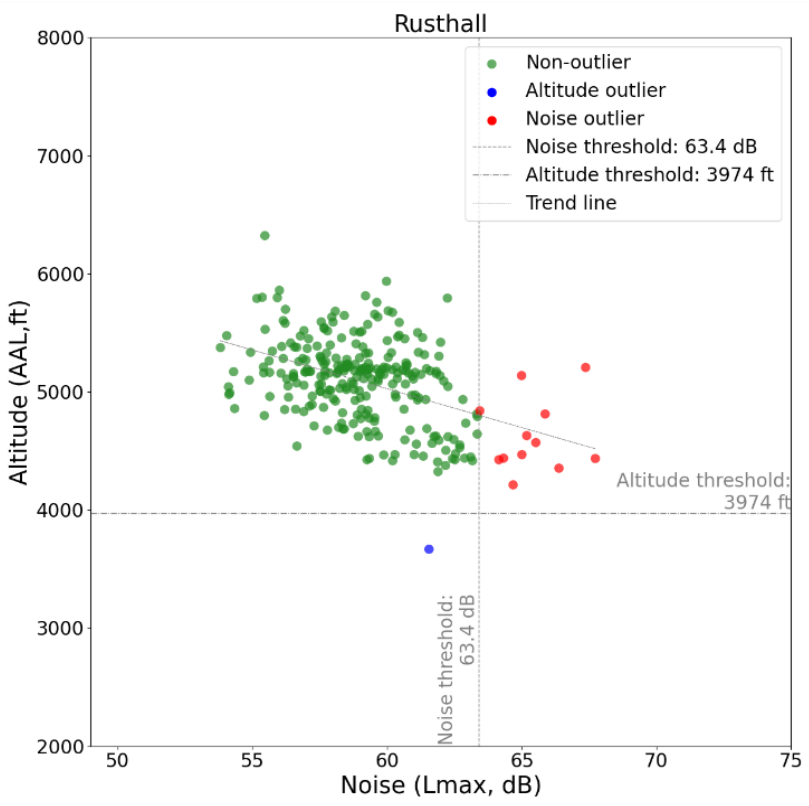
Trial results and outliers on TUFGA 1D

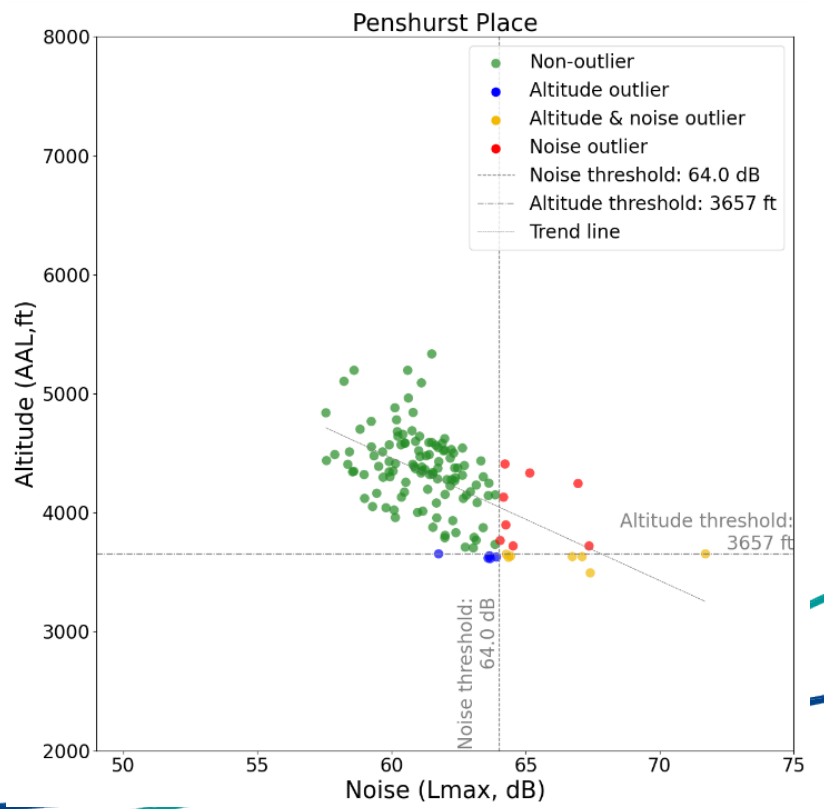
Wadhurst, Rusthall and Penshurst Place were the three noise monitors located under TUFGA 1D route. Rusthall is one of the permanent monitors and therefore captured the highest number of flights.

Starting at Wadhurst, there were 5 noise outliers and no altitude outliers. Out of the 5 noise outliers, 4 were within +1.2dB difference from the threshold. At Rusthall, there was 1 altitude outlier, which did not exceed the noise threshold, and 12 noise outliers. 3 outliers were within 1dB difference, 7 were between 1dB and 3dB, and 2 outliers were approximately 4dB louder than the threshold.

At Penshurst Place, a number of flights in each category were observed. Most of the altitude outliers (except 2) were within 50ft from the altitude threshold.





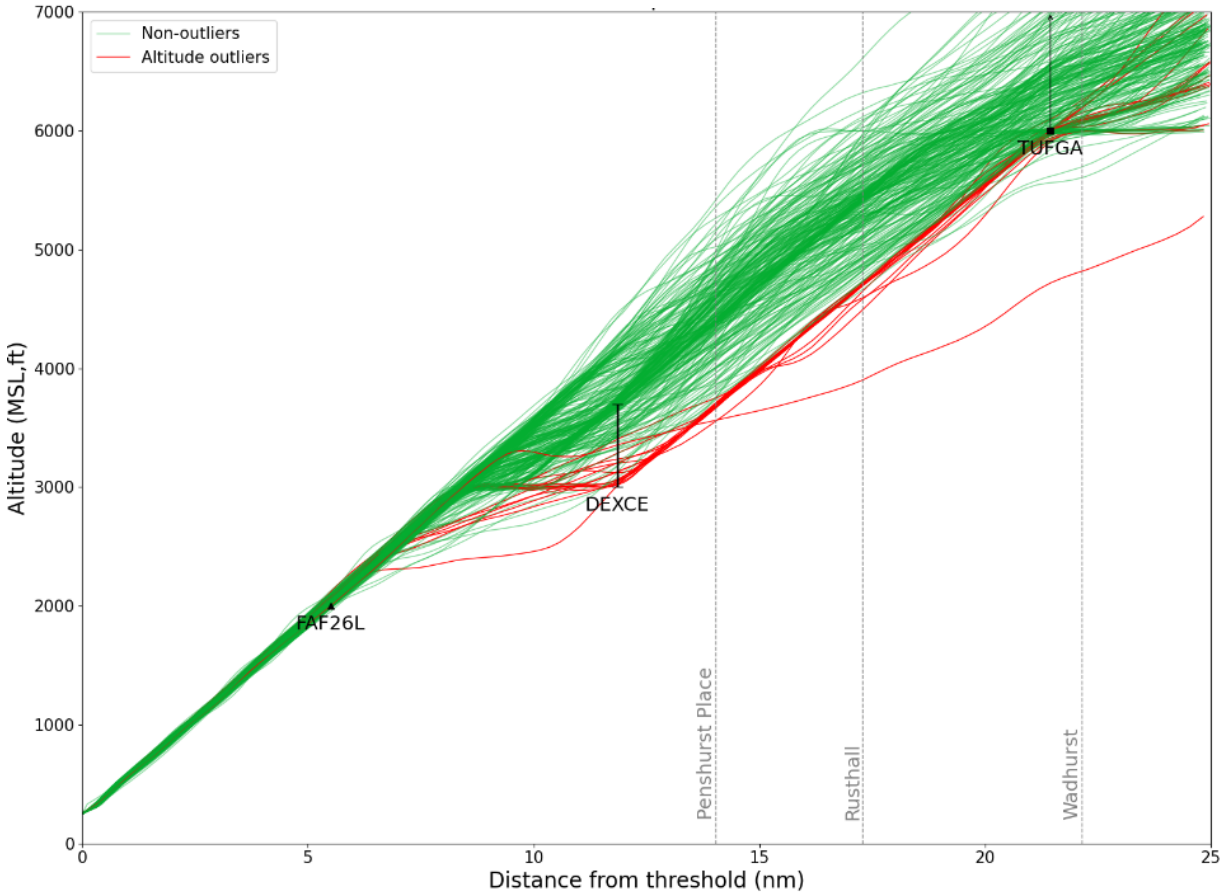


Trial results and vertical profiles on TUFGA 1D

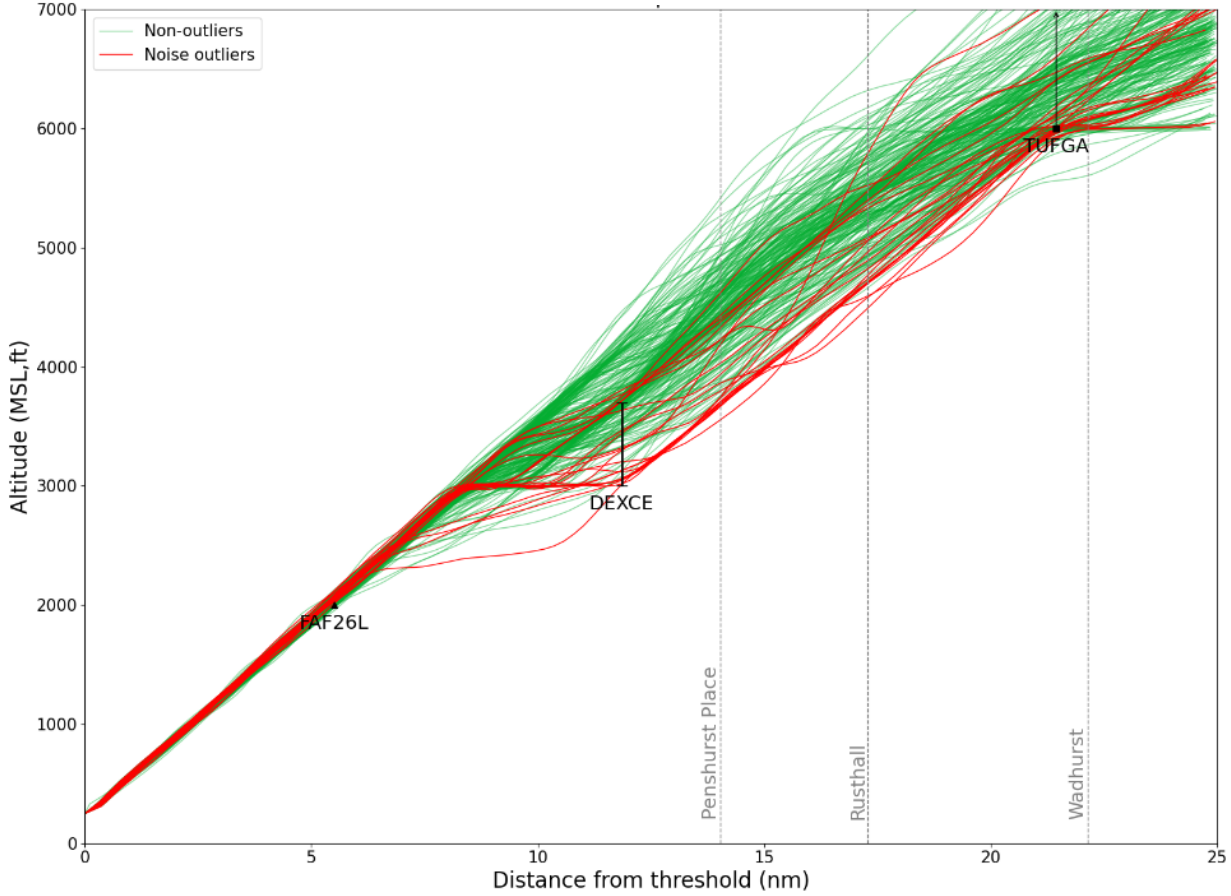
The graphs below show the vertical profiles of PBN flights and identify which of them were outliers.

Whilst altitude outliers are the lowest flights, noise outliers occur throughout the full spectrum of altitudes. This is evidence of the other variables that contribute to the noise picture, including aircraft energy management and configuration, and challenging weather conditions.

Altitude outliers



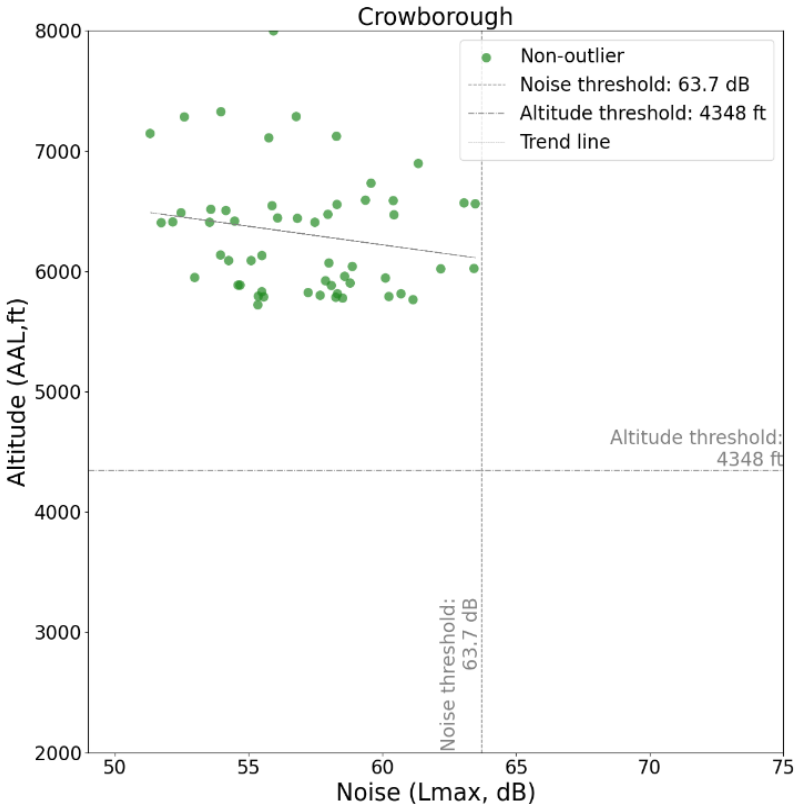
Noise outliers

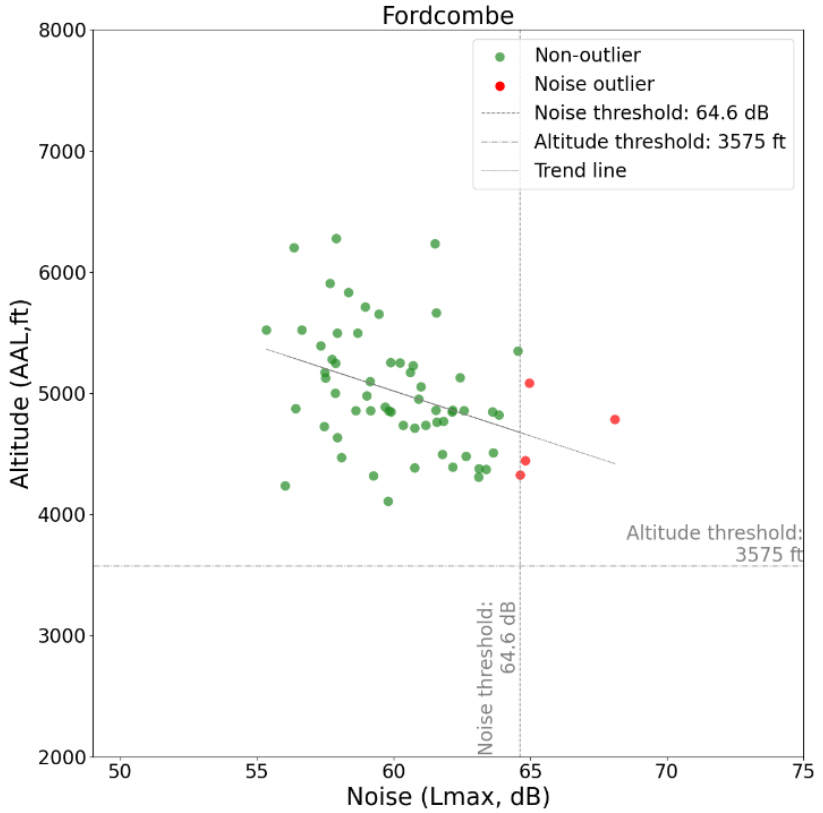


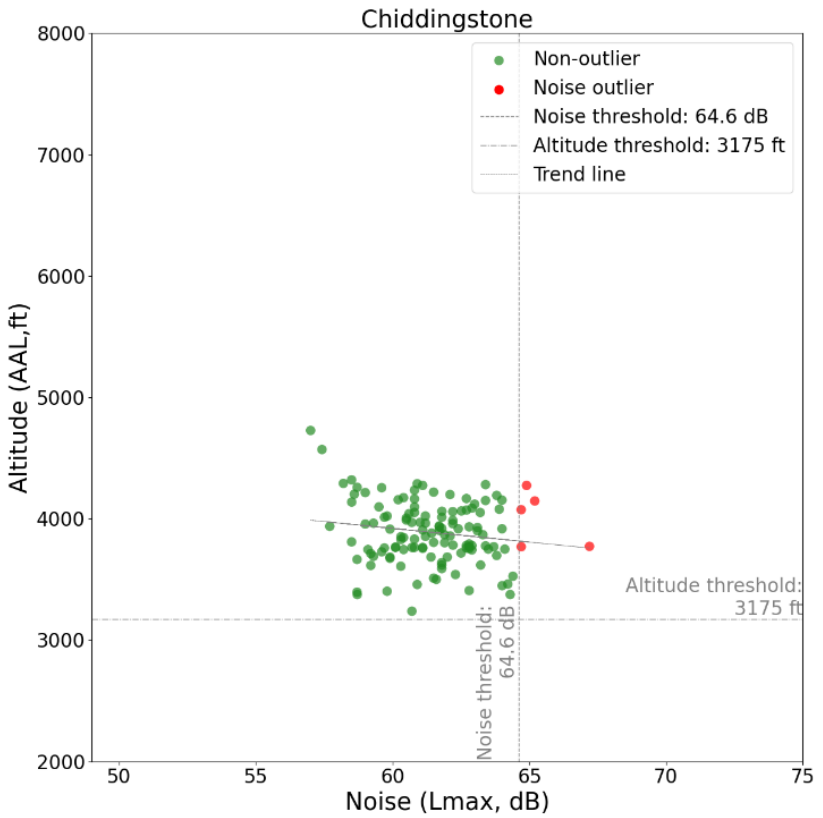
Trial results and outliers on VURJU 1D

Crowborough, Fordcombe and Chiddingstone were the three noise monitors located under VURJU route. Choddingstone is one of the permanent monitors and therefore captured the highest number of flights.

There were no altitude outliers at any of the monitors on this route. In terms of noise outliers, there were 4 at Fordcombe and 5 at Chiddingstone. Out of the 4 noise outliers at Fordcombe, 3 were below 0.5dB difference from the threshold. At Chiddingstone, 4 noise outliers exceeded the thresholds by less than 0.6dB.







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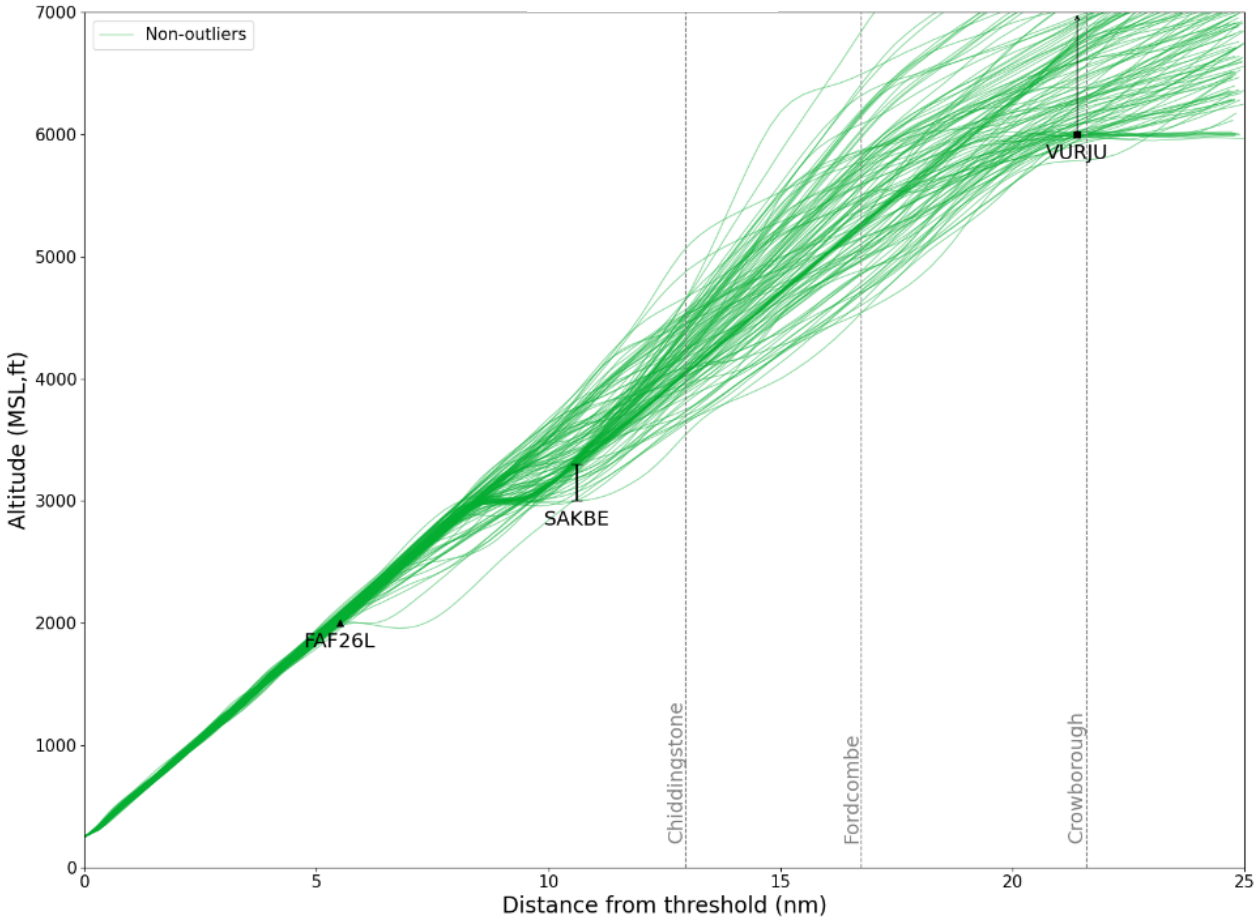
Trial results and vertical profiles on VURJU 1D

The graphs below show the vertical profiles of PBN flights and identify which of them were outliers.

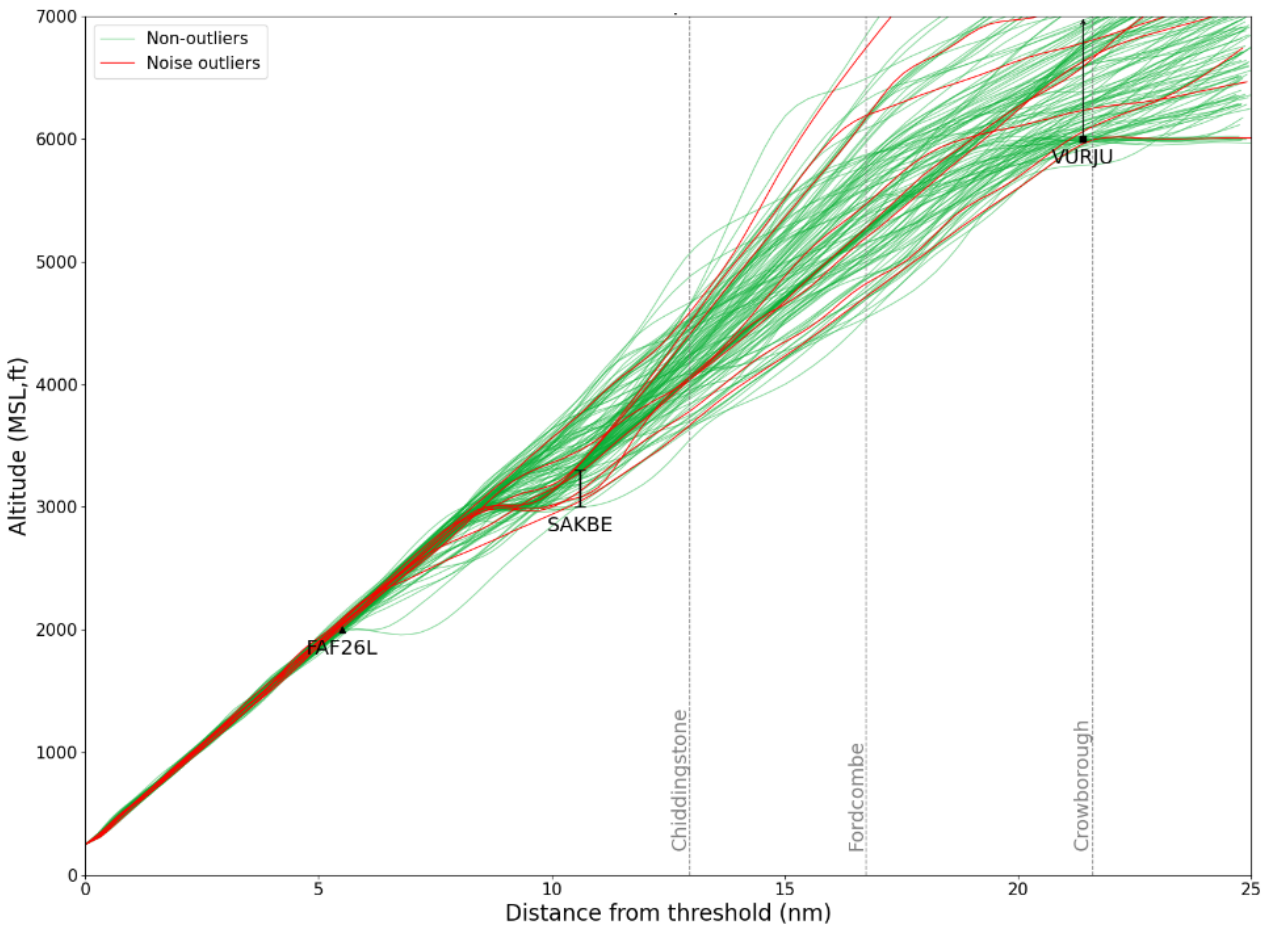
There were no altitude outliers on the VURJU 1D route.

Similarly to the TUFGA 1D route, noise outliers occur throughout the full range of altitudes.

Altitude outliers



Noise outliers

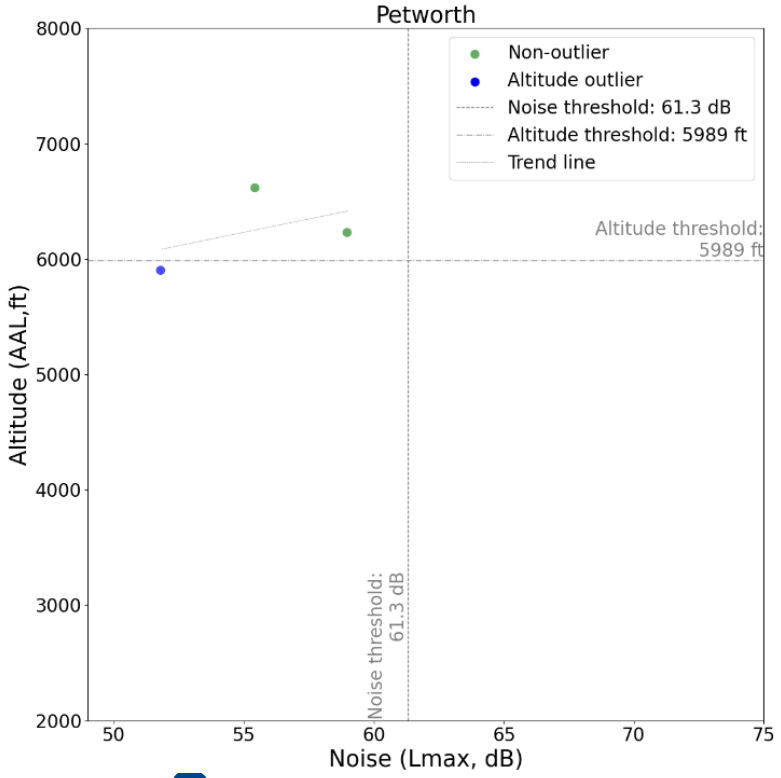


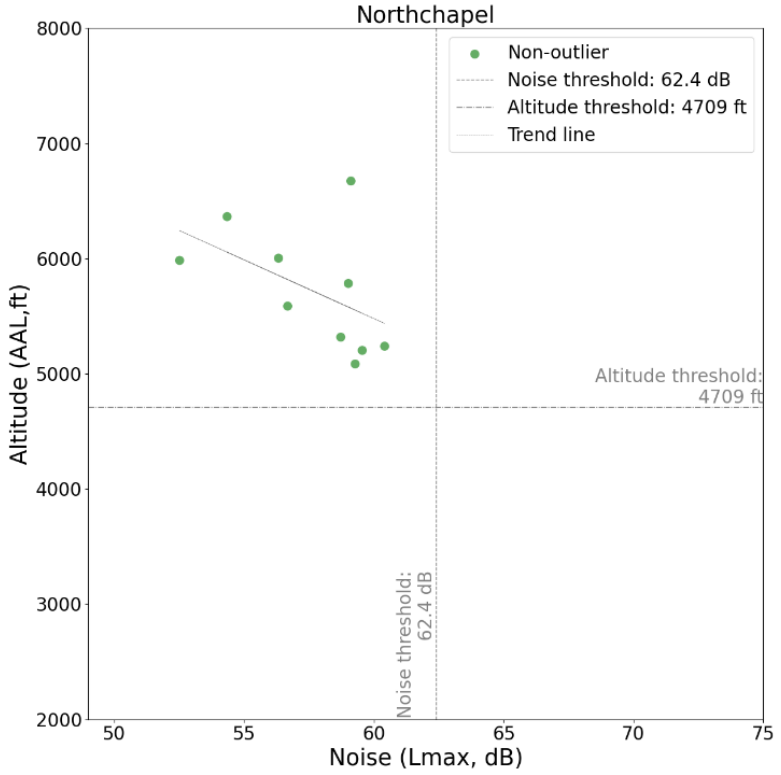
Trial results and outliers on EFMUC 1A

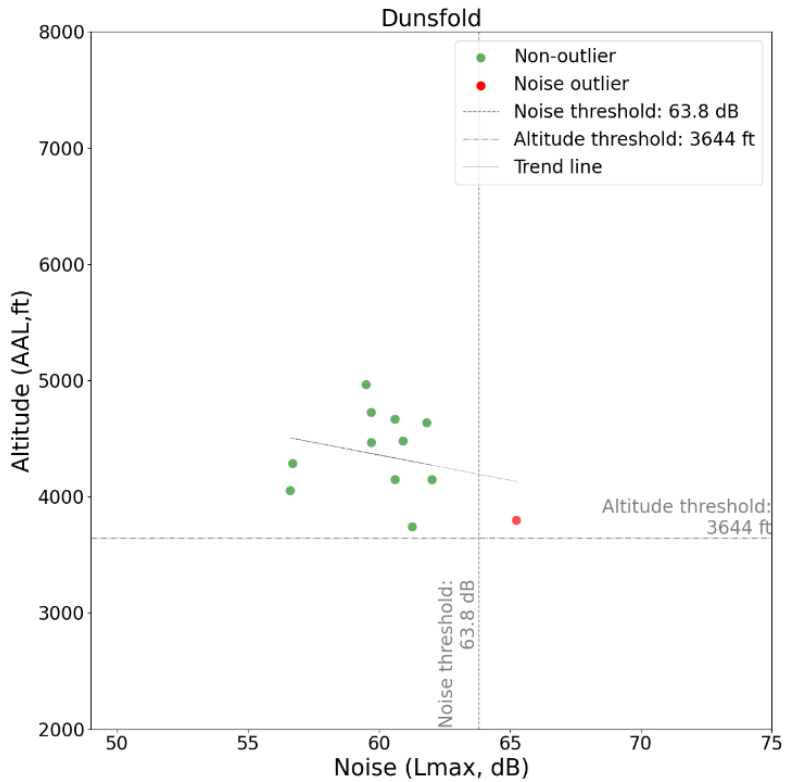
EFMUC 1A was the least flown route out of the three fitted with noise monitors. There were 3 altitude outliers on the Petworth monitor, but only 1 had a noise recording.

There were no outliers at NorthChapel.

There were no altitude outliers on Dunsfold and there was 1 noise outlier, which exceeded the threshold by 1.5dB.







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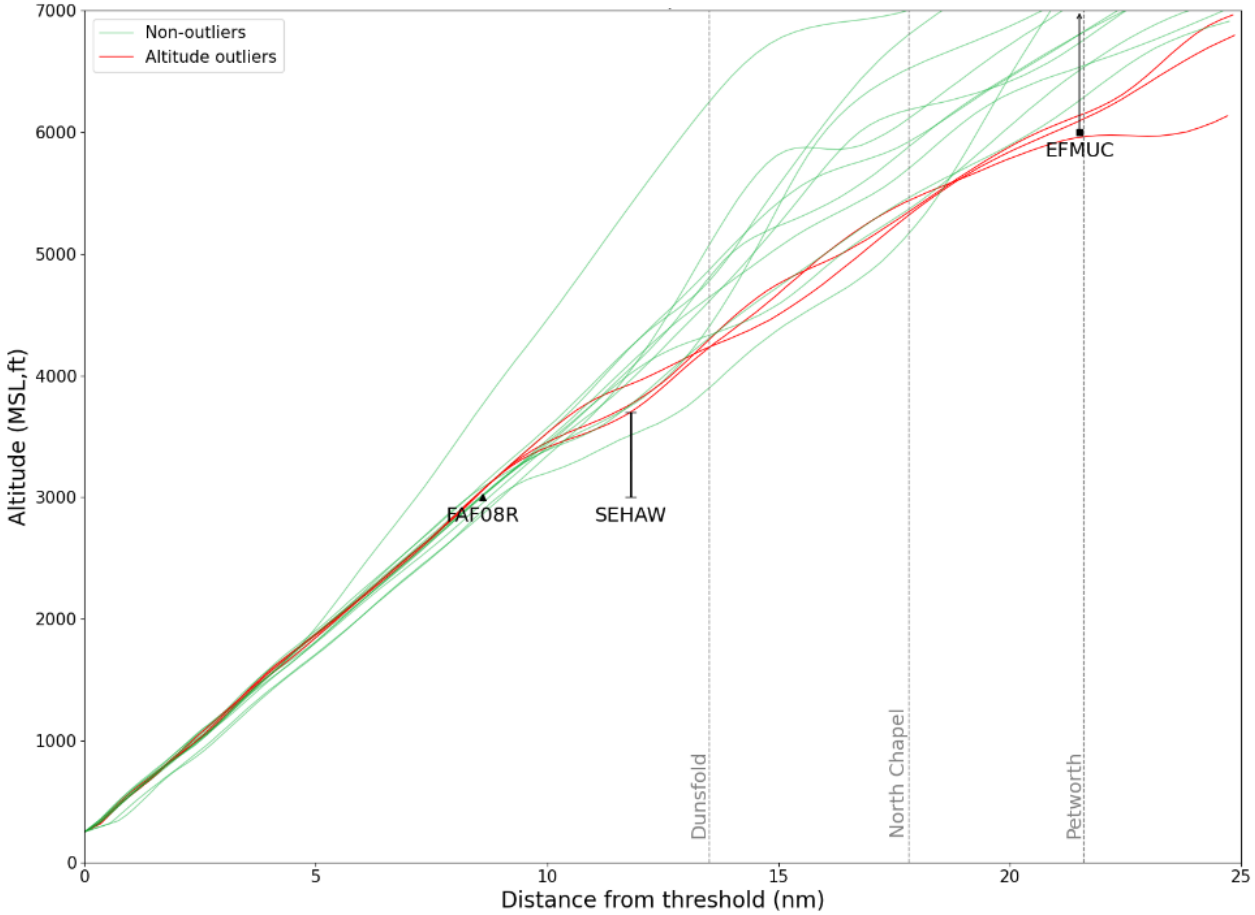
Trial results and vertical profiles on EFMUC 1A

The graphs below show the vertical profiles of PBN flights and identifies which of them were outliers.

There were 3 altitude outliers and 1 noise outlier on the EFMUC 1A route.

Altitude outliers



Noise outliers