Safety and Airspace Regulation Group

# Report of the CAA's Post Implementation Review of Birmingham International Airport Airspace Change Proposal – Runway 15 Southerly RNAV-1 Standard Instrument Departure Procedures

CAP 1792

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The latest version of this document is available in electronic format at www.caa.co.uk

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# References

1) Birmingham Airport Limited Runway 15 Airspace Change Proposal Standard Instrument Departure Post Implementation Review report.
2) Civil Aviation Authority Birmingham Airport Runway 15 Airspace Change Proposal CAP1938 Decision (2016).
3) The Civil Aviation Authority, Air Navigation Directions, 2001.
4) The Civil Aviation Authority, Airspace Modernisation Strategy, 2018.
5) Birmingham Airport Airspace Change Trial Report of Southbound RNAV SIDs for Runway 15.

# Executive Summary

1. The CAA's airspace change process is a seven-stage process that is set out in detail in CAP 725. Under this process, in 2012 Birmingham Airport Limited (BAL) submitted proposals to the CAA to change the Standard Instrument Departure (SID) procedures to support the Runway 15 extension at Birmingham International Airport (BIA) and implement new RNAV-1[1] SIDs. The airspace change was approved by the CAA (with conditions) on 4 April 2016 and became notified for operational use in the UK Aeronautical Information Package (AIP) on 23 June 2016.

2. Stage 7 of this process is a Post Implementation Review (PIR) that normally begins one year after implementation of the change. The sponsor provided PIR data to the CAA on 7 July 2017, followed up with supplementary diagrams in May 2018, following which the CAA commenced the PIR of the implemented change (Note: the diagrams were later updated in January 2019). The content and outcome of this review process by the CAA is discussed in detail in this report including its annexes.

3. On 2 January 2018, the CAA introduced a new process for making a decision whether or not to approve proposals to change airspace design (CAP1616). However, as this ACP was fully implemented prior to the introduction of that document, and the PIR data received by the CAA prior to its introduction, this review has been undertaken in accordance with CAP725 and the Department for Transport's Guidance to the Civil Aviation Authority on Environmental Objectives Relating to the Exercise of its Air Navigation Functions (2014).

[1] Performance-based navigation (of which RNAV-1 is a type) is satellite aviation guidance; in comparison to ground-based navigation aids (such as those used by conventional SIDs) performance based navigational technology will allow aircraft to fly much more accurate and flexible tracks. Satellite guidance will also allow the UK's complicated and busy airspace to be redesigned, increasing capacity and efficiency while maintaining or enhancing safety performance. A route structure optimised for satellite guidance with aircraft flying a pre-programmed trajectory will also reduce the need for tactical intervention by air traffic controllers to instruct pilots to change direction, bringing down the cost of air traffic control, and optimise the climb and departure profiles of aircraft (which is the most expeditious routeing of aircraft so far as airlines are concerned, and which also burns the least fuel and overall causes the least noise.

4. During the review process, the CAA considered data provided by BAL in respect of the changes to the Runway 15 RNAV-1 SIDs. The CAA has also considered a submission from the Barston Parish Council relating to impacts of aircraft noise over Barston. As a result, the CAA has reached the following conclusions:

## Operational conclusions

5. As a result of the implementation of the RNAV-1 SIDs, there have been no adverse impacts on any aspects of service delivery and specifically a high standard of safety has been maintained, and there have been no adverse impacts on the efficiency of the use of airspace.

6. A minor chart amendment is required to reflect speed restrictions as designed and shown in the navigation data base coding tables.

## Complaints conclusion

7. We have analysed the enquiries/complaints received by the change sponsor and the CAA as part of this Review. As a result of our analysis, we have concluded that the correspondence received is consistent with the traffic patterns we were expecting and observed when carrying out our aircraft track analysis, and does not give rise to any unforeseen impacts of the proposal.

## Environmental conclusions

8. The CAA has concluded that the benefits and impacts of the implemented airspace change proposal are as expected. No unanticipated adverse impacts of environmental outcomes have been identified as the result of the revised southbound SIDs supporting Runway 15.

## Confirmation of Runway 15 Southerly SIDs Implementation

9. In respect of the change proposal to introduce Runway 15 RNAV-1 SIDs to the south, the CAA confirms that no modification of the RNAV-1 departure designs is required by BAL. A very minor chart amendment is required as detailed in paragraph 6. Upon publication of CAP 1792, the process in respect of this change is concluded and the change is confirmed.

## The PIR Report

10. This report, and its annexes and attachments, provide a summary of the information the CAA has reviewed and taken into account before reaching these conclusions. However, all the information the CAA has taken into account is published on our airspace change portal (specifically in the website location for CAP 725 changes).

# Conditions attached to the CAA's decision to approve the change

## Conditions

11. As set out in the Decision, CAP 1398 Annex A, the following condition was placed on the sponsor as detailed in Annex A to the decision document:

| | |
|---|---|
| 1 | *BAL is to initiate a Trial for the use of Option 5 for all non-jet aircraft departing runway 15 at Birmingham International Airport departing via DTY, WCO, CPT or COWLY.*<br><br>*Within 28 days of the date of this decision BAL is to have agreed with the CAA the scope, start date and duration of the Trial. The Trial should commence as soon as practicable (and in any event in the next 6 months).*<br><br>*The aim of the Trial will be to assess the impact on all the communities close to Birmingham International Airport as well as any impacts on the ATC operation re capacity and safety.*<br><br>*BAL shall engage with communities when designing the trial.*<br><br>*BAL will agree the objectives of the Trial with the CAA within 28 days taking into account of CAA Policy pertaining airspace trials.*<br><br>*BAL is to report to the CAA on the outcome of the trial.* |

12. On 1 July 2016 BAL requested that the CAA remove this condition. The CAA published BALs request and sought views on whether that condition be removed. The window for comments closed on 9 September 2016. After considering the comments received together with BAL's request the

CAA agreed to BALs request to remove that condition on 13 February 2017.

## Additional noise measures - Noise Preferential Routes (NPRs).

13. In addition to the conditions set out in the decision document, BAL also voluntarily undertook a trial of raising the ceiling of all NPRs to 4000ft amsl in July 2016. Noise Abatement Procedures (such as NPRs) are not a matter for the CAA, nonetheless we have looked at this work. The trial found that by raising the ceiling for aircraft on a southbound departure from Runway 15 from 3000ft to 4000ft amsl, (including COWLY, CPT, DTY, WCO SIDs) a reduction in the overflight of Balsall Common was observed. Therefore, the NPR ceiling for southbound departures from Runway 15 has been raised to 4,000 feet amsl.

14. Whilst the CAA notes the outcome of the trial, the CAA examined whether any change was discernible with traffic departing on the Runway 15 southbound SIDs. The change to the ceiling altitude of the NPR is not apparent or discernible in the post implementation track data plots provided by BAL. There has however been some narrowing of the lateral pattern of the departing aircraft; this is particularly noticeable in the Balsall Common area, however, this is attributable to the design of the RNAV-1 SID designs.

Note: BAL has advised the CAA that the impact of the change would be small but would help prevent the occasional direct overflight of Balsall Common by aircraft being vectored.

# Scope and Background of the PIR

## What is a Post Implementation Review

15. The CAA's approach to decision-making in relation to proposals to approve changes to airspace is explained in its Guidance on the Application of the Airspace Change Process, CAP 725. This detailed Guidance provides that the seventh and last stage of the process is a review of the implementation of the decision, particularly from an operational perspective, known as a Post Implementation Review (PIR).

16. The Guidance states that the purpose of a PIR is to determine whether the anticipated impacts and benefits in the original proposal and published decision are as expected, and where there are differences, what steps (if any) are required to be taken.

17. If the impacts are not as predicted, the CAA will require the change sponsor to investigate why, so the CAA can determine whether further action is needed to change the airspace structure or to revise flight procedures to meet the terms of the original decision.

18. A PIR is therefore focused on the effects of a particular airspace change proposal. It is not a review of the decision on the airspace change proposal, and neither is it a re-run of the original decision process.

## Background to our conclusions in this PIR Decision

19. On 4 April 2016, the CAA approved the changes to the SIDs from BIA Runway 15. In our Decision document published on 6 April 2016 (as amended on 13 April 2016), we provided factual information and background to the change. Such detail is not represented in this PIR although objectives and anticipated impacts are re-produced for ease of reference. We recommend readers of this report read the Decision (CAP1398) in conjunction with this document. In making our Decision, we set out a number of conditions that our approval was predicated upon.

## Relevant events since the change

20. The traffic levels from BIA have increased since the decision was made (April 2016), such an increase is in line with the overall and general increase in air transport movements experienced in the UK. The revised operation of the Runway 15 SID has neither attracted nor stifled operations from the airport, nor has a different traffic mix been observed at the airport since the decision was made.

21. Barston Parish Council (BPC) disagreed with the CAA's decision to approve the change that is the subject of this review. As a consequence of discussions with BPC after the decision, the CAA invited BPC to submit any comments or data that it wished the CAA to take into account when carrying out its PIR. BPC duly did so. To the extent that submission includes information relevant to the task of the PIR, (that is whether the change has delivered the anticipated impacts and benefits set out in the original airspace change proposal and decision, and if not to ascertain why, and determine the most appropriate cause of action) the CAA has analysed that information and taken it into account when carrying out this review. A detailed analysis of this information is set out later in this review under the Environmental Assessment section.

## Data collected for the purpose of the PIR

### Sources of Information

22. During the review process, the CAA considered:

- A review of complaints made and feedback received during the 12 months post-implementation period (i.e. July 2017 to July 2018).
- A comparative assessment of pre-implementation and post-implementation traffic patterns (i.e. pre-change traffic patterns using the previous conventional SIDs and the post-change traffic patterns using the RNAV SIDs).
- A review of feedback from the airport operators regarding the flyability of the SIDs regarding the ability of aircraft to adhere to the trajectory of the SID in both lateral and vertical dimensions terms.
- A submission from Barston Parish Council relating to impacts from aircraft noise over Barston which provided analysis from two noise consultants.

23. BAL provided all of the PIR data requested by CAA.

# Objectives and Anticipated Impacts

## The original proposal and its objectives

24. For ease of reference we refer to the CAA Decision document where we highlighted the original proposal, its objectives and the anticipated impacts in the following paragraphs.

25. In accordance with the terms of a planning application decision made on 2 November 2009 the physical length of its single runway at BIA was extended. This enabled BAL to declare (that is make available to aircraft traffic) an extended runway length, in both directions. The runway at BIA can be operated as Runway 15 (on a bearing of 150 degrees) or Runway 33 (on the reciprocal bearing of 330 degrees). The runway is used for all arriving and departing aircraft regardless of destination/origin depending on the strength and direction of prevailing wind. However, when meteorological conditions permit, Runway 33 is used as BAL's preferential runway.

26. Departures and arrival procedures are designed specifically in relation to the declared start and end points of the runway. To declare a revised runway length it was necessary for BAL to publish new departure procedures for Runway 15 and new arrival procedures for Runway 33. Departure procedures are known as Standard Instrument Departures (SIDs).

27. The original proposal concerned the SIDs departing on Runway 15 towards the southeast. The arrival procedure on the reciprocal runway (Runway 33) was the subject of separate airspace change proposals Birmingham 33 ACP and was not part of the CAA's decision regarding the revised operation of Runway 15 (Reference 2).

28. BAL, as the sponsor, developed an airspace change proposal for the amendments requested in accordance with the CAA's Airspace Change Process that existed at that time (CAP725).

29. BAL stated in that proposal that its overriding objective was to design safe procedures that complied with the relevant international design criteria.

Subject to satisfying that overriding criteria, their objective was to minimise so far as possible the impact on local communities of making the changes necessary (in terms of the impact of noise, emission and visual impact) as a consequence of the longer runway.

30. There are six SIDs departing from Runway 15. Four are used by aircraft on routes departing from Runway 15 ultimately heading in a southerly and south-easterly direction (the SIDs covered by this PIR report).

## Anticipated Impacts

31. Subject always to our primary duty to maintain a high standard of safety, the CAA needed to assess the anticipated environmental impact of the proposed change that we were asked to decide on, in order to take that impact into account together with the other material considerations, such as making the most efficient use of airspace, the requirements of operators and owners or the interests of others in relation to the use of airspace and so on. With regard to this second reason for an environmental assessment, the CAA set out its analysis of the environmental impact of the proposed change below (and in more detail in the Environmental Assessment Report. The CAA reached the following conclusions with respect to the anticipated environmental impact of the proposal:

32. The CAA did not anticipate any reduction in $CO_2$ emissions (fuel burn) resulting solely from the changes proposed because this proposal largely reflected, where possible, as close a replication to the tracks flown previously below 4000ft amsl, with no significant changes to track mileage or vertical profile. Since this proposal required no changes to ground infrastructure, we anticipated that there would be no effects on land-take and biodiversity specifically as a result of the introduction of RNAV-1 SIDs from runway 15 at BIA.

33. Since the proposed change does not alter operations below 1000ft amsl the CAA anticipated there will be no effect on local air quality and nor did the CAA anticipate there would be any effects on Areas of Outstanding Natural Beauty or National Parks.

34. The CAA assessed the anticipated impact of aircraft noise that resulted from the changes proposed and in so doing had regard to the altitude-based priorities as given to the CAA by the Secretary of State in the 2014

Air Navigation Guidance to CAA on Environmental Objectives (set out in Annex B to the decision) and also the guidance in respect of the environmental impact of new technology of the type that is the subject of this proposal as follows:

> "*With PBN, the overall level of aircraft track-keeping is greatly improved for both approach and departure tracks, meaning aircraft will be more concentrated around the published route. This will mean noise impacts are concentrated on a smaller area, thereby exposing fewer people to noise than occurs with equivalent conventional procedures.*
>
> *…Concentration as a result of PBN is likely to minimise the number of people overflown, but is also likely to increase the noise impact for those directly beneath the track as they will be overflown with greater frequency than if the aircraft were more dispersed.*
>
> *…The move to PBN will require the updating of existing route structures such as Standard Instrument Departures (SIDs), Standard Terminal Arrival Routes (STARs) and Initial Approach Procedures (IAPs). Updating individual routes in terminal areas can fall into one of two categories: "replication" where the existing route alignment is preserved as much as possible whilst catering for the greater navigational accuracy of PBN, or "redesign" where seeking to optimise the introduction of PBN will require consideration of a different alignment."*

35. Prior to the runway extension, the, then, existing conventional SIDs from Runway 15 had a small right then left turn specifically to take aircraft away from village of Hampton-in–Arden, known as the Hampton Turn. RNAV-1 procedures have a different design criteria compared to Conventional SIDs, the Hampton Turn could not be replicated using RNAV-1 design criteria (specifically the Hampton turn was not technically possible) with the earliest possible turn for a RNAV-1 SID being at 2.2 nm from the DER. As it was therefore not possible to exactly replicate the existing tracks we anticipated a different noise impact from before the RNAV procedures were implemented

# CAA PIR Assessment

36. In addition to considering the information provided by BAL (as set in paragraph 22), the CAA undertook its own analysis and review of the outcomes of the change, including a review and consideration of:

- Complaints made and feedback received during the 12 months post-implementation period (i.e. July 2017 to July 2018);
- A comparative assessment of pre-implementation and post-implementation traffic patterns (i.e. pre-change traffic patterns using the previous conventional SIDs and the post-change traffic patterns using the RNAV SIDs);
- A review of raw radar data and vertical profiles achieved by departing aircraft to determine if the SIDs were flown correctly by the aircraft operators;
- A review of raw radar data to analyse the impacts of aircraft noise;
- A gate analysis to test the position of aircraft over Barston and Balsall Common.
- A review of feedback from the airport operators regarding the flyability of the SIDs regarding the ability of aircraft to adhere to the trajectory of the SID in both lateral and vertical dimensions terms.
- Leq contours post implementation.

## Operational Assessment

37. The CAA examined the track data plots presented by the sponsor and reviewed the evidence provided by the sponsor with regard to the set of PIR reporting requirements as highlighted at Annex A. We completed an analysis of all the new procedures flown and compiled a report which is at Annex B. A further analysis from the Instrument Flight Procedure regulator is at Annex C. We also took account of feedback from operators provided by BAL. The following is a summary of the CAA's assessment.

### Safety

38. Since implementation, no issues have been raised by the ANSPs or aircraft operators (other than a minor query with the speed restriction on departure). The CAA is therefore satisfied that since the implementation of the proposal, a high standard of safety has been maintained by the

operation provided at BIA and allied surrounding airspace within which the SIDs are located.

## Airspace efficiency

39. No issues on airspace efficiency have been brought to the attention of the CAA by ANSPs or aircraft operators, which is not surprising given the nature of the change. The permanent implementation of the 2Y (Option 6) RNAV-1 SIDs proposal from Runway 15 at BIA has neither increased nor reduced the efficiency of integrating traffic through the controlled airspace to the south of Birmingham.

## Operational Feedback

**Flyability.**

40. BAL sought feedback from its regular operators through the Birmingham Airport Flight Safety Committee (FLOPSC). BAL reported that the operators were content with the performance of the RNAV-1 SIDs, although one query was raised concerning the 210kts speed restriction until waypoint BBS06. BAL checked with their designers and fed back to the committee that the restriction was required due to the close proximity of all the initial waypoints. This was accepted by the FLOPSC.

41. However, on review of the UK AIP SID charts we noted that a speed restriction has not been shown on all of the four SID charts illustrating the speed restriction applies until BBS06 but it is in the database coding tables. The CAA checked the content in the SID charts provided by one particular chart provider and we found that the same details had been exactly re-produced on the charts which are used by aircraft operators who would be using that data source. We therefore believe this may have given rise to the query, and as such, the CAA has decided to instigate an amendment to the chart to show the 210kts speed restriction at BBS06 and remove the annotation shown at BBS02. An amendment to the UK AIP charts will therefore be made following the production of this report.

## Air Navigation Service provision

42. The revised RNAV-1 departure procedures has not caused any impacts on service provision which is provided by the ATC units on departure.

### Traffic

43. BIA provided the details of aircraft movements as part of their Post Implementation Review submission:

**Table 1 – Annual movements.**

| Year | Total number of movements | Total number of southbound SIDs |
|---|---|---|
| 2012 | 87,920 | 11,480 |
| 2013 | 89,165 | 11,333 |
| 2014 | 92,261 | 12,910 |
| 2015 | 94,942 | 13,507 |
| 2016 | 107,513 | 15,677 |

For the periods of the traffic samples provided by BAL for the PIR analysis, the numbers of flights using the southbound SIDs have been re-produced for comparison purposes and are shown in Table 2.

**Table 2 – Movements for southerly departure routes.**

| SID | Pre-implementation | Post implementation |
|---|---|---|
| | 15-21 Jun 13 | 23-30 Jun 16<br>(8 Days- see Note 1) |
| Compton | 62 | 89 |
| Cowly | 132 | 91 |
| Daventry | 67 | 96 |
| Westcott | 1 | 4 |
| Mosun* | 20 | 13 |
| | | |
| | 22-28 Sep 13 | 22-28 Sep 16 |
| Compton | 114 | 134 |
| Cowly | 198 | 157 |
| Daventry | 98 | 164 |
| Westcott | 8 | 4 |
| Mosun* | 16 | 35 |
| | | |
| | 22-28 Dec 13 | 22-28 Dec 16 |
| Compton | 66 | 59 |

| SID | Pre-implementation | Post implementation |
|---|---|---|
| Cowly | 128 | 75 |
| Daventry | 76 | 88 |
| Westcott | 10 | 2 |
| Mosun* | 29 | 20 |
| | | |
| | 1-7 Mar 14 | 1-7 Mar 17 |
| Compton | 41 | 53 |
| Cowly | 121 | 95 |
| Daventry | 68 | 98 |
| Westcott | 1 | 1 |
| Mosun* | 25 | 26 |

Notes:

1. A traffic sample of 8 days was used for June 2016 data to show a comparable number of departures.

2. *The Mosun departure route is a non-standard departure and is not a SID. The details are left in for reference as the departure tracks appear in the traffic samples.

**Utilisation and Track Keeping**

44. The utilisation of the available southerly departure routes has not been affected by the changes as all aircraft which would have flown the conventional SIDs have been flying the RNAV-1 SIDs, except for a very small number of non-RNAV-1 departures. Non-RNAV-1 operators fly a non-standard departure which follow the flight paths of the RNAV-1 SID and are then directed by ATC. These departure tracks are embedded within the track dispersion plots which we have reviewed and commented upon in Annexes B and C.

45. The CAA review of the track keeping and vertical profiles of the RNAV-1 SIDs is shown at Annexes B and C. Our analysis concludes that the SIDs are being operationally flown as anticipated.

46. The CAA also carried out an analysis of the raw track data and conducted a gate analysis to determine if the intended track was being flown by the aircraft operators, and to examine if the track dispersion and environmental impacts were as anticipated. We also analysed the data provided illustrating the flight paths flown by operators before the change to compare impacts with the new procedures flown after the change was implemented.

47. The analysis on the raw track data and gate analysis is in the following Environmental Assessment below; the report on the pre and post implementation track dispersion and density diagrams is detailed in Annex B. Interested parties should read the guidance in Annex B before reading the track analysis and associating the comments with the relevant diagrams.

# Environmental Assessment

## Analysis methodology

48. The sponsor provided data to enable the CAA to conduct an analysis of the environmental impacts including the consideration of the noise impacts of the change and assessment of Leq Noise contours post implementation (see Annex A of this report for a list of information provided) for the airspace change post implementation review. The CAA has assessed that data; an analysis of raw radar data is set out below (paragraphs 57-59); a comparison of pre and post implementation track keeping by the Environmental Airspace Regulator is set out in Annex B and summarised below.

49. An assessment was made of the pre and post change track data plots provided by BAL as part of their PIR submission. The data was considered broadly to identify trends in changes to the position and spread of the track data (the latter being taken as an indication of flight track accuracy and the effect of implementation of a PBN proposal.) The position of the track data plots was considered in terms of BAL's intended outcomes of the ACP, particularly, with reference to identified locations such as Barston and Balsall Common as detailed in both their submitted ACP and Post Implementation Documents.

50. Metrics were used to compare the predicted noise impacts associated with the change against recorded post implementation noise data. This detail was also compared with data received from stakeholders including noise studies undertaken on behalf of Barston Parish Council (the analysis of the Barston Parish Council submission follows later in this section).

51. The SIDs which are the subject of this PIR were required for a new runway extension. We have compared the tracks of departures of the Runway 15 southerly SIDs before the new runway was operational with the post operational data, and used the 2014 trial data of the proposed SID change

as a baseline for assessing whether the benefits and impacts were as expected. Locations where complaints were noted to have been made were used as reference locations for the purposes of describing the observed differences in track data plots.

## Analysis of aircraft tracks and heights post implementation

52. Post Implementation Reviews assess whether the anticipated impacts and benefits, set out in the original airspace change proposal and decision, are as expected and where there are differences, what steps (if any) are required to be taken. This review was an iterative process which was determined by the scale and impact of the airspace change itself.

53. In accordance with the CAA PIR requirements, Birmingham airport supplied 4 months of radar data from 1st June 2016 to 30th September 2016, from their Noise and Track Keeping (NTK) system representing post implementation.

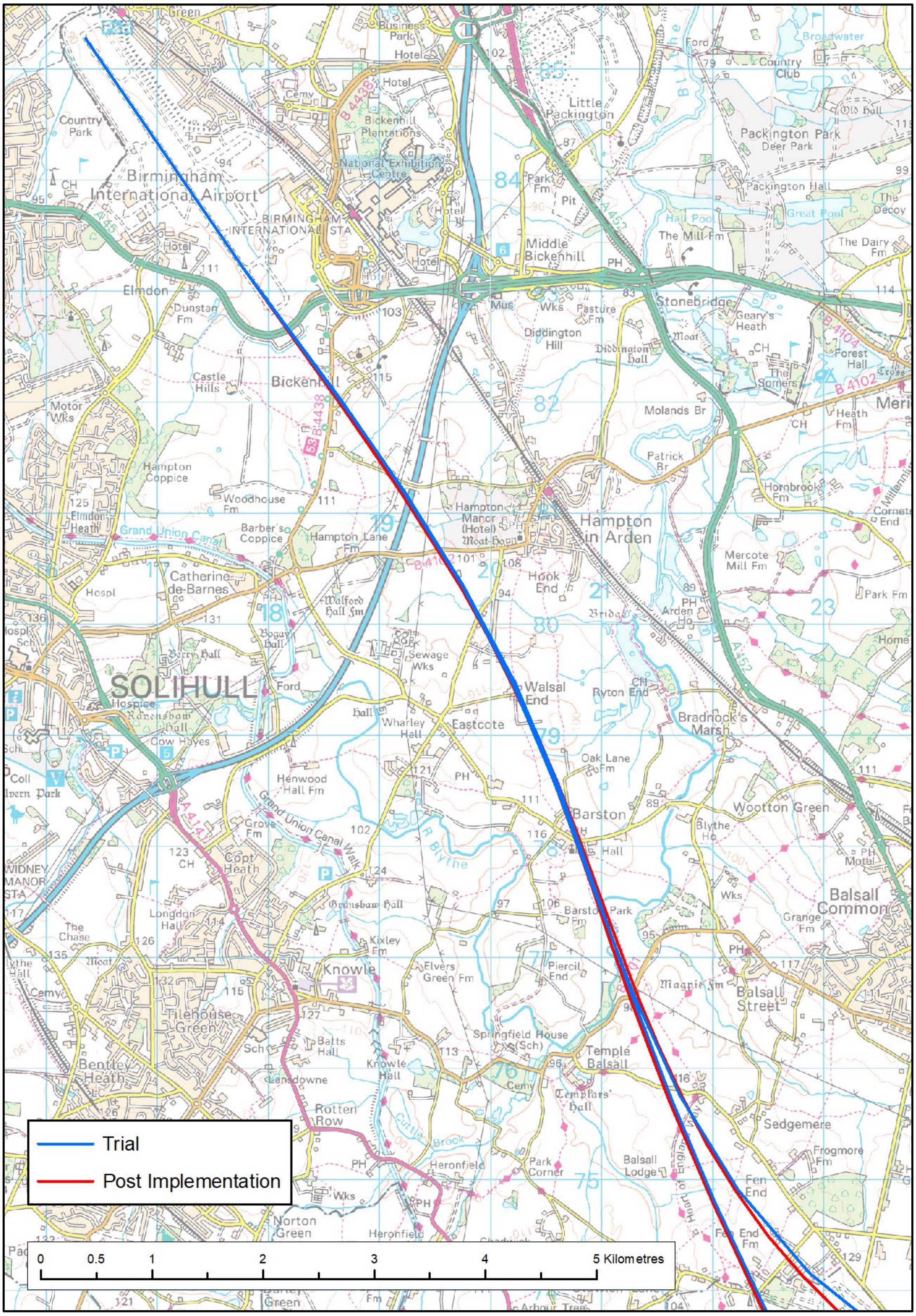
54. Runway 15 departure flight tracks and profiles were extracted from the PIR raw radar data and analysed by the CAA. The purpose was to compare this track keeping data with data from the trial period in order to assess the impacts on Barston and Balsall Common. The analysis is shown below.

55. Additionally, the Airspace Regulator (Environmental) undertook an analysis of pre and post implementation track data for the 4 traffic samples as provided by BAL. The detailed analysis is at Annex B.

## The Raw Radar Data Analysis undertaken by CAA

57. **Figure 1** (on the following page) presents a comparison of the mean departure tracks calculated from the trial and post implementation radar data relating to locations of Barston and Balsall Street East. The post implementation mean track shows very close agreement with that from the trial.

**Figure 1: Comparison of mean departure tracks for trial and post implementation**



**Figures 2 and 3** (below) break down the track position and aircraft height analysis into gate plots showing aircraft position relative to overhead Barston and Balsall Common. Since data for post implementation from 2016 covers three months, rather than the trial period of one month, the data are plotted separately. Whilst there is greater variation within the post implementation data, because it covers much greater seasonal weather variation, it is clear that track positions are consistent with the trial route option 6.

In order to produce an ATC gate analysis software uses virtual vertical planes in space, which are placed like gates on the (South Flow) departure flight path of runways 15 as shown in Figure 2. There may be numerous gates used, however in the case of this assessment for the Birmingham 15 departure analysis, gates were positioned at key points, these being: overhead Barston, and abeam Balsall Common. The flight data including the date and time of entry into the gate is obtained from the software for the aircraft that crosses the gate.

**Figure 2: Gate analysis overhead Barston**

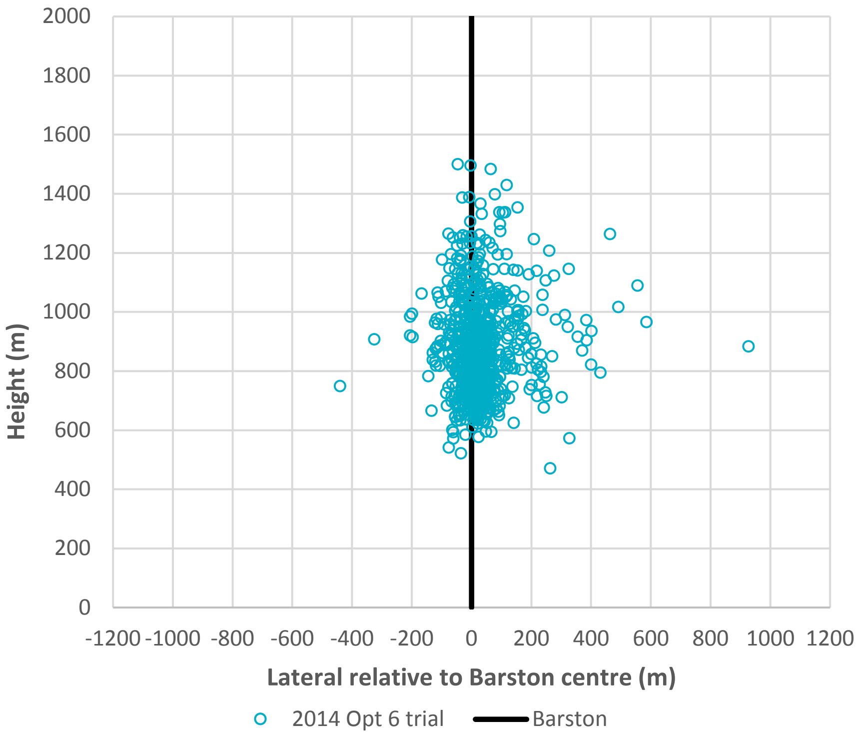



**Diagram 1 – 2014 Option 6 Trial – Gate Analysis Barston.**

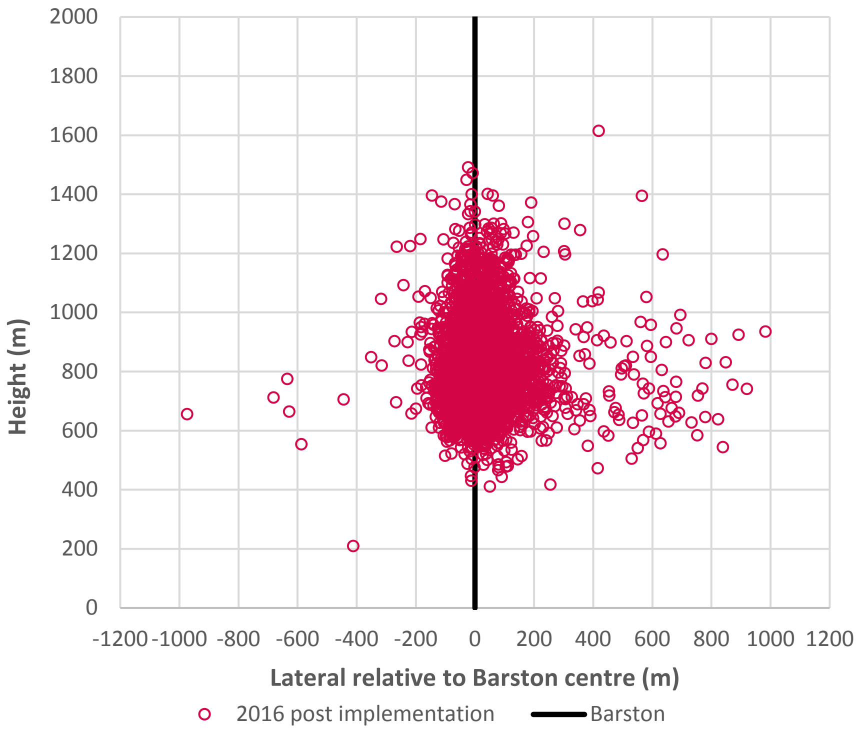



**Diagram 2 – 2016 Post-implementation – Gate Analysis Barston.**

Figure 2 Diagram Explanation:

In the two graphs above, the vertical black solid line represents the location of Barston village. Circles to represent aircraft position in relation to Barston are then shown in various colours for the specific periods of trials and the post implementation period as described below.

In diagram 1, the position of aircraft flying the Option 6 trial in 2014 is shown by the turquoise circles in both the lateral displacement from Barston and in the vertical plain in relation to altitude in metres above Birmingham aerodrome runway level. The main core of the departures is overhead

Barston as the main core of the departures (the turquoise circles) is on or either side of the vertical solid black line, and the altitude of departures is mainly above 600m as they pass Barston.

In diagram 2, the position of aircraft flying the approved RNAV-1 SID during the post implementation period in 2016 is shown by the red circles in both the lateral displacement from Barston and in the vertical plain in relation to altitude in metres above Birmingham aerodrome runway level. The main core of the departures is just to the east of the centre of Barston village although departures are still also flying to the west of the village; the altitude of departures is mainly above 500m as they pass Barston.

**Figure 3: Gate analysis abeam Balsall Common**

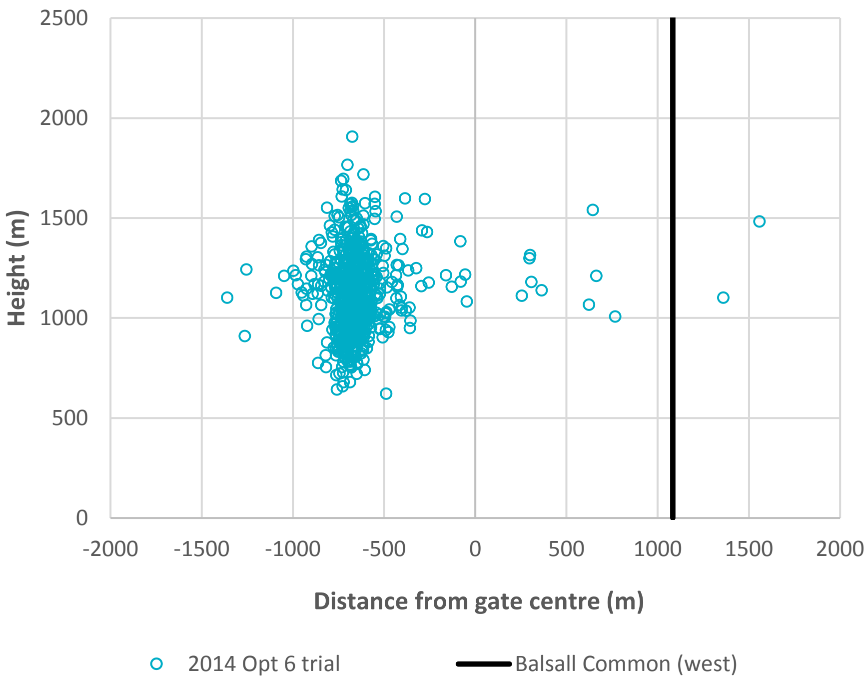



**Diagram 1 – 2014 Option 6 Trial – Gate Analysis Balsall Common.**

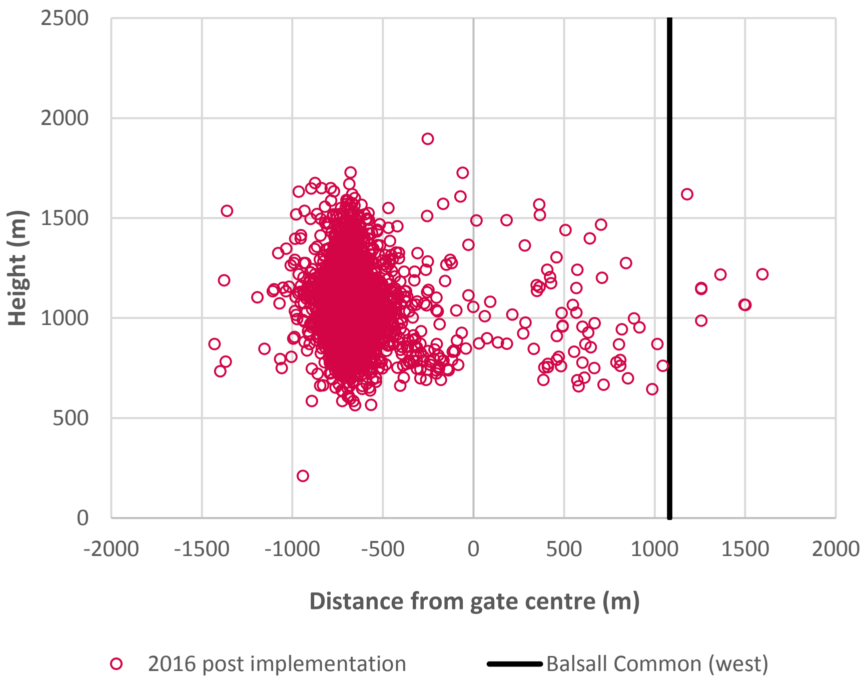



**Diagram 2 – 2016 Post-implementation – Gate Analysis Balsall Common.**

Figure 3 Diagram Explanation

In the two graphs above, the vertical black solid line represents the location of Balsall Common. Circles to represent aircraft position in relation to Balsall Common are then shown in various colours for the specific periods of trials and the post implementation period as described below.

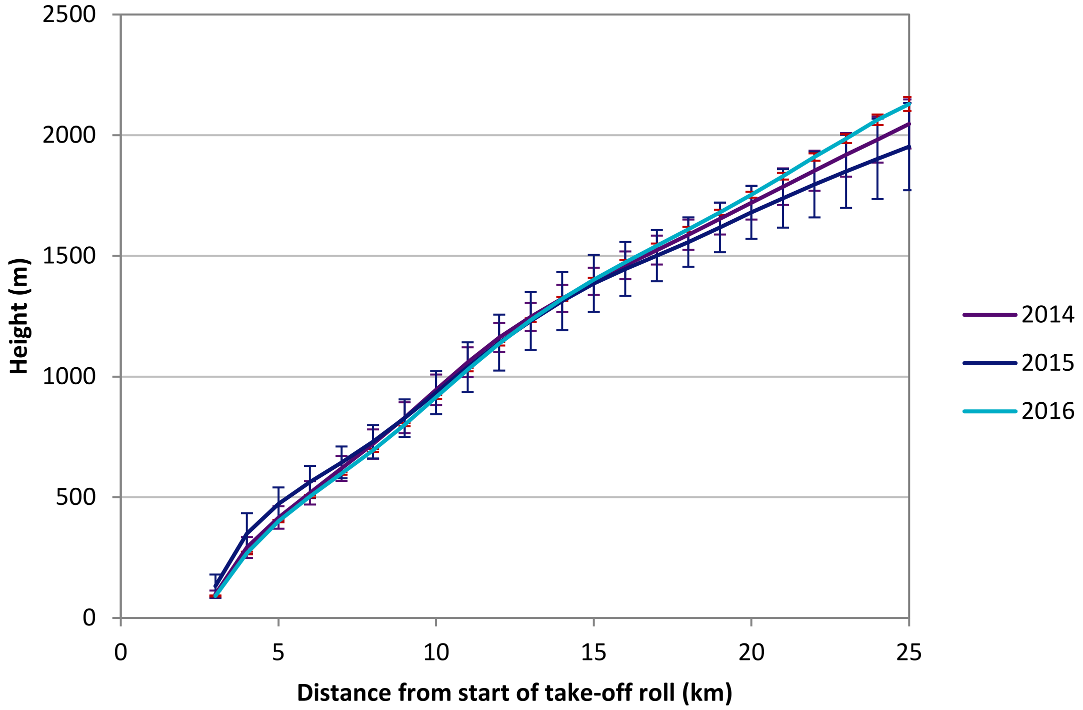
In diagram 1, the position of aircraft flying the Option 6 trial in 2014 is shown by the turquoise circles in both the lateral displacement from Balsall Common (west) and in the vertical plain in relation to altitude in metres above Birmingham aerodrome runway level. The main core of the departures is approximately 1625 m to the west of the solid vertical line location marker, and the altitude of departures is mainly above 600m as they pass Balsall Common (west).

In diagram 2, the position of aircraft flying the approved RNAV-1 SID during the post implementation period in 2016 is shown by the red circles in both the lateral displacement from Balsall common (west) and in the vertical plain in relation to altitude in metres above Birmingham aerodrome runway level. The main core of the departures is approximately 1500 m to the west of the solid vertical line location, marker for Balsall Common and the altitude of departures is mainly above 600m as they pass Balsall Common (west).

58. It is, however, apparent that the average aircraft height after departure has reduced since the trial. We have concluded that this is due to changes in the type of aircraft operating and not due to the airspace design. First, the trial data provided was from January 2015 and thus included fewer operations by charter airlines that operate more intensively during the summer period. For example, Airbus A320 family aircraft made up 31% of the summer 2016 data sample, but only 4% of the January 2015 sample. Secondly, Flybe who operated the single most dominant type in January 2015, the Embraer ERJ 170 (36% of ops) operated an approximate equal mix of the ERJ 170 and Bombardier Dash 8 Q400 turboprop during summer 2016.

59. In order to make a consistent comparison, the most dominant type of operating during both the trial and post-implementation period, the Boeing 737-800, was analysed in detail. Previously the dominant 737-800 operator was KLM operating the 737-800 to Amsterdam, a short route of 240nm distance from Birmingham. In summer 2016, Ryanair was the dominant operator operating to a range of central, eastern and southern European destinations, an average distance of 900nm from Birmingham. The longer distance and higher fuel load consequently result in Ryanair departure heights being lower than those of KLM. Comparing the largest common sample of Ryanair Boeing 737-800 departures, we can assess whether the airspace change has had any impact on departure heights. Comparing Ryanair Boeing 737-800 height profiles between both trials and the summer 2016 post implementation data we find the mean heights are statistically the same (see **Figure 4** below). Thus, in our view the airspace design has not itself contributed to the reduction in aircraft height.

**Figure 4: Departure height profiles for Ryanair Boeing 737-800 aircraft during the two trial periods and post implementation. Error bars show the 95% confidence interval about the mean height.**



## LAeq 16 hour Noise Contour Analysis

60. Examination of the Leq Noise contours provided as part of the consultation on this change against those produced as part of the PIR shows a number of differences (see below). Since the purpose of this change was to take account of changes to the position of the Departure End of the Runway (or DER) which was moved with the extension of the runway 391M to the southeast, as a consequence of this, and as a result of no further changes being made to the operation, weather conditions and fleet mix (all of which influence the resulting contours) using the airport, it would be expected that LAeq (16 hour) noise contours would be simply shifted an equivalent distance to the shift in the Departure End of the Runway.

61. However, as noted below, further minor differences can be observed through comparison of the two sets of contours:

**The extents of the 2013 (Without Departures Airspace Change and with Arrivals Airspace Change) Calculated Contours**

57(dB(A)Northern Extent: The northern extent of the 57dB(A) contour closes at the point at which it abuts the M6 motorway and railway line corridor.

Southern Extent: The 57Leq contour closes on the southern side of the B4101 to the east of the junction with Magpie Lane.

Eastern Extent: The 57dB(A) contour closes at the junction of Moor End avenue and Gloucester Way, Marston Green. The ‘Without Departures Airspace Change and With Arrivals airspace change and with Arrivals Airspace Change’ are co-incident at this point in the 2013 Scenario.

The Eastern Extent closes on the junction of Moorend Avenue and Gloucester Way, Marston Green. The ‘without departures airspace change and with arrivals airspace change’ and ‘with departures airspace change and with arrivals airspace change’ are co-incident at this point.

**The extent of the 2016 Calculated Leq contours**

57(dB(A)Northern extent: The contour extends as far as the Junction of the M42 Motorway at Castle Bromwich in the vicinity of Bromford Road and the Bridge over the River Tame tributary.

Eastern Extent:  As far as the junction of the A4177 and the A452.

Southern Extent:  As far as Oaks Farm Balsall Street East in the South.

**Extents of the 2022 57dB(A) Leq Contour**

Northern Extent of the 57dB(A) Contour (Coincident with that calculated for the with Departures airspace Change and with Arrivals Airspace Change): Bude's Bridge, Ashold Farm Lane, Bromford.

Southern Extent of the 57dB(A) Contour Contours not co-incident with those calculated for With Departures Airspace Change and Arrivals Airspace Change:  West/South West Bend in Fernhill Lane, Balsall Street.

Contour calculated for With Departures Airspace Change and with Arrivals Airspace Change lies slightly (a road's width) to the South West of that calculated for Without Departures Airspace Change, until a point to the Western side of the contour at a point south of the Oak House on Barston Lane.

Eastern Extent:  57dB(A) Contour:  The eastern Extent of the 57 dB(A) Contour lies over the National Exhibition Centre Station.  At this point also the with and without Departures airspace Change calculated contours are exactly co-incident.

62. No overall environmental benefits of this change were anticipated.  The new design was necessary to facilitate airport operations from the new runway position.  There was not expected to be any change to the calculated noise impacts as a result of this change. However, as a direct result of the change to the departure point on runway there was expected to be a corresponding shift of equivalent dimensions to the calculated noise contours and footprints.

63. Whilst this contour review showed slight differences in the contour orientation, this was as expected given the shift in the departure point on the runway.  No major differences from the anticipated impact were noted in key locations.

## Track dispersion analysis

64. We undertook a track analysis which is detailed in Annex B to determine whether the track distribution was as anticipated (by the sponsor) and the CAA when reaching its airspace decision in April 2016.

65. Our analysis of track data, particularly if considered in terms of the different altitude “slices” of at and below 4,000ft, and 4,000 – 7,000ft supplied by BAL as part of their PIR submission was that the track data showed the traffic pattern that was as expected as a result of the displacement of the runway threshold, and subsequent implementation of the SIDs.

66. As illustrated in Annex B, we have directly compared the June 2013 samples with the June 2016 post implementation samples as that provided a like for like comparison in terms of number of departures. However, we took account of the other post implementation samples and determined there was no discernible difference between those and the June 2016 sample, but it was noted the September 2016 sample had a higher number of southbound departures (509) compared with June 2016 (297). We have observed a shift in the traffic patterns as highlighted below:

67. On the southbound track, the main concentration of the traffic pattern has slightly shifted to the east when passing Hampton In Arden and shifted eastwards as the departures fly southbound as indicated below. Analysing expanded density plot diagrams (for the June 2013 and 2016 traffic samples) the estimated approximate displacement values towards the east are shown below.

On all southbound SIDs:

By Hampton In Arden: 200m.

By passing Eastcote: 500m.

By passing Barston: 700m.

By passing Temple Balsall: 800m.

By passing Balsall Common between 700-800m.

By passing Oldwich Lane: 800m.

By passing Honiley 600m.

68. On the DTY SID:

By comparing the track density plots, after passing Honiley (BBS06), when departures turn towards Kenilworth, by the time they have passed Meer End, we estimate the approximate displacement of the core departure track has moved towards the south by approximately 1200m resulting in more overflight above Kenilworth above 4000ft.

69. The traffic patterns are slightly more concentrated than they were with the use of the conventional SID. This is what we would expect to see from RNAV-1 departure procedures using the design criteria applied to the RNAV-1 SIDs.

70. As a result of the RNAV-1 SIDs, some people are overflown less, however, as anticipated, some people who were overflown before experience more overflight as a result of the shift in traffic patterns and impacts of concentration arising from the RNAV-1 SID design.

71. Locations where it is possible to discern changes in overflight, where it is not possible to determine whether there has been any change in overflight, where there is no change to overflight, and where there is less or more overflight are listed below:

- Bickenhill – no discernible difference.
- Hampton in Arden – no change in overflight, however, the main core has moved approximately 200m closer to Hampton in Arden.
- Eastcote - is overflown less as the main core has moved approximately 500m further away to the east.
- Walsall End – is overflown more as the main core has moved approximately 500m to the east.
- Barston – is overflown more as the main core has moved approximately 700m to the east.
- Balsall Common - no change in overflight, however, the main core has moved approximately 700-800m closer to Balsall Common.
- Temple Balsall - is overflown less as the main core has moved approximately 800m to the east.

- Oldwich Lane - is overflown less as the main core has moved approximately 800m to the east.
- Kenilworth – is overflown more above 4000ft.

72. Below 4001ft, some departures appear to be in this altitude band for a slightly longer period. Altitude plots provided by BAL appear to show a longer period of time spent below 4001 feet initially on take-off suggesting a lower (shallower) climb profile is being adopted. Traffic remains at and below 4000ft for a longer period than is shown in the pre-implementation views. This decreased gradient was also observed through the Post Implementation Review noise analysis where changes to both the fleet mix were identified as a contributory factor and also the destinations served. As noted previously, this period of departures being slightly lower as described above is a result of other factors and is not as a direct consequence of the change.

73. These impacts of the re-designed southbound SIDs are what the CAA would have expected from the SID designs.

## $CO_2$ Emissions

74. The CAA did not anticipate any reduction in $CO_2$ emissions due to the replication nature of the change proposal, and therefore there were no significant changes to track mileage or vertical profile with the RNAV-1 SID design. The environmental focus of the proposed change was the noise impact. For this reason, no Post Implementation emissions analysis was requested or completed by the sponsor.

## Local Air Quality

75. There was no requirement for consideration of local air quality as part of this change as there are no Air Quality Management Areas (Areas where there is a risk of Air Quality Objectives being exceeded) likely to be affected, therefore No local air quality Impacts were anticipated or considered as a result of the change. The change was not expected to affect traffic below 1,000ft, the airport is not located within or adjacent to any AQMA's, therefore under the terms of CAP725 the change was not expected to impact on Air Quality. Local air quality was considered by Solihull Metropolitan Borough Council (SMBC) as part of the planning process for the extension of the runway. Solihull Metropolitan Borough Council also concluded that the proposal would be likely to have a negligible impact beyond the airport.

76. Therefore, no assessment of Local air quality was required to be completed as part of the Airspace Change Proposal environmental assessment or as part of the Post Implementation Review considerations.

# Data provided by Third Parties for the purpose of the PIR

## CAA review of submissions provided by Barston Parish Council

77. In response to the Airspace Change decision, on 10 July 2017, Barston Parish Council submitted two reports regarding impacts of the change to the village of Barston which is directly under the flight path of the Option 6 SID approved by the CAA. These reports were a noise measurement report by Randtech Consulting and a Noise Analysis report by Rupert Taylor Ltd.

78. The CAA reviewed these two reports and our comments and conclusions concerning these reports are detailed below.

**RandTech Report**

79. RandTech Consulting were commissioned by Barston Parish Council to undertake an assessment noise exposure in the village of Barston. Noise monitoring was undertaken over a 7-day period in a large rear garden of a house, approximately in the middle of the village. The sound level meter was set to record individual maximum noise levels, one hour $L_{Aeq}$ levels and $L_{A90}$ background levels.

80. Monitoring took place between 1400 on 1 September 2016 and 1400 on 8 September 2016. Barston is exposed to both arrival and departure noise. The Airspace Change Proposal concerned only departure noise, however the report gives no indication of the proportion of arrival and departure flights during the measurement period nor does it distinguish between departure or arrival noise exposure levels. The report notes that daytime one hour LAeq,1h noise exposure levels vary between 55 and 60 dB and cites one 16 hour day exposure level of 58 dB $L_{Aeq}$,16h and night time $L_{Aeq}$,8h value of 54 dB.

81. In contrast, the background level noted over the 7 days was 38 dB, which the report states illustrates the ‘intrusion and nuisance” created by aircraft for the residents of Barston’.

82. The RandTech report concludes that the level of aircraft noise being imposed on Barston constitutes a clear nuisance and is “*significantly detrimental to quality of life for the residents*”. It goes on to say the “any improvements in this situation will only occur if changes are made to flight operations that decrease the number of flights over the village or increases the distance between the individual aircraft and the residents at ground level in Barston.”

**Rupert Taylor Report**

83. The second report by Rupert Taylor Ltd, considers the criteria upon which the 2016 decision was made and concludes that different criteria would have found in favour of Option 5. We have reviewed and analysed the information in this report. We note that it makes no assessment whether Option 5 would have mitigated ‘intrusion and nuisance’ experienced by Barston. In any event we have concluded that this report is not relevant to the scope of the PIR which as we set out in more detail in paragraph 15 to 18 above is to assess whether the change once implemented has had the anticipated benefits and impacts for that reason we have not included that analysis in our PIR report.

**CAA Comments on the Barston Parish Council submission**

85. The CAA has therefore concluded on the basis of our assessment of the post implementation data and of the representations made on behalf of Barston Parish Council that the impact of the implementation of this change is as anticipated.

86. As the evidence of the Leq contours provided as part of the post implementation submission made by Birmingham Airport shows, Barston continues to fall outside the 57dB(A) contour which is the level of noise viewed as the onset of significant community annoyance. In fact the noise contours calculated evidence that for the case both with and without both the arrivals and departures airspace change, and with a departures airspace change, the contour areas are almost exactly co-incident.

## Community Stakeholder observations

87. As part of the data collection process, the Change Sponsor was required to accept, process and collate noise enquiries/complaints and feedback relating to the implementation of this airspace change. Within their PIR data submission, the Change Sponsor included details in relation to a total of 716 enquiries/complaints concerning 1,127 'events' which they have determined as falling within scope of this Review. This data has been reviewed and assessed by the CAA for the purpose of this PIR.

88. The 716 enquiries/complaints that the Change Sponsor has determined fall within scope of this Review were generated by 258 individuals, all of whom submitted their enquiry/complaint via the airport's dedicated Customer Relations Management (CRM) system. The main themes identified by the Change Sponsor when analysing these enquiries/complaints concerned aircraft noise, off-track aircraft and low flying aircraft.

89. The airport's CRM system requires individuals submitting an enquiry/complaint to provide a full postcode and this information was included in the Change Sponsor's PIR submission. From complaints data received, we have analysed the impacts of the locations from where 10 or more complainants reside. Three locations (Balsall Common, Hampton in Arden and Marston Green) met the criteria and for each location we have compared the traffic patterns associated with Birmingham airport both before and after the implementation of the change; the outcome of this analysis is summarised below. By restricting our analysis to locations with 10 or more complainants, we have been proportionate in our considerations, prioritising those locations that appear to have generated the greatest response from communities.

- **Balsall Common**:

  Forty individuals from this area generated 287 enquiries/complaints – one individual was responsible for 169 enquiries/complaints. Balsall Common is located to the east of the centreline for the COWLY, CPT, WCO and DTY SID procedure. Whilst Balsall common is overflown by aircraft flying the northerly departure routes using the TRENT and WHITEGATE SIDs, (note: the Whitegate SIDs was removed on 23 May 2019), those particular departure procedures were not part of the southerly SIDs airspace change proposal.

Focussing initially on the maps displaying aircraft tracks in June and September 2013, there is a noticeable 'void' between the tracks following the TRENT SID (turning north) and those following the COWLY, CPT, WCO and DTY SID (heading south); none of the southbound tracks pass over Balsall Common. On reviewing the corresponding maps from June and September 2016, we note that southbound tracks now occupy the 'void' and that they therefore pass closer to the western/south-western outskirts of Balsall Common. This is reflected in the track density maps for both periods. Whilst we can conclude that southbound tracks do not directly overfly Balsall Common, the implementation of this airspace change proposal increases the possibility of aircraft departing to the south passing closer to it. The impact to Balsall Common is therefore as expected.

- **Hampton in Arden**:

Thirty two individuals from this area generated 48 enquiries/complaints. Hampton in Arden is located to the east of the centreline of the TRENT, WHITEGATE, COWLY, CPT, WCO and DTY departure procedure. Whilst Hampton in Arden is affected by aircraft flying the northerly TRENT and WHITEGATE SIDs and all southbound SIDs, the TRENT and WHITEGATE departure procedure did not form part of this airspace change that is the subject of this review and therefore it has not been included within the following analysis.

When comparing the maps displaying aircraft traffic from June and September in 2013 and 2016, there is a displacement of the departure traffic pattern of around 200 which has shifted slightly towards the east and it is now slightly closer to Hampton in Arden.

We therefore conclude that the implementation of this airspace change proposal has had a minimal impact on Hampton in Arden and therefore the impact is as expected.

- **Marston Green:**

Thirty one individuals from this area generated 38 enquiries/complaints. Marston Green is located adjacent to the runway and therefore is not affected by any of the procedures implemented following the approval of this airspace change.

90. The main conclusion of this analysis is that there have been no unanticipated noise impacts arising as a result of the implementation of the Runway 15 RNAV-1 SIDs to the south.

91. In addition to the feedback noted and considered above, the CAA has also analysed the correspondence which it received directly from stakeholders following the implementation of this airspace change.

92. The CAA has received a total of four enquiries/complaints which specifically relate to Birmingham airport and aircraft activity associated with it. All fell outside of the conditions contained within the CAA's regulatory decision, sought clarification on the requirements of the airspace change process and/or concerned un-related aircraft activity. As this correspondence did not specifically concern the impact of aircraft activity following the implementation of this airspace change, it was not considered for the purposes of the PIR conclusions.

93. To summarise, we have analysed the enquiries/complaints received by the Change Sponsor and the CAA as part of this Review. As a result of our analysis, we have concluded that the correspondence received is consistent with the traffic patterns we were expecting and observed when carrying out our aircraft track analysis and does not indicate any unforeseen impacts of the proposal.

# Conclusion

## Operational Conclusions

94. The CAA is satisfied that since the implementation of the proposal, a high standard of safety has been maintained by the operation provided at BIA and allied surrounding airspace within which the SIDs are located

95. The CAA is also satisfied that the permanent implementation of the Runway 15 southbound '2Y' (Option 6) RNAV-1 SIDs at BIA has neither increased nor reduced the efficiency of integrating traffic through the controlled airspace to the south of Birmingham.

96. Following examination of track data by the IFP regulator (as highlighted in Annex C), the lateral and vertical profile of the SIDs are being flown as expected and no operational issues have been brought to the attention of the CAA. We do however require a minor chart correction to reflect the speed restriction of 210kts by waypoint BBS06 rather than BBS02; which will be amended as soon as possible.

## Environmental conclusions

97. The CAA's conclusion in this PIR is that the environmental impacts consequential on the implementation of the airspace changes are as they were expected to be. The implemented Runway 15 southbound SIDs have resulted in a change of track over the ground, the impact of which is as expected.

98. The CAA's conclusion is that the noise impact of the new design was as expected.

99. Noise: As part of the ACP BAL commissioned Leq Noise modelling. The results were published as part of the consultation document for this change however the results of modelling the revised SIDS were concluded to be indistinguishable from the current SIDS on the basis of Leq. A review of the Leq contours carried out as part of the post implementation assessment showed slight differences in the contour orientation, however other than as

noted in this report, no major differences from the anticipated impact were noted in key locations.

100. $CO_2$ Emissions: The impact of this change on $CO_2$ emissions was small; the focus of the design being to address the noise impact rather than the emissions impact.

101. Local Air Quality: LAQ has not been affected by this change.

## Complaints conclusion

102. As a result of our analysis, we have concluded that the correspondence received is consistent with the traffic patterns we were expecting and observed when carrying out our aircraft track analysis and does not indicate any unforeseen impacts of the proposal

## Overall conclusion and confirmation of BIA Runway 15 SIDs to the south

103. Following the implementation and operation of the new Runway 15 RNAV-1 SIDs to the south which were designed to minimise as far as possible the impact of the extended runway on local communities, there have been no operational issues arising.

104. From the review of the track data provided, we can conclude that the impact of the of the 2Y (Option 6) SIDs have been as expected.

105. The CAA's airspace change process in respect of the BIA airspace change request dated 14 August 2013 (as amended) has now been confirmed and concluded.

# Note on plain language

106. The CAA has attempted to write this report as clearly as possible. Our approach has been to include all the relevant technical material but also to provide a summary and of the conclusions the CAA has reached in reliance on it in as understandable a way as possible. Nevertheless, when summarising a technical subject there is always a risk that explaining it in more accessible terms can alter the meaning. For that reason, the definitive version of our assessment and conclusions are in the attached technical reports.

# Annexes

**Annex A.** Birmingham Runway 15 southerly SIDs PIR data provision Requirements - evidence provided.

**Annex B.** Departure Track Analysis Assessment.

**Annex C.** CAA IFP Analysis.

# Annex A – BIA Runway 15 SIDs PIR data provision Requirements - evidence provided

1. On 7 April 2017, the CAA requested BAL to provide a variety of PIR data requirements to be submitted to the CAA by 7 July 2017. In response, BAL provided the CAA with a single source PDF document which is provided on the CAA website (Doc Ref 01: Birmingham Airport Airspace Change Proposal Runway 15 Post Implementation Review) to illustrate:

   - An update on progress regarding investigation of the potential to implement a 3.2 degree glideslope for Runway 33 arrivals.
   - An update on progress with the review of the airport's noise abatement procedures.
   - Traffic numbers since 2012.
   - An annual summary of aircraft fleet mix since 2012.
   - An analysis of complaints and feedback received during the 12-month post implementation period.
   - A number of track dispersion and track density plots to show flightpaths before and after the change.
   - Raw radar data for departures between June and September 2016.
   - Feedback from regulator aircraft operators.
   - Details of stakeholder feedback collection mechanisms.

2. All of the data requested by the CAA has been provided by BAL.

3. Following a request from the CAA, a supplementary set of diagrams (Doc Ref 07: Birmingham Airport Airspace Change Proposal Runway 15 Post Implementation Review – Supplementary Information Request) was provided by BAL which was designed to improve resolution of the original diagrams provided. These were later updated with a key and SID traffic statistics (Doc Ref 09: Supplementary Information Request 2), then slides were re-sequenced to facilitate direct comparison between pre and post implementation track diagrams (Doc Ref 11 Supplementary Information Request 2.1).

# Annex B – Birmingham International Airport Departure Track Analysis Assessment

**INTRODUCTION**

1. To enable the CAA to conduct the PIR analysis, the sponsor provided traffic pattern plots for the traffic samples in June, September, December of 2013 and March 2014 before the change, and traffic samples for comparative months throughout the first year of operation; these were various seven-day periods during June, September, December of 2016 and March 2017. The traffic sample dates are shown below at paragraph 14.

2. The sponsor did not provide any commentary to explain the nature of the diagrams, therefore the CAA has added explanatory detail to assist interested parties interpret these diagrams. Before reading this CAA analysis of the data provided, it is recommended that readers first read the Birmingham consultation document, the change proposal, and the CAA decision document, all via this link: Birmingham ACP . The following CAA analysis should then be read in conjunction with viewing the relevant diagrams provided in the PIR data from the sponsor.

3. The CAA analysed the samples relating to the pre, and post implementation traffic patterns. In this assessment, we refer to the diagrams supplied by BAL. These are:

   Departure procedures:

   - Track dispersion plots in the altitude band up to 4000ft amsl;
   - Track dispersion plots in the altitude band up to 7000ft amsl;
   - Track dispersion plots from 4000-7000ft amsl;
   - Track Density diagrams

4. It should be noted that in the final stages of the PIR analysis, following clarification on a number of queries raised by the CAA, the sponsor advised that the diagrams included both a very small percentage of non-RNAV-1 departures. Up until 18 August 2016, these departures followed the flight path of the DTY4E departure; however, as alluded to in the main report, due to a reduction in non-RNAV-1

operations, BAL decided to replace the DTY 4E with a non-standard departure to better reflect the track being flown by the DTY2Y RNAV-1 SID. Therefore, since 18 August 2016, non-RNAV-1 departures have flown the departure as follows:

‘Climb straight ahead to 2 DME, turn right to track 165 degrees to 4 DME, then left turn own navigation to DTY’.

The diagrams which show the traffic patterns post implementation therefore show all departures, i.e. the RNAV-1 and the non-standard non-RNAV-1 departure as described above. It is impossible to determine precisely which tracks are the non-RNAV-1 departures in the early stages of departure where they are mixed in with the RNAV-1 Departures; however, MOSUN non-standard departures (these are not SIDs and were not subject to the airspace change proposal) are apparent when aircraft are vectored off to the south west towards MOSUN, as are the non-standard DTY departures to the east as they pass north of Kenilworth, although these tracks could be RNAV-1 departures being vectored when above 4000ft.

## **ABBREVIATIONS/TERMINOLOGY**

5. In this analysis, we refer to a number of technical aspects relating to the design of the arrival and departure procedures; to aid understanding, we have attempted to explain these terms in a non- technical manner:

DER Departure End of Runway (normally the end of the physical length of the runway).

DME Distance measuring equipment which provides a distance in nautical miles from a navigational aid located on the ground and interpreted by aircraft on board navigation systems.

NM Nautical mile.

WP (FO = flyover) Waypoint (flyover means that the aircraft will fly over the position of the waypoint before turning to intercept the next segment of the procedure).

WP (FB = flyby) Waypoint (flyby means that the aircraft will anticipate the turn before the waypoint to allow tangential interception of the next segment of the procedure).

Path Terminator Is a set of defined codes, each of which defines a specific type of flight path and a specific type of termination of that flight path. Examples of these in the Birmingham Departure Instrument Flight Procedures (IFPs) are course to altitude (CA), course to fix (CF) and track to fix (TF).

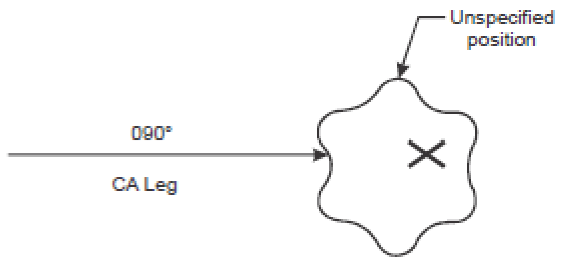
6. The coding that is used within the Flight Management System (FMS) to capture the defined path and which is stored in the navigation data base is reflected through an Industry standard called ARINC Specification 424. The current version is ARINC 424-20, although earlier versions are still employed in many navigation data bases with varying functional capability. RNAV 1 defines a subset of functional blocks termed as ‘Path Terminators’ for use in the design of instrument flight procedures. In this way, all RNAV 1 qualified aircraft are capable of executing leg transitions and maintain tracks consistent with ARINC 424 path terminators. The required path terminators for RNAV 1 are:

- Initial Fix (IF)
- Track to Fix (TF)
- Course to Fix (CF)
- Course from a Fix to an Altitude (FA)
- Direct to a Fix (DF)
- Manual Termination (FM)

7. Although RNAV 1 defines the above Path Terminators, only a subset has been used in the designs for the Birmingham RNAV-1 SIDs. Those used are described as follows:

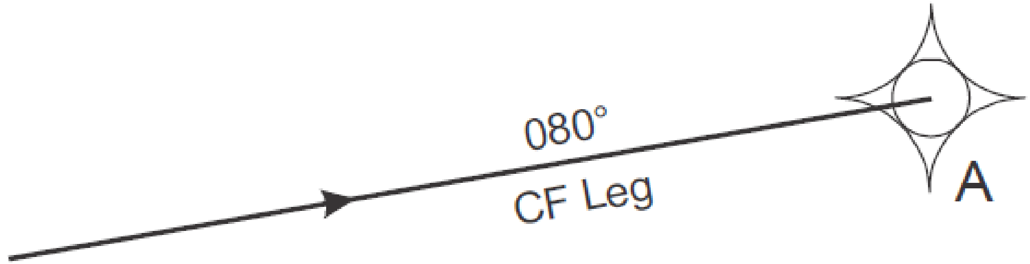
**Course to Altitude (CA)**

A CA is used to define the course of an outbound route segment that terminates at an altitude with an unspecified position.



**Course To Fix (CF)**

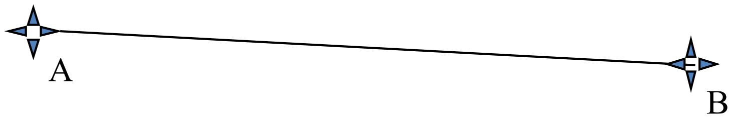
A CF leg is defined as a geodesic path that terminates at a fix with a specified course at that fix. The inbound course at the termination fix and the fix are provided by the navigation database.




Course to Fix (CF) Leg

**Track to Fix (TF)**

A TF leg is defined as a geodesic path between two fixes (waypoints). It is the preferred leg type in RNAV Terminal Procedures that are not using ground based navaid references. The TF defines a great circle track over the ground between two known database fixes. The first fix is either the previous leg termination or an initial fix leg.




Track to Fix (TF) Leg

Path: Geodesic Path between A and B with Termination at Fix B

**Track Dispersion.** Is where the flights tracks over the ground of a procedure are varied due to the use of path terminator, differing aircraft types, operator standard operating procedures (SOPs) and wind conditions as examples. Track dispersion tends to spread the noise over a wider area.

**Track Concentration**. Is where the tracks over the ground are concentrated on predictable flight tracks. Concentration of tracks can allow for noise sensitive areas to be avoided but it is not always possible to avoid all populated areas.

**SID Nominal Track (NT).**

The nominal track is the intended track to be flown when adhering to the speeds as shown on the procedure chart used by flight crews. The adherence to this published nominal track will vary in accordance with how the procedure has been designed to achieve either dispersion or concentration of flight tracks and external factors effecting aircraft ground speed e.g. wind conditions.

**Airport / SID Designator:** Birmingham International Airport / DTY2Y / COWLY2Y /WCO2Y / CPT2Y southerly departures Runway 15.

**GUIDE TO INTERPRETING TRACK DISPERSION AND DENSITY DIAGRAMS**

8. Attached to this document at **Document References: 01, 07, 09, and 11** (via links to the PIR Data) are the PIR track dispersion and track density plots which have been provided by BAL. The track density plot diagrams are similar to that shown in the primary BAL consultation document (page 11). The track dispersion plots show individual track data for the relevant periods both prior to the change and following the change (see the explanation below to understand the difference). The PIR data was provided by BAL in four separate sets following requests from the CAA to update the PIR data set diagrams to order to assist interested parties interpret the diagrams with improved resolution and clarity.

9. In the first and second set of diagrams, the ‘before and after’ track diagrams are located on separate pages, therefore, for comparison purposes, it will be necessary to either view two electronic copies alongside each other to see before and after implementation track diagrams which should facilitate ease of comparison for interested parties, or, print the documents to compare before and after track

plots. Alternatively, **we would recommend** that it may be easier for interested parties to examine the fourth set of PIR data diagrams **Doc Ref 11** which when viewed, will show sets of track dispersion and track density plots before and after implementation immediately following each other, however, a cross reference with **Doc Ref 01** may also still be helpful. Using this set enables any viewer using the up or down arrows on the Adobe tool set to quickly see one or other diagram, so by flicking back and forward, changes to traffic patterns can potentially be understood more easily than using the first two sets of the data sample diagrams.
Note: all the PIR data sets have been provided on the CAA website in the interests of transparency to highlight what data has been received and examined, and we have considered all of the diagrams provided. Our analysis in Table 1 focuses on the June 2013 and June 2016 traffic samples for comparison purposes; the analysis compares the impact of 292 departures in June 2013 with 297 departures in June 2016. However, we have determined that the remaining samples of September 2016, December 2016 and March 2017 are extremely similar to the June sample of 2016, although the September 2016 sample has the highest number of southbound departures (509), but the traffic pattern is similar to all the post implementation months with lower numbers.

10. To fully understand this review, readers will have to view the track dispersion diagrams which are associated with the descriptions of track dispersion and track density diagrams which are shown in Table 1. The explanations of track distribution are described using references to locations shown on the diagrams to help to describe impacts of the RNAV-1 departure procedures.

11. The Adobe PDF diagrams may be expanded using the plus or minus function in the Adobe toolset to see more detail of the mapping., With the use of the down or up arrows, it is possible to see the immediate difference between the track over the ground flown by aircraft before the change compared with track over the ground flown following the change.

## TRACK DISPERSION DIAGRAMS

12. Track dispersion diagrams portray each aircraft track on a map, based on radar data. Tracks are overlaid upon each other, such that if many tracks are overlaid on top of each other, individual tracks may no longer be visible. They are useful for illustrating the dispersion of the traffic pattern but are not as useful for determining the density/concentration of tracks.

## TRACK DENSITY DIAGRAMS

13. Track density diagrams portray the concentration of flight tracks using a colour code to indicate differing concentrations of flight tracks. They are sometimes referred to as “heat plot” diagrams. Whilst they can be used to illustrate traffic dispersion, they are most useful for

illustrating if traffic is concentrated along a route or over a geographic location. Depending on the key used for portraying track concentration, individual tracks towards the outer limits of the dispersion may not be visible on the diagram.

## TRAFFIC SAMPLES AND DIAGRAM INTERPRETATION

14. The traffic sample periods are from June, September, December of 2013 and March 2014 and respective monthly periods for 2016/17 as follows:

| Month | Specific Dates | Number of Departures | Number of Southbound Departures |
|---|---|---|---|
| Jun 2013 | 15-23 | 435 | 292 |
| Jun 2016 | 23-30 | 429 | 297 |
| Sep 2013 | 22-28 | 606 | 162 |
| Sep 2016 | 22-28 | 673 | 509 |
| Dec 2013 | 22-28 | 433 | 122 |
| Dec 2016 | 22-28 | 365 | 252 |
| Mar 2014 | 01-07 | 387 | 260 |
| Mar 2017 | 01-07 | 408 | 279 |

Note: Individual departure numbers for each SID are shown on each slide.

15. Each set of diagrams for the period of traffic samples provided portrays a coloured density plot. Diagrams were revised following the initial provision; with regard to the density plot keys, the following notes should be noted:

Note 1: The key to the density plots in the original sample and the first 'Supplementary Request' from the CAA relate to the altitude.

Note 2: The key to density on the revised plots provided in the second and third supplementary data in December 2018 and January 2019 relate to numbers of aircraft; slide number 2 of the data provided explains accordingly.

Note 3: In the Doc Ref 11, the ordering of the slide set provided in January 2019 was revised to enable a quick comparison between pre and post implementation traffic patterns by using the up and down arrow function of the Adobe toolset.

## GUIDE TO OUR ASSESSMENT OF THE BIRMINGHAM RUNWAY 15 SOUTHERLY RNAV DEPARTURE PROCEDURES

### SID TRACK PLOTS

16. In Table 1, we are showing our assessment of the revised RNAV SID.

- Column 1 shows the **CAA Web Link** to the relevant diagram, the document title and the name of the AIP chart departure procedure.
- Column 2 describes the relevant segment of the SID design, with an approximate geographical description, together with the RNAV waypoints.
- Column 3 shows the design path terminator used in the design.
- Column 4 describes the traffic pattern before the change and the forecast traffic pattern (in blue) and whether dispersion or concentration was expected.
- Column 5 is a qualitative description of the traffic pattern and track-keeping of the new RNAV1 SID and a comparison with the conventional SID before the change.
- Column 6 indicates whether the impact of the change is as expected.

### DEPARTURE PROCEDURES TRACK ANALYSIS

17. In the Table 1 below, for analysis purposes, we have divided the analysis of the track dispersion of the modified RNAV SID design into a number of segments; this is shown in Column 2.

18. In Table 1 Column 4 where we describe the traffic pattern before the change and the forecast traffic track keeping performance in terms of dispersion or concentration, to assist understanding of what was to be expected following the change, we refer to the following comments made in the consultation material:

The supplementary Consultation Document Appendix A (page 7) illustrated the nominal track of the RNAV-1 SID design. The consultation did not specifically show predicted traffic patterns in a sense of describing or illustrating any concentration or dispersion of departing traffic, but it did describe on pages 4-5 how the SID was designed and where the nominal track of the SID departures would take departing aircraft in relation to local communities.

The initial departure would fly straight ahead until 2.2NM where a turn to the right would commence after passing Hampton in Arden. This would take the departing aircraft ground track between the track flown before the change and the initial Option 5 nominal track (which was shown in the main consultation document but following the supplementary consultation was replaced with the proposed Option 6). Appendix D of the supplementary consultation document showed the traffic pattern before the change. BAL described that they had observed a degree of increased dispersion in years leading up to the consultation due to what BAL described as a change in aircraft performance.

The departure track of the implemented Option 6 was predicted to split earlier from the arrival track of the Runway 33 arrival flight path reducing the time those properties beneath the extended runway centreline would be overflown.

The nominal track of the proposed and implemented Option 6 SID design lies approximately between Knowle and Balsall Common and over areas with a lower population density and predominantly over open countryside, and as a consequence, there would be a change to the ground track which would fly overhead Barston.

The nominal track did not lie as far west as the track before the change was implemented, but was also not as far east as the initial proposal of the Option 5 design.

CAA Note 1: Whilst not described in the supplementary consultation material itself for the Option 6 design, to assist with understanding of where aircraft would fly after the routes separate at Honiley, we have added additional comments to illustrate how the southbound routes split after Honiley.

After passing Barston, departures would turn left towards the car testing track near Honiley, after which the departures would split into 4 different tracks heading off towards Daventry (DTY), Wescott (WCO), Cowley (COWLY) and Compton (CPT)

We then describe whether concentration or dispersion could be expected.
CAA Note 2:

We would have considered that departing aircraft would follow the nominal track fairly accurately and be fairly close to the nominal track as shown in the supplementary Consultation Document Appendix A, although at the turns illustrated by the black waypoints, aircraft would fly on the inside of the turn as aircraft 'fly by' the waypoint as opposed to flying over the waypoint where the SID design has 'fly by turns' turns designed in the procedure. Given the design of the SIDs we would expect to see more concentration than a dispersed traffic pattern until such time that traffic is vectored when above the NPR vectoring altitude of 4000ft.

18. In Table 1 Column 6, the comparison is the basis on which we decide whether or not the RNAV SID has met its objective and whether the impact of the change is as expected.

**Table 1 – CAA Track Analysis of the Birmingham International Airport Departure Procedures**

| **CAA Web Ref Procedure & AIP Chart Ref** (1) | **Segment / Stage / Phase of SID/** (2) | **Path Terminator Employed** (3) | **Traffic pattern before the change and**<br>**Forecast Track Keeping Performance (Dispersion or Concentration) [this is a description of what the sponsor expected the traffic pattern to be].** (4) | **Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID.** (5) | **CAA Assessment of whether the impact of the changes is as expected** (6) |
|---|---|---|---|---|---|
| **TRACK DISPERSION AND TRACK DENSITY PLOTS (ONLY UP TO HAMPTON IN ARDEN / BBS02)** | | | | | |
| Doc Ref 01<br>Doc Ref 11<br><br>UK AIP AD 2 EGBB Charts:<br>6-8<br>6-9<br>6-10<br>6-11<br><br>Coding tables:<br>6-14<br>6-15<br>6-16<br>6-17 | Straight ahead as far as Hampton in Arden (2.2NM after DER)<br><br>From DER to approximately BBS02 | **ALL SIDs:**<br><br>CA to 900ft<br><br>CF to BBS02<br><br>TF to all following waypoints | Departures fly straight ahead and commence a turn before reaching Hampton in Arden. The Hampton-in Arden turn is in evidence; the traffic turns more to the west of, and to avoid overflying Hampton in Arden; this turn is known as the Hampton turn<br><br>Sponsor's forecast:<br><br>The initial departure would fly straight ahead until 2.2NM where a turn to the right would commence after passing Hampton in Arden.<br><br>CAA expectation: Concentration. | Departures are flying straight ahead to approximately 2.2 NM after take-off until passing Hampton in Arden and then commence a turn towards Barston. There is no evidence of the 'Hampton Turn' associated with the previous conventional SID procedure. The traffic pattern is slightly more concentrated with a slight displacement eastwards towards Hampton in Arden which we estimate to be approximately in the region of 200m. | The impact of the change is as expected. |

| CAA Web Ref Procedure & AIP Chart Ref (1) | Segment / Stage / Phase of SID/ (2) | Path Terminator Employed (3) | Traffic pattern before the change and Forecast Track Keeping Performance (Dispersion or Concentration) [this is a description of what the sponsor expected the traffic pattern to be]. (4) | Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID. (5) | CAA Assessment of whether the impact of the changes is as expected (6) |
|---|---|---|---|---|---|
| **UP TO 4000FT TRACK DISPERSION PLOTS** | | | | | |
| Doc Ref 01<br>Doc Ref 11<br><br>UK AIP AD 2 EGBB<br><br>Charts:<br>6-8<br>6-9<br>6-10<br>6-11<br><br>Coding tables:<br>6-14<br>6-15<br>6-16<br>6-17 | Up to 4000ft amsl | **ALL SIDs:**<br><br>CA to 900ft<br><br>CF to BBS02<br><br>TF to all following waypoints | After take-off, departures climb straight ahead, and commence the Hampton In Arden turn, and then follow the SID nominal track to towards Temple Balsall and Wroxall and are dispersed from immediately after take-off out to around 4000ft. For the DTY departures, the turn at Temple Balsall towards the east is evident, again with some dispersion.<br><br>Traffic can be seen to be remaining at and below 4000ft for a shorter distance than is shown in the post implementation review plot.<br><br>Sponsor's forecast:<br><br>The initial departure would fly straight ahead until 2.2NM where a turn to the right would commence after passing Hampton in Arden. This would take the departing aircraft ground track between the track before the change and the initially proposed (but not implemented) Option 5.<br><br>The nominal track of the RNAV-1 SID lies approximately between Knowle and Balsall Common which would result in aircraft flying overhead Barston.<br><br>The nominal track is not as far west as the conventional SID track, and is also not as far east as the initial proposal of the Option 5 design.<br><br>CAA Addition:<br><br>After passing Barston, departures would turn left towards the car testing track near Honiley, after which the departures would then split into 4 different tracks heading off towards Daventry (DTY), Wescott (WCO), Cowley (COWLY) and Compton (CPT) | A greater degree of concentration of tracks is evident in the post implementation track diagrams compared with the pre-implementation plots.<br><br>On the southbound track, the main concentration of the traffic pattern has shifted to the east. We have expanded the density plot diagrams (for the June 2013 and 2016 traffic samples) to assess the displacement values which are shown below.<br><br>**On all southbound SIDs:**<br><br>By comparing the track density plots, we estimate the approximate displacement of the core departures to have moved towards the east by the distances indicated below:<br><br>By Hampton In Arden: 200m.<br><br>By passing Eastcote: 500m.<br><br>By passing Barston: 700m.<br><br>By passing Temple Balsall: 800m.<br><br>By passing Oldwich Lane: 800m. | The impact of the change is as expected. |

| CAA Web Ref Procedure & AIP Chart Ref (1) | Segment / Stage / Phase of SID/ (2) | Path Terminator Employed (3) | Traffic pattern before the change and<br><br>Forecast Track Keeping Performance (Dispersion or Concentration) [this is a description of what the sponsor expected the traffic pattern to be]. (4) | Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID. (5) | CAA Assessment of whether the impact of the changes is as expected (6) |
|---|---|---|---|---|---|
| | | | CAA expectation: Concentration. | **On the DTY SID:**<br><br>By comparing the track density plots, , departures turn towards Kenilworth slightly before reaching Honiley and by the time they pass Meer End, we estimate the approximate displacement of the core departure track to have moved towards the south by approximately 1200m.<br><br>The majority of the traffic can be seen to be flying further towards the east than was the case before the change.<br><br>Departures now fly over Barston before turning left towards Honliey.<br><br>Aircraft on the DTY SIDs appear to be turning to the East (towards Kenilworth) later compared with the track plots of the conventional SID.<br><br>It should be noted that traffic overflying Balsall Common turning towards the north are departures flying the northbound conventional SID which are not the subject of this PIR.<br><br>For traffic turning to the west (the MOSUN non-standard departures), the traffic appears to turn later than before the change,<br><br>Altitude plots provided by BAL appear to show a longer period of time spent below 4001 feet initially on take-off suggesting a lower (shallower) climb profile is being adopted. | Impact of the change is as expected. |

| CAA Web Ref Procedure & AIP Chart Ref (1) | Segment / Stage / Phase of SID/ (2) | Path Terminator Employed (3) | Traffic pattern before the change and<br>Forecast Track Keeping Performance (Dispersion or Concentration)<br>[this is a description of what the sponsor expected the traffic pattern to be]. (4) | Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID. (5) | CAA Assessment of whether the impact of the changes is as expected (6) |
|---|---|---|---|---|---|
| | | | | Traffic remains at and below 4000ft for a longer period than is shown in the pre-implementation views;<br>This decreased gradient was also observed through the Post Implementation Review noise analysis where changes to both the fleet mix were identified as a contributory factor and also the destinations served.<br>This was also noted by the ERCD analysis which is detailed in the main report. | |
| **4000ft TO 7000FT TRACK DISPERSION PLOTS** | | | | | |
| Doc Ref 01<br>Doc Ref 11<br><br>UK AIP AD 2 EGBB<br><br>Charts:<br>6-8<br>6-9<br>6-10<br>6-11<br><br>Coding tables:<br>6-14<br>6-15<br>6-16<br>6-17 | Between 4,000 and 7,000ft (climbing)<br><br>From approximately Balsall Common to Whitnash (the southern extremity of the track plot).<br><br>From approximately BBS04 to extremity of diagram. | TF | **DTY SIDS:**<br><br>DTY departures turn towards Kenilworth shortly after passing Balsall Common and the majority of departures (but not all) route towards the northern area of Kenilworth. Some departures overfly Kenilworth as they depart to the southeast.<br><br>CAA Addition:<br><br>After passing Barston, departures would turn left towards the car testing track near Honiley, after which the departures would then split into 4 different tracks heading off towards Daventry (DTY), Wescott (WCO), Cowley (COWLY) and Compton (CPT).<br><br>CAA expectation: Concentration. | **DTY SIDS:**<br><br>DTY departures are slightly further to the east as they fly further south towards Honiley and BBS06 in a more concentrated traffic pattern before turning towards Kenilworth. For displacement values, see above.<br><br>There is a shift in the eastbound track of the DTY departures which now fly towards the centre of Kenilworth as the traffic pattern is displaced further to the south.<br><br>Using the track density plot diagrams, we estimate the displacement of the core departure track to be | The impact of the DTY SID change is as expected, although we note radar vectoring is evident above 4000ft. |

| CAA Web Ref Procedure & AIP Chart Ref (1) | Segment / Stage / Phase of SID/ (2) | Path Terminator Employed (3) | Traffic pattern before the change and Forecast Track Keeping Performance (Dispersion or Concentration) [this is a description of what the sponsor expected the traffic pattern to be]. (4) | Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID. (5) | CAA Assessment of whether the impact of the changes is as expected (6) |
|---|---|---|---|---|---|
| | | | | approximately 1200m after passing Meer End.<br><br>Approximately 30% of the traffic on the DTY SID can be seen to overfly Kenilworth in the post implementation plot whereas this is not the case in the pre-implementation plot.<br><br>A greater proportion of DTY departures are overflying **Kenilworth and Stoneleigh** between 4,000 and 7,000ft in a dispersed fashion. The dispersion is most likely due to radar vectoring above 4000ft | |
| | | | **WCO, COWLY and CPT SIDs**<br><br>WCO, COWLY and CPT departures continue southbound after passing Balsall Common routeing towards Honiley and Hampton on the Hill. The traffic pattern appears dispersed as a result of radar vectoring and the split of the 3 departure routes.<br><br>There are some departures which turn right to the southwest after passing Balsall Common. These are the non-standard departures routeing towards the waypoint known as MOSUN for traffic departing to the southwest. After the turn, traffic passes overhead Kingswood above 4000ft.<br><br>Note: these departures were not subject to the change proposal and are therefore not part of the PIR.<br><br>Forecast traffic patterns:<br><br>The nominal track of the RNAV-1 SID lies approximately between Knowle and Balsall | **WCO, COWLY and CPT SIDs**<br><br>The WCO, COWLY and CPT departures are slightly further to the east as they fly further south towards Honiley and BBS06 in a more slightly concentrated traffic pattern. At Honiley / BBS06, the traffic pattern splits off towards the areas of Hampton on the Hill and Whitnash.<br><br>Using the track density diagram the displacement of the core departure pattern has moved approximately 600m towards the east until it resumes a similar pattern to that before the change.<br><br>After Honiley, the spread of traffic is very similar to the traffic pattern before the change and most likely due to radar vectoring into the ATC en-route network. | The impact of the WCO, COWLY and CPT SID changes are as expected, although we note radar vectoring is evident above 4000ft. |

| CAA Web Ref Procedure & AIP Chart Ref (1) | Segment / Stage / Phase of SID/ (2) | Path Terminator Employed (3) | Traffic pattern before the change and Forecast Track Keeping Performance (Dispersion or Concentration) [this is a description of what the sponsor expected the traffic pattern to be]. (4) | Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID. (5) | CAA Assessment of whether the impact of the changes is as expected (6) |
|---|---|---|---|---|---|
| | | | Common which would result in aircraft flying overhead Barston<br><br>The nominal track is not as far west as the conventional SID track, and is also not as far east as the initial proposal of the Option 5 design.<br><br>CAA Addition:<br><br>After passing Barston, departures would turn left towards the car testing track near Honiley, after which the departures would then split into 4 different tracks heading off towards Daventry (DTY), Wescott (WCO), Cowley (COWLY) and Compton (CPT)<br><br>CAA expectation: Concentration. | The non-standard MOSUN departures which turn right to the southwest after passing Balsall Common are still in evidence, although throughout the traffic samples, the point at which they turn to the southwest varies.<br><br>The departure pattern over Kingswood for these non-standard departures are also variable throughout the traffic samples but the majority are all above 4000ft before they reach Kingswood.<br><br>CAA Note:<br><br>The impact of the MOSUN non - standard departure change was not subject to the airspace change process and therefore it was not assessed in the ACP. We have however, made reference to these departures as they appear on the PIR traffic pattern slides. | |

## UP TO 7000ft TRACK DISPERSION PLOTS

As we have analysed the departure tracks in the previous sections up to 4000ft and from 40000-7000ft, to avoid duplication, we have not specifically commented on these track data diagrams.

## TRACK DENSITY PLOTS

| | | | | | |
|---|---|---|---|---|---|
| Doc Ref 01<br>Doc Ref 11<br><br>UK AIP AD 2 | From DER to approximately Hampton in Arden / BBS02 | **ALL SIDs:**<br><br>CA to 900ft | See first section above.<br><br>After departure, the traffic pattern is concentrated towards the Hampton in Arden turn. | See previous section above<br><br>The departure traffic pattern is slightly more concentrated and has moved slightly towards the east towards | Impact as expected. |

| CAA Web Ref Procedure & AIP Chart Ref (1) | Segment / Stage / Phase of SID/ (2) | Path Terminator Employed (3) | Traffic pattern before the change and<br><br>Forecast Track Keeping Performance (Dispersion or Concentration)<br>[this is a description of what the sponsor expected the traffic pattern to be].<br>(4) | Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID.<br>(5) | CAA Assessment of whether the impact of the changes is as expected<br>(6) |
|---|---|---|---|---|---|
| EGBB<br><br>Charts:<br>6-8<br>6-9<br>6-10<br>6-11<br><br>Coding tables:<br>6-14<br>6-15<br>6-16<br>6-17 | | CF to BBS02 | Forecast Pattern:<br><br>See previous sections (track dispersion plots).<br><br>CAA expectation: concentration. | Hampton in Arden by approximately 200m. | |
| Doc Ref 01<br>Doc Ref 11 | Hampton in Arden to Temple Balsall<br><br>BBS02-BBS04 | **ALL SIDs**<br><br>TF | After the Hampton in Arden turn, departures follow the SID design towards Temple Balsall. The traffic pattern is concentrated.<br><br>Forecast Pattern:<br><br>See previous sections (track dispersion plots).<br><br>CAA expectation: concentration. | After passing Hampton in Arden, as departures approach waypoint BBS02, they turn towards Temple Balsall. The traffic pattern is concentrated although it has shifted slightly towards the east towards Balsalll Common and it overflies the village of Barston. We estimated the approximate displacement to the east is:<br><br>By passing Eastcote: 500m.<br><br>Passing Barston: 700m.<br><br>Passing Temple Balsall: 800m. | Impact as expected. |
| Doc Ref 01<br>Doc Ref 11 | Temple Balsall to Honiley<br><br>BBS04-BBS06 | **ALL SIDs**<br><br>TF | After Temple Balsall, departures turn towards Kenilworth (following the DTY SID), or towards Hatton (following the WCO/COWLY/CPT SIDs). The traffic pattern is concentrated.<br><br>Forecast Pattern:<br><br>See previous sections (track dispersion plots). | After passing Temple Balsall, departures continue towards Honiley and remain in a concentrated traffic pattern, although this pattern is slightly further towards the east compared with the traffic pattern of the conventional | Impact as expected. |

| CAA Web Ref Procedure & AIP Chart Ref (1) | Segment / Stage / Phase of SID/ (2) | Path Terminator Employed (3) | Traffic pattern before the change and Forecast Track Keeping Performance (Dispersion or Concentration) [this is a description of what the sponsor expected the traffic pattern to be]. (4) | Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID. (5) | CAA Assessment of whether the impact of the changes is as expected (6) |
|---|---|---|---|---|---|
| | | | CAA expectation: concentration. | SID. We estimated the approximate displacement to the east is:<br><br>By passing Oldwich Lane: 800m.<br><br>By passing Honiley: 600m. | |
| Doc Ref 01<br>Doc Ref 11 | Honiley to Kenilworth (DTY SID)<br><br>BBS06-BBE09 | **DTY SID**<br><br>TF | After Temple Balsall, departures turn towards Kenilworth with some dispersion at the turn. Departures towards Kenilworth gradually 'thin out' given the reduced numbers of aircraft following the DTY SIDs (67). The impact is more evident in the track dispersion plots.<br><br>Forecast Pattern:<br><br>See previous sections (track dispersion plots).<br><br>CAA expectation: concentration. | As DTY departures approach Honiley, they turn towards Kenilworth. This is a flyby turn, and the turn occurs much later compared with the design of the conventional SID; there is a distinct shift of the eastbound track further to the south as it takes up the track towards the centre of Kenilworth. The traffic pattern is more concentrated over the centre of Kenilworth. By the time departures pass Meer End, the displacement to the south is approximately 1200m.<br><br>In the June sample, there are a greater number of departures in 2016 (96) compared with the 67 in 2013, so the density plot is slightly more evident towards Kenilworth. | Impact as expected. |
| Doc Ref 01<br>Doc Ref 11 | Honiley towards Hatton<br><br>BBS06-BBN13<br>BBS06-BBE13<br>BBS06-BBS13<br><br>Note: the diagrams do not show traffic | **ALL SIDs**<br><br>TF | Ditto<br><br>After passing Honiley, departures continue slightly more widespread towards Hatton due to the fact that there is a split into 3 departure routes towards WCO, COWLY and CPT.<br><br>Forecast Pattern:<br><br>See previous sections (track dispersion plots). | After passing Honiley, departures continue towards the vicinity of Hatton, although a split into 2 separate flows is apparent. The traffic pattern is concentrated and remains slightly further towards the east until after passing Wroxall where the traffic pattern follows the 2 separate flows which is | Impact as expected. |

| CAA Web Ref Procedure & AIP Chart Ref (1) | Segment / Stage / Phase of SID/ (2) | Path Terminator Employed (3) | Traffic pattern before the change and Forecast Track Keeping Performance (Dispersion or Concentration) [this is a description of what the sponsor expected the traffic pattern to be]. (4) | Qualitative description of the track-keeping of the new RNAV SID (traffic pattern) & comparison with conventional SID. (5) | CAA Assessment of whether the impact of the changes is as expected (6) |
|---|---|---|---|---|---|
| | patterns as far as the latter waypoints. | | CAA expectation: concentration. | similar to the track flown by the conventional SIDs. | |

**Table 2. BAL noted complaint locations in relation to SID waypoints,**

19. For reference we note some (but not all) complaint locations relating to complaints submitted to BAL.

| Waypoint Name | Nearest Complaint location | Flight data altitude band |
|---|---|---|
| Between DER and BBS02 | Hampton in Arden | Climbing from runway end not above 4000ft |
| BBS02 | Balsall Common (N) | Climbing from runway end not above 4000ft |
| BBS04 | Balsall Common (S) | Climbing from Runway end not above 4000ft |
| BBS06 | Baddesley Clinton | Climbing from Runway end – not above 4000ft |
| BBE09 | Kenilworth | Climbing from Runway end not above 4,000ft |
| BBE12 | NE Leamington Spa | At or above 4000ft |
| BBN13 | S/Central Leamington Spa | At or above 4000ft |
| BBE13 | Kenilworth | At or above 4000ft |
| BBS13 | Kenilworth | At or above 4000ft |

**CONCLUSIONS FROM TRACK ANALYSIS**

20. According to the CAA's report into the review of implementation of RNAV Standard Instrument Procedures at Gatwick airport: *the improved track-keeping ability of P-RNAV (now referred to as RNAV-1 SIDs) will result in less dispersal of flights across the NPR swathes. Thus the noise impact of the over-flying aircraft will affect less people. However, those who are directly beneath the flight path will experience a greater number of over-flights.* This is true too of any situation where Conventional SIDS are being replaced with RNAV such as the case with the new SIDs implemented at Birmingham international Airport.

21. The consultation document associated with this change stated that the distribution of departing traffic between the two NPRs is typically 34% northbound and 66% southbound (using runway usage data for 2011). However, it is important to note that Runway 15 is typically in use for 40% of the time (annually). The NPR's at Birmingham airport extend up to a level of 4,000ft. for southbound SIDs, at which point aircraft can be vectored away from the centre line of the NPR. The NPR swathe for Runway 15 is 2 km wide, centred around the centreline of the SID (the SID procedure).

22. Aircraft are required to follow the NPR until their requisite altitude has been achieved, unless they have been re-directed by ATC for safety reasons. Upon reaching the requisite altitude aircraft can then fly onwards to their destination.

23. An important element in the establishment of NPRs is the objective that the aircraft should adhere as closely as possible to the nominal ground track. However, using current methods there will always be a degree of dispersion around the nominal ground track of the procedure, particularly during turns.

24. From a review of the traffic samples provided we have concluded that:

(1) Whilst no specific illustrations were provided in the consultation material relating to traffic patterns expected after the change, and only a textual description was provided of the anticipated impacts of the RNAV-1 SID designs (as outlined in paragraph 18 above), given the straightforward design of the RNAV-1 SIDs which were implemented, we conclude that the traffic patterns of the post implementation departure tracks are what we would expect to see from such designs. Whilst some departures diverge away from the SID nominal track, these may be associated with either radar vectoring when above 4000ft amsl, to avoid weather, or the non-standard departures which route to the south-west towards MOSUN (the non-standard MOSUN departure procedure is not an RNAV-1 SID and was not subject to the airspace change process and did not form part of our decision) and the non-standard departure to DTY which is used by relatively few aircraft.

(2) There has been a slight shift in the southbound traffic pattern towards Hampton in Arden (approximately 200m) and a shift in the pattern as it passes Balsall Common (approximately 700-800m between Barston and Temple Balsall) which has resulted in overflight of Barston. These impacts are what the CAA would have expected from the SID designs.

(3) There has been a shift in the core eastbound track of the DTY SIDs towards the south (approximately 1200m in the vicinity of Meer End) resulting in more overflight of Kenilworth above 4000ft.

(4) The traffic patterns are slightly more concentrated than they were with the use of the conventional SID. This is what we would expect to see from RNAV-1 departure procedures using the design criteria applied to the RNAV-1 SIDs.

(5) As a result of the RNAV-1 SIDs, some people are overflown less, however, some people who were overflown before may have more overflight as a result of the slight shift in traffic patterns and impacts of concentration arising from the SID design.

(6) Some departures appear to be slightly lower. Altitude plots provided by BAL appear to show a longer period of time spent below 4001 feet initially on take-off suggesting a lower (shallower) climb profile is being adopted. Traffic remains at and below 4000ft for a longer period than is shown in the pre-implementation views; This decreased gradient was also observed through the Post Implementation Review noise analysis where changes to both the fleet mix were identified as a contributory factor and also the destinations served.

# Annex C – Track Analysis of Raw Radar Data - Assessment by the CAA IFP Regulator

## INTRODUCTION

1. As part of the Post Implementation Review (PIR) data provision requirements, the sponsor provided pre-and post-implementation track data of departures. Data supplied by BAL included track dispersion plots of departures from 0-4000ft, 4-7000ft. 0-7000ft, traffic density plots and raw radar data of Runway 15 southerly departures.

2. Due to a lack of clarity and low resolution on the original material provided, the CAA sought further diagrams. The sponsor provided a second set of data, therefore both sets of diagrams have been used during the analysis which are available on the CAA website. The raw radar data which contains samples of tracks flown by aircraft was provided in .shp file format; this was processed and imported into a Computer Aided Design (CAD) system for analysis. We expect that most interested parties will not be able to access that data but in line with our policy on transparency, the material is published on our website with the other material provided for the PIR. To illustrate the difference in presentation of this raw radar data, we have included two sample diagrams at the end of this Annex.

3. It should be noted that in addition to the Runway 15 southbound departures shown in all of the PIR data diagrams (except for the original set of track density plot diagrams where only southbound departures were shown), the sponsor also included track data for departures to the north. This data was not required under this PIR and therefore the traffic patterns to the north have not been analysed.

4. In order to determine whether the procedures were being flown correctly, the CAA Instrument Flight Procedures (IFP) Regulator examined all sets of Runway 15 southbound data. The outcome of our analysis is detailed below.

## UTILISATION AND TRACK KEEPING

5. The review of utilisation and track keeping of the SIDs was carried out by analysing the radar tracks of flights over a specified period compared to the nominal tracks of the published procedures.

6. All Runway 15 ‘2 Yankee’ departures considered in this report (CPT 2Y, WCO 2Y, DTY 2Y and COWLY 2Y) share the same initial departure profile laterally to waypoint BBS06 (the car testing track close to the location of Honiley). Aircraft departing on the above SIDs are all required to climb straight ahead to an altitude of 900ft (amsl) and continue onto waypoint BBS02 (just east of Eastcote), followed by a right turn to BBS04 (just to the east of Temple Balsall), and then a left turn to BBS06. After passing BBS06, the procedures then diverge to their respective directions to the end of the SIDs where they then join the national airways en-route structure.

The placements of waypoints BBS02, BBS04 and BBS06 is such that the residential area of Balsall Common is avoided by traffic departing from Runway 15 at Birmingham airport, however the village of Barston which is located between waypoints BBS02 and BBS 04 lies underneath the departing flight path.

7. Radar track data was provided to the CAA for all Runway 15 departures during the following periods:

| **Pre- implementation - 2013 / 2014** | **Post implementation 2016 / 2017** |
|---|---|
| | |
| 15 – 21 June 2013 | 23 – 30 June 2016 |
| 22 – 28 September 2013 | 22 – 28 September 2016 |
| 22 – 28 December 2013 | 22 – 28 December 2016 |
| 01 - 07 March 2014 | 01 – 07 March 2017 |

8. Based on the data provided, it has not been possible to categorise the tracks either by procedures flown or flights being radar vectored. However, given the straight forward nature of the designs and the uncomplicated turns in the designed procedures, any deviation from the intended track is likely due to radar vectoring when departures are above 4000ft (the Noise Preferential Route (NPR) vectoring restriction), or possibly weather avoidance. It should also be noted that it is common ATC practice to radar vector departures onto a more expeditious flight path when traffic conditions permit.

9. A total of 1875 flight tracks were found within the above data set. A total of 620 departures are excluded from this analysis as they are departures to the South West and North, both of which are outside of scope for this review. This left a sample of 1255 flights for analysis.

10. During the sample period, 12 flights (equating to less than 1% of the sample) appeared to have overflown or flew north east of Balsall Common. These are assumed to be traffic which is being radar vectored rather than following the ‘2 Yankee’ Standard Instrument Departures from Runway 15.

11. Fifty-nine flights (less than 5%) appear to have avoided Balsall Common with a slight right turn after departure. Due to trajectory and dispersion of the tracks, these tracks are not considered to be following the 2 Yankee Standard Instrument Departures from Runway 15.

12. The remaining 1181 flight tracks demonstrates that majority of the flights (94% of the sample data) appear to have consistently flown the ‘2 Yankee’ procedures up to BBS06 before either continuing on the remainder of the procedure or being vectored away from the Standard instrument departures.

13. Of these 1181 flights, radar track data shows little dispersion from the initial climb out to passing waypoints BBS02, BBS04 and BBS06, which is the expected behaviour of an RNAV SID. This represents 94% of the sample size and is a

positive indication that a large portion of flights departing from Runway 15 at Birmingham airport are utilising the ‘2 Yankee’ SID instructions. Furthermore, based on the level of dispersion up to BBS06, it appears that aircraft are complying with the designed procedure with a good level of track keeping.

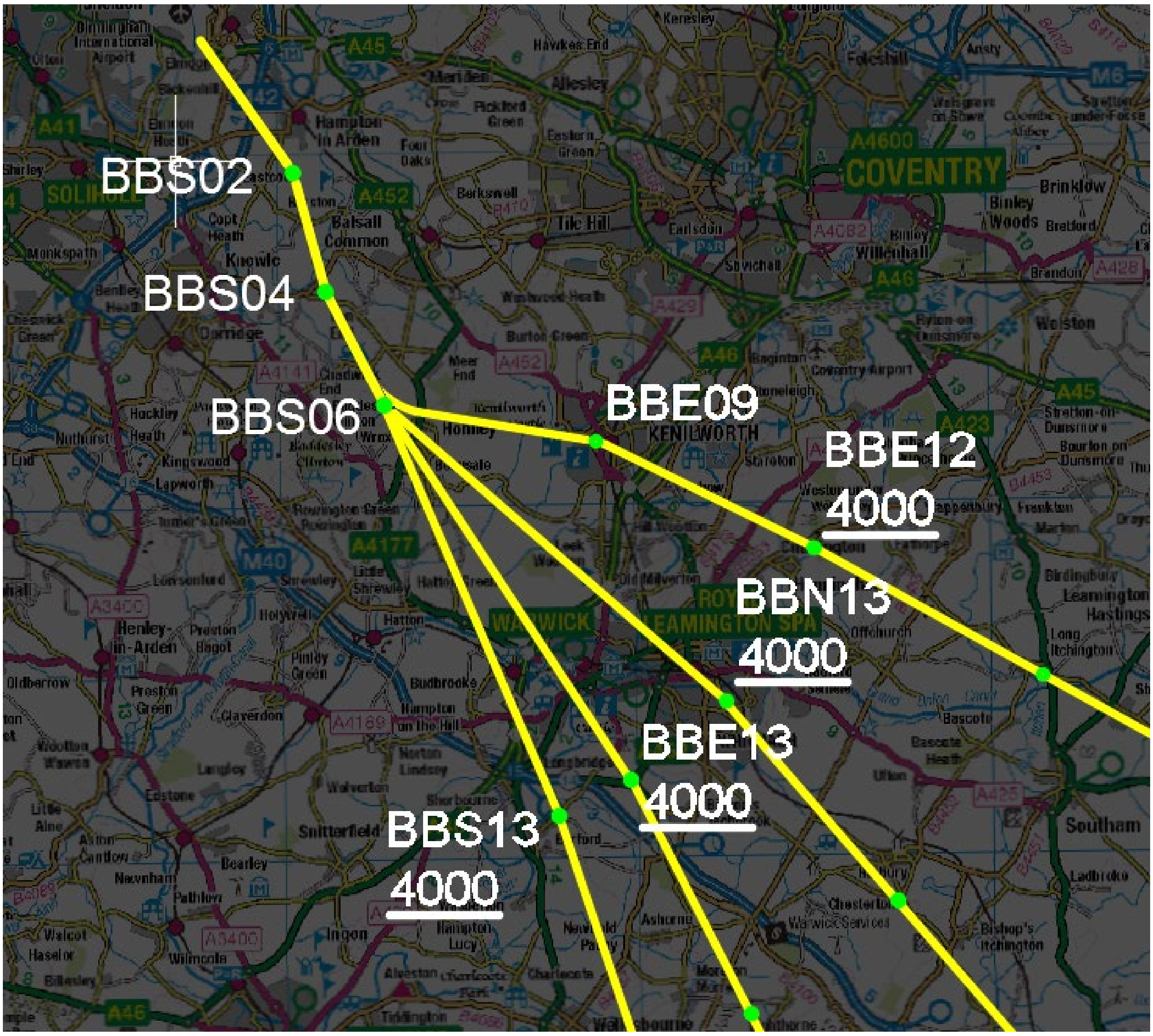
14. As departures approach waypoint BBS06, the radar tracks noticeably disperse in different directions:

- Departures following the Daventry (DTY) 2Y SID turn left before they reach BBS06 and fly towards waypoint BBE09 (Kenilworth). Before reaching the waypoint at BBE09, the DTY2Y departures would make a small turn to the next waypoint at BBE12 (just to the east of Cubbington) and after a very slight track adjustment continue to the end of the SID at Daventry. The track density plot shows an expected concentration of departures towards BBE09, although the track dispersion plots show deviation away from the intended flight path this is no doubt a result of radar vectoring. We therefore conclude that the DTY 2Y procedure is being flown as the procedure design intended.

- Departures following the Compton, Cowley and Westcott SIDs continue towards BBS06 and then after passing the waypoint, the traffic pattern splits into two noticeable tracks as shown in the track density plots. The track dispersion plots show a dispersion of departures to the south, and a number of departures are turned to the south west before BBS06 which is most likely to be traffic following a flight planned departure route towards the Bristol area for onward flight to trans-Atlantic destinations or to other locations in the south west or some western European destinations. As this is the waypoint after which the nominal tracks diverge towards the respective SID termination points, a level of dispersion is expected. However, the level of dispersion demonstrated by the sample is noticeably wider than would be expected, this is expected to be due to radar vectoring and not a function of the relative SID designs. Having taken due consideration of radar vectoring practices by ATC, we conclude that the Compton, Cowley and Westcott ‘2Y’ procedures are being flown as the procedure design intended

15. Whilst we have determined that the lateral track keeping of departures is as the procedure designs intended, from the track data provided in the up to 4000ft track dispersion diagrams and the 4000ft-7000ft diagrams, it was straight forward to determine if the vertical profile was being achieved without annotating the 4000ft waypoints onto a separate chart, and then comparing the waypoint positions with the track dispersion diagrams. The CAA therefore provides two sets of diagrams to show the location of the 4000ft waypoints (see Figs 1 and 2 below) to enable comparison of waypoints against the track dispersion plots in order to demonstrate whether the vertical profile was being achieved.

**Fig 1. CAA diagram to show 4000ft waypoints.**



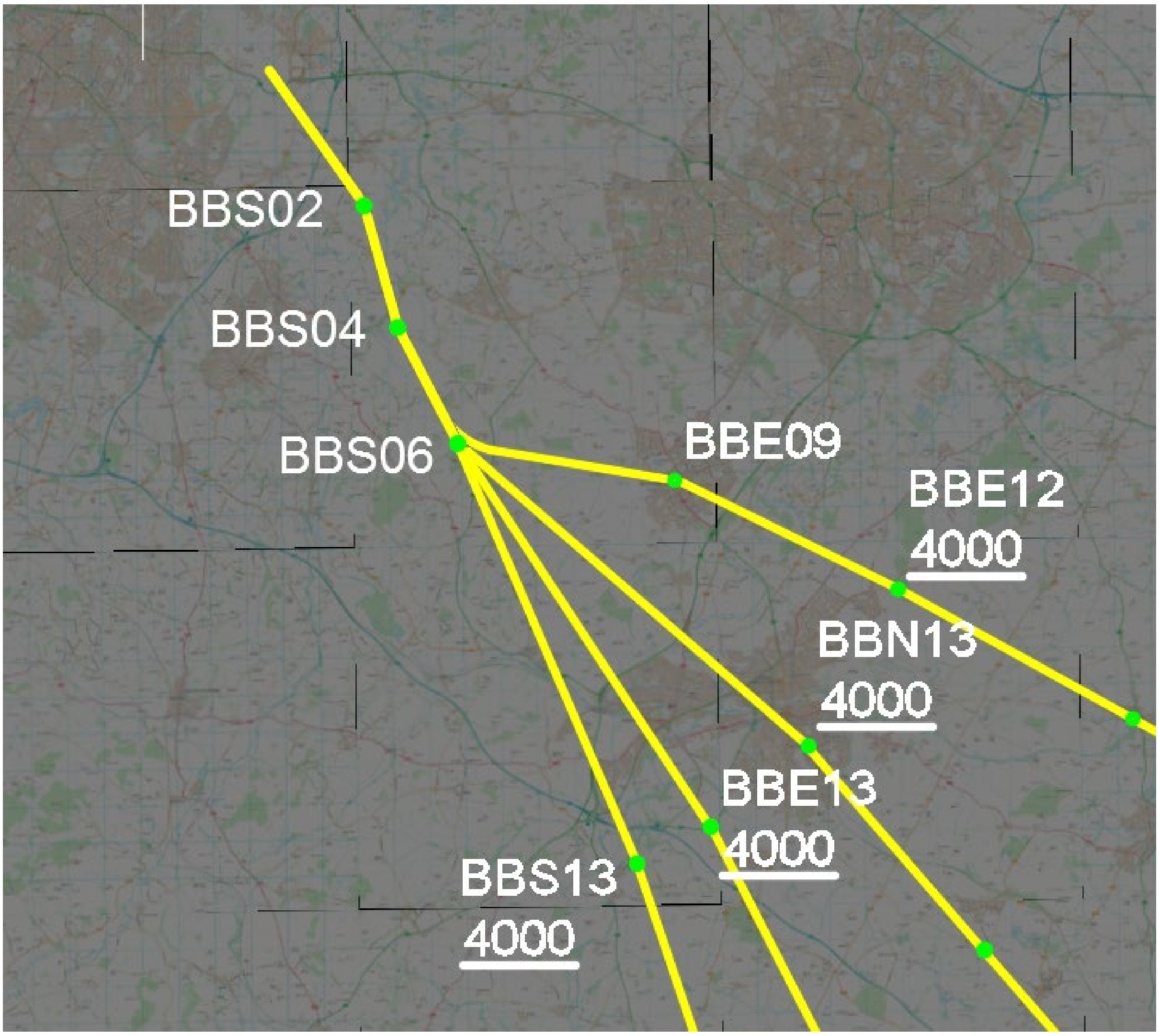

The 4000ft waypoints are located at positions BBE12 (DTY2Y), BBN13 (WCO2Y), BBE13 (COWLY2Y), and BBS13 (CPT2Y).

From the track dispersion diagrams, it can therefore be seen that departures are reaching 4000ft well before Kenilworth and before reaching BBE09. BBE12 is located 3.7NM after BBE09, therefore the designed vertical profile is being achieved.

For other departures following the WCO, COWLY and CPT '2Y' SIDs, all departures are reaching 4000ft by Wroxal which is just after position BBS06. BBN13 and BBE13 are located 6.9NM after BBS06, and BBS13 is located 6.8NM after BBS06, therefore the designed vertical profile is being achieved.

In Fig 2 below, a different expansion is shown to illustrate the same waypoint location for interested parties.

**Fig 2. CAA diagram to show 4000ft waypoints.**




However, the CAA ERCD department also conducted a gate analysis and reference to vertical profiles are therefore covered in the main body of the report in the Environmental Assessment section.

**CONCLUSION**

16. The "2 Yankee" RNAV 1 SID Standard Instrument Departures were uncomplicated RNAV 1 procedures. Having reviewed the track keeping data provided by the sponsor, it has been concluded aircraft departing from Birmingham Airport on the above departure procedures are performing as expected from an RNAV-1 Instrument Flight Procedure Design perspective. No flyability issues have been brought to the attention of the CAA IFP regulator since implementation and therefore we conclude that the RNAV 1 SIDs have been flown correctly by operators. From an operational point of view, no design modifications are required.

**Fig 3. Diagram of raw radar data for Birmingham Runway 15 RNAV-1 departures post implementation – all departures (periods as per paragraph 7 of Annex C)**

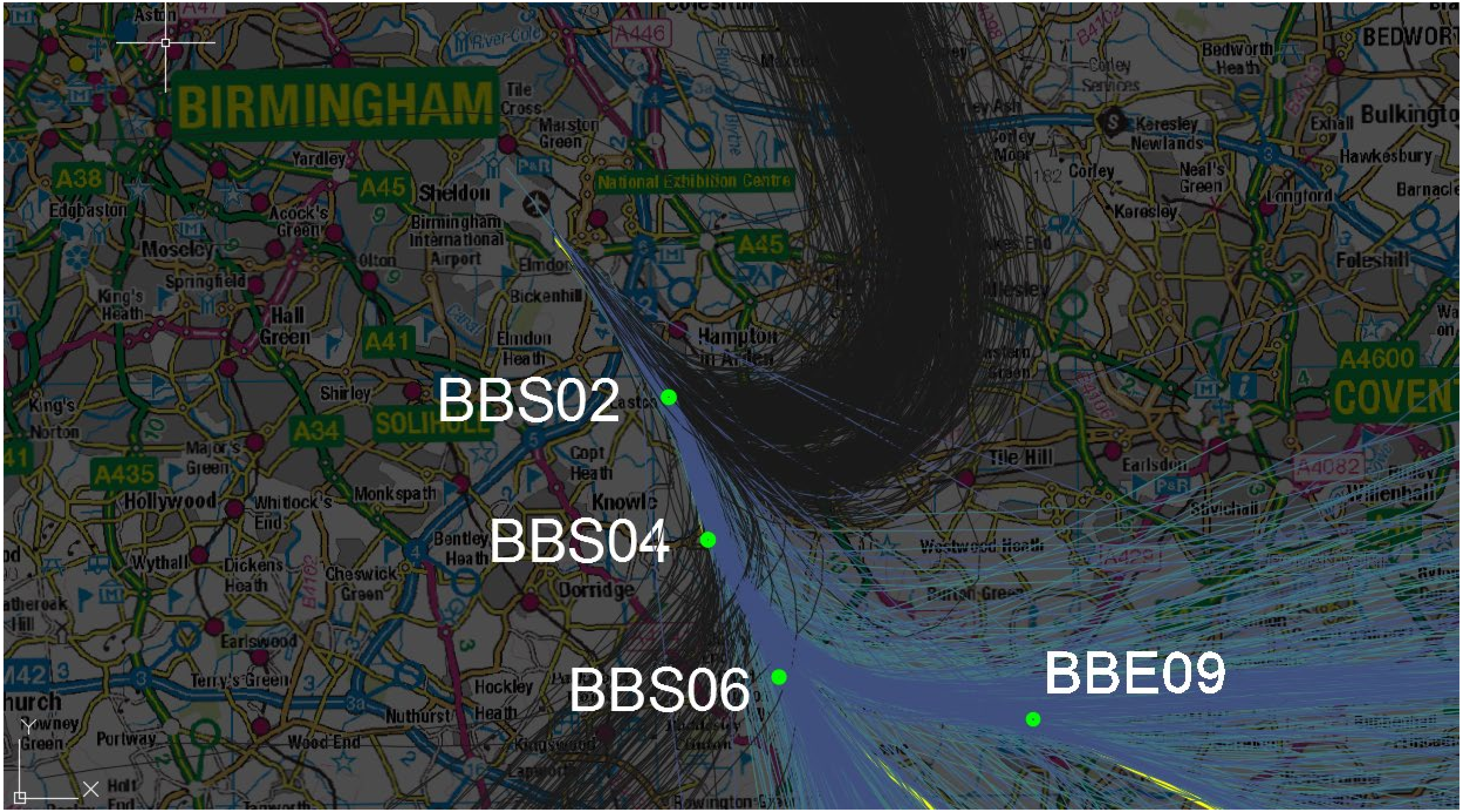


**Fig 4. Diagram of raw radar data for Birmingham Runway 15 RNAV-1 departures post implementation – all departures (periods as per paragraph 7 of Annex C) with northerly and south west departures removed.**

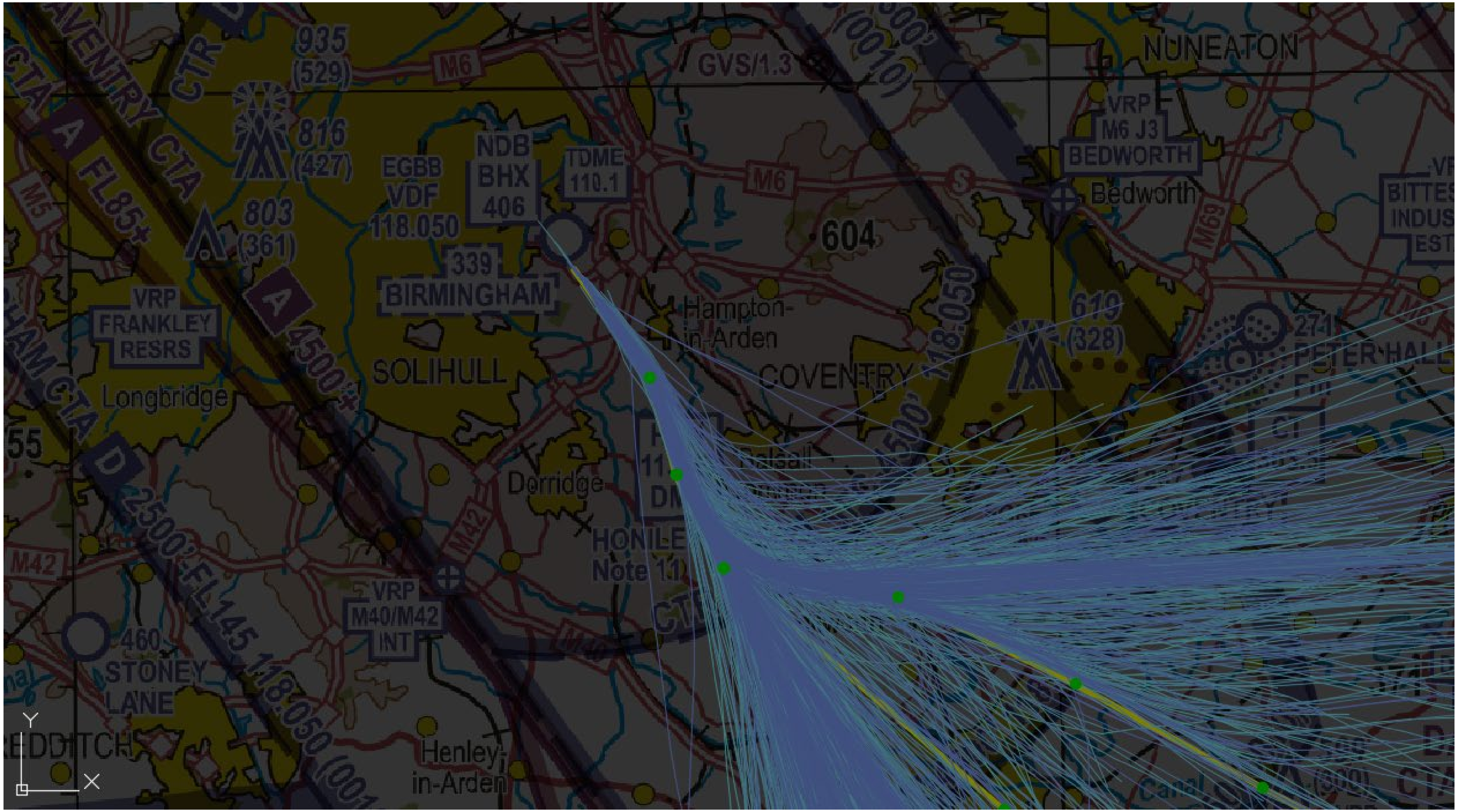


**Fig 5. Diagram of raw radar data for Birmingham Runway 15 RNAV-1 departures post implementation – all departures (periods as per paragraph 7 of Annex C) with northerly and south west departures removed.**
**Note: The track data has been transposed onto OS background by the CAA to assist with interpretation.**