

Annex C. London Luton Airport Runway 26 Brookmans Park RNAV-1 SID Track Analysis Review.

INTRODUCTION

1. Before reading this analysis of the data provided, it is recommended that readers first read the London Luton Airport Consultation document and the London Luton Airport Airspace Change Proposal (ACP).
2. To enable the CAA to conduct the PIR analysis, the change sponsor provided traffic pattern plots for a number of periods before and after implementation. The initial implementation was in 2015, however, due to flyability issues with some Boeing aircraft, the SID design had a minor modification which was then implemented in February 2017. Therefore, to enable the PIR analysis to consider the impacts of the modification the PIR data collection period was extended to September 2017.
3. The CAA's focus has been to analyse traffic patterns after February 2017 which were flown after the minor modification; however, the CAA has also analysed one set of traffic pattern data from the 2016 traffic samples so that interested parties can see the impacts that were evident with the initial implementation. The pre-implementation airspace designs are referred to as 'Conventional SID' and the post-implementation designs as 'RNAV-1 SID'.
4. The CAA believes that the sample of traffic patterns are consistent with the traffic patterns throughout the year, where seasonal variations with stronger winds and higher temperatures may result in some variations in certain phases of the departures procedure; for example, stronger winds from the north west may result in aircraft having a higher ground speed around the turn at Hemel Hempstead, and therefore turns could be wider; conversely, strong south westerly winds may result in aircraft flying the turn at Hemel Hempstead a lot tighter which could mean departures are slightly closer to Flamstead and Redbourn.
5. Whilst all data provided by London Luton Airport Operations Limited (LLAOL) for the PIR is available on the [CAA Website](#), the following data samples have been used within this review:
 - (1) Track dispersion plots July 2015 Conventional SID vs July 2016 RNAV-1 SID - track dispersion plots for departures in altitude bands in 1000ft intervals up to 7000ft.
 - (2) Track dispersion plots August 2014 Conventional SID vs March 2017 and August 2017 RNAV-1 SID.
 - (3) Track density plots August 2014 Conventional SID vs March 2017 and August 2017 RNAV-1 SID.
 - (4) Track dispersion plots July 2015 Conventional SID vs August 2017 RNAV-1 SID - track dispersion plots for departures in altitude bands in 1000ft intervals up to 7000ft.

- (5) Track Density diagrams for Runway 26 Conventional and RNAV-1 SIDs via Brookmans Park.
- (6) Track dispersion plots for Runway 26 Conventional and RNAV-1 SIDs via Brookmans Park.
- (7) Daily track plots during February, March and April 2017 only.
- (8) Monthly track dispersion plots by aircraft type.
- (9) Monthly track dispersion plots by airline.

It should be noted that for comparison purposes, we have combined relative traffic samples into single PDF documents and re-sequenced some slides to enable direct electronic comparison using the Adobe toolset for interested parties which have this capability.

ABBREVIATIONS/TERMINOLOGY

- 7. In this review, 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 and abbreviations:

amsl

Above mean sea level

AIP Chart

These AIP charts are the UK Aeronautical Information Publication SID procedures for the runway 26 SIDs via Brookmans Park.

DER

Departure End of Runway. For aeroplanes the SID begins at the DER, which is the end of the area declared suitable for take-off, in the case of Luton the Take-off Distance Available (TODA End) is a declared position off the end of the physical runway.

FMS

Flight Management System

IFPs

Instrument Flight Procedures

Navaid

Navigation aid

NM

Nautical mile. Equivalent to 1.852 km.

NPR

A Noise Preferential Route (NPR) is a path for aircraft to take until they reach a specific release altitude. Once an aircraft reaches the NPR release altitude, Air Traffic Control (ATC) can instruct the aircraft to turn onto a more direct heading to its destination, this is called vectoring, which, may take the aircraft outside the NPR corridor (normally defined as a swathe for track keeping monitoring purposes). There may be occasions where it is necessary for safety reasons (e.g. to avoid severe weather conditions) for ATC to vector aircraft off NPRs below the release altitude.

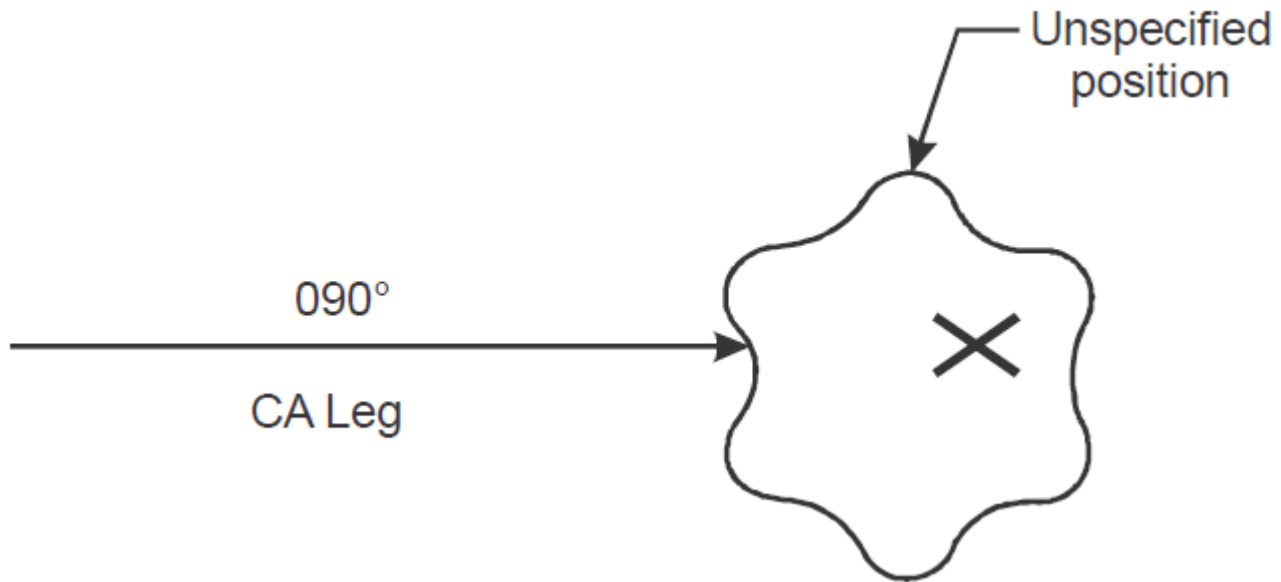
As part of this ACP and new narrower 2 km NPR was established around the RNAV-1 SID. For this NPR, the release altitude was increased from 3,000ft to 4,000ft and an ATC procedure was implemented that restricted vectoring until aircraft crossed the railway line between St Albans and Harpenden (unless deviation was required for safety reasons such as bad weather or to keep clear of other traffic).

Path Terminator

A 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 Luton departure Instrument Flight Procedures (IFPs) are course to altitude (CA), direct to fix (DF) and track to fix (TF).

Course to Altitude (CA)

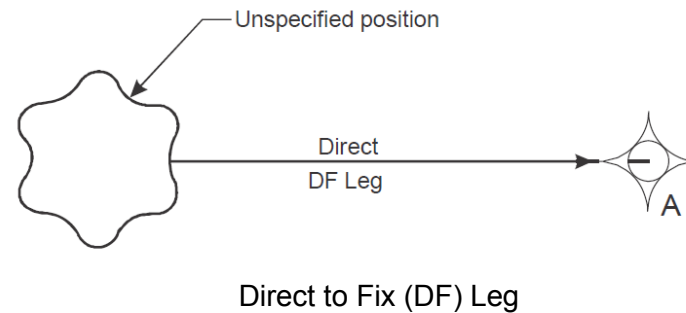
A CA is used to define the course of an outbound route segment that terminates at an altitude with an unspecified position.



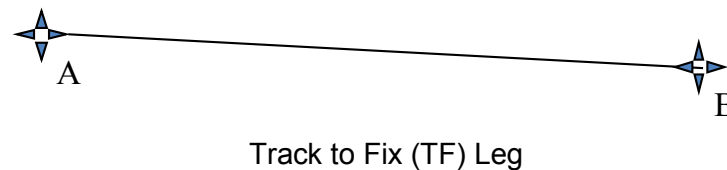
Course to an altitude (CA) leg.

Direct to a Fix (DF)

A DF leg defines an unspecified track starting from an undefined position to a defined fix. It is used to define a route segment from an unspecified position on the aircraft's present track to a specified fix or waypoint. A DF path terminator does not provide a predictable, repeatable flight path, therefore, it is effective in dispersing the flight tracks over the widest area. When a DF is used it ensures that the shortest track distance is flown from the unspecified position to the fix or waypoint.

**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 navigational aid (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.



Area Navigation (RNAV)

Area navigation is a method of navigation which permits aircraft operation on a desired flight path without constraints of ground-based navigation aids. Area navigation is an enabler for Performance-based navigation (PBN), which is defined as a type of area navigation (RNAV) in which the navigation performance requirements are prescribed in navigation specifications.

RNAV-1

RNAV-1 is a navigation specification, which is defined as a set of aircraft and aircrew requirements needed to support PBN operations on the Luton SIDs. This navigation specification requires a minimum lateral track accuracy of +/- 1nm for 95% of the time.

Runway extended centreline

The runway extended centreline is an imaginary line that continues (extends) from the physical centreline of the runway

Standard Instrument Departure (SID)

A SID is as a designated instrument departure route linking an aerodrome, or a specified runway at an aerodrome, with a specified significant point, normally on a designated ATS route.

SID Nominal Track (NT)

The SID nominal track is the intended track to be flown when adhering to the speeds as shown on the procedure chart. 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.

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 sensitive areas.

Track Dispersion

Is where the flight tracks over the ground of a procedure are varied due to the use of path terminator, differing aircraft types, standard operating procedures (SOPs) used by aircraft operators and wind conditions. Track dispersion typically spreads the noise over a wider area.

Vectoring

There may be occasions where it is necessary for ATC to vector aircraft off NPRs and onto a more direct heading. Typically, departures that are vectored by ATC tend to be dictated by the need to integrate Luton departures with other traffic.

WP Flyby (FB)

Waypoint flyby means that the aircraft will anticipate the turn before the waypoint to allow tangential interception of the next segment of the procedure. The faster the aircraft is travelling towards the FB WP, the further the aircraft will be from the FB WP before it commences the turn. Conversely, the slower the aircraft is travelling towards the FB WP, the closer the aircraft will be to the WP before it commences the turn.

WP Flyover (FO)

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

GUIDE TO INTERPRETING TRACK DISPERSION AND DENSITY DIAGRAMS

8. Attached to this document (via Links) are the track dispersion and density plots which have been provided by LLAOL. These are similar to and include diagrams which are identical to those shown in the LLAOL consultation document except that the technical production methodology has been upgraded, so there may be different colour tints to the diagrams in PIR data. The before and after implementation track diagrams are in the same PDF documents to facilitate ease of comparison.
9. Where relevant, the track analysis review is described using references to locations shown on the diagrams.

Track Dispersion Diagrams

10. The track dispersion diagrams portray aircraft ground tracks on a map. 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 useful for determining the density/concentration of tracks.

Track Density Diagrams

11. 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. 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.

GUIDE TO READING THE CAA REVIEW OF TRACK ANALYSIS

SID TRACK PLOTS

12. Tables 1-4 show the CAA's Runway 26 Brookmans Park RNAV-1 SID Track Analysis Review. For analysis purposes, we have divided the track dispersion analysis into a number of segments; this is shown in Column 2. In Tables 1 and 4, where altitude bands are shown, we have used the altitude bands as segments for the purposes of showing comparisons of pre-implementation track plots and post - implementation track plots.
- **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 and/or location relative to the RNAV-1 waypoint;
 - **Column 3** identifies the design path terminator used in the design, where relevant;
 - **Column 4** describes the traffic pattern before the change (i.e. traffic pattern for Conventional SID) and in **blue** describes the expected traffic pattern (i.e. based on the observation from the 2014 RNAV-1 Trial);
 - **Column 5** is a qualitative description of the new RNAV-1 SID traffic pattern and a comparison with the conventional SID before the change;
 - **Column 6** is comparison of the new RNAV-1 SID vertical profile with the conventional SID vertical profile (Tables 1 and 4 only);
 - **Column 7** indicates whether the expected track pattern has been achieved; and
 - **Column 8** indicates whether the departure procedure is being flown correctly by operators as designed and whether the design is considered acceptable.

DEPARTURE PROCEDURES TRACK ANALYSIS

EXTRACTS FROM CONSULTATION DOCUMENT – DESCRIPTION OF TRAFFIC PATTERN BEFORE THE CHANGE AND EXPECTED TRAFFIC PATTERN BASED ON AN RNAV-1 TRIAL

SAMPLE FLIGHT TRACKS (SAMPLE 1) FOR CONVENTIONAL SID BEFORE THE AIRSPACE CHANGE – TRACK DISPERSION PLOT – APRIL 2014 STAKEHOLDER CONSULTATION DOCUMENT PAGE 7 FIG 2:

Departures climb straight ahead until passing 1030ft amsl (500ft above aerodrome elevation) then turn left towards the southwest. Departures form a concentrated traffic pattern along the runway extended centreline before the turn, and then a concentrated pattern centred along the NPR centreline to the M1 Junction 10 (J10).

After the M1 J10, aircraft continue along a south-westerly track on the NPR centreline and the majority fly in between Noise Monitoring Terminals NMT 02 and NMT 03.

After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans. Departures then fly a wide turn, which, takes them overhead the northern extremity of Hemel Hempstead and outside the conventional SID 3km wide NPR swathe.

After passing Hemel Hempstead, aircraft complete the turn onto an easterly track, and the majority of departures fly over the north of St Albans and Sandridge, where they then take a wide dispersed traffic pattern towards Hatfield and Welwyn Garden City.

SAMPLE FLIGHT TRACKS (SAMPLE 2) FOR CONVENTIONAL SID BEFORE THE AIRSPACE CHANGE – TRACK DENSITY PLOT - APRIL 2014 STAKEHOLDER CONSULTATION DOCUMENT PAGE 16 FIG 5:

Departures climb straight ahead until passing 1030ft amsl (500ft above aerodrome elevation) then turn left towards the southwest. Departures form a concentrated traffic pattern along the runway extended centreline before the turn, then the main core of departures form a concentrated pattern along the NPR centreline to the M1 Junction 10 (J10), but, there is also some dispersion either side of the main core of departures.

After the M1 J10, aircraft continue along a south-westerly track along the NPR centreline, forming a concentrated pattern along the NPR centreline with some dispersion either side of the main core, with the dispersed pattern extending over noise monitors NMT 02 and NMT 03.

After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans and Sandridge. Departures fly a dispersed pattern over a widespread area from over the southern extremities of Redbourn in the north to over the northern extremities of Hemel Hempstead in the south (whilst the NPR swathe is not illustrated in this diagram, the turn is such that aircraft are flying outside the conventional SID 3km wide NPR swathe – illustrated by the fact departures overfly the populated areas of northern Hemel Hempstead which lies outside the NPR swathe).

After passing Hemel Hempstead, aircraft complete the turn onto an easterly track in a wide dispersed traffic pattern, although there is a more concentrated pattern (the orange tint) forming after passing the A5183 from St Albans to Redbourn, with the main concentrated pattern flying over Sandridge then routing to Hatfield. Other tints of orange indicate strands of some concentration (difficult to determine) on the eastbound track as departures pass south of Redbourn. Either side of the main core of departures overhead Sandridge, there is a widespread pattern of departures, spread to the north of Sandridge and to the south of Sandridge (over north St Albans) which extends towards Hatfield and Welwyn Garden City.

SAMPLE FLIGHT TRACKS FROM THE RNAV-1 FLIGHT TRIAL AT 220KTS USED TO FORECAST THE IMPACT OF THE CHANGE – TRACK DENSITY PLOT - APRIL 2014 STAKEHOLDER CONSULTATION DOCUMENT PAGE 19 FIG 8:

Departures climb straight ahead until passing 1030ft amsl (500ft above aerodrome elevation) then turn left towards the southwest. Departures form a concentrated traffic pattern along the runway extended centreline before the turn, then the main core of departures form two patterns along the NPR centreline to the M1 Junction 10 (J10). The main core is concentrated along the NPR centreline; a second less dense pattern is evident over Slip End with some departures flying slightly wider than the main core of departures.

After the M1 J10, the main core of departing aircraft continue along a concentrated south-westerly track centred along the NPR centreline, although there are some departures flying slightly to the west of noise monitor NMT 02.

After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans and Sandridge. Departures fly a more concentrated traffic pattern around the turn flying between Redbourn in the north and Hemel Hempstead to the south, and thus the wide dispersion seen with the conventional SIDs is no longer apparent. Flights over Redbourn and Hemel Hempstead is less apparent in this density plot compared to the conventional traffic pattern in Fig 5.

After passing Hemel Hempstead and the M1, aircraft complete the turn onto an easterly track in a concentrated traffic pattern, which, continues towards Sandridge then routing to Hatfield. Some departures are still flying over the northern parts of St Albans, and vectoring towards the northern part of Hatfield is evident after passing the A5183, which, extends towards Welwyn Garden City.

SAMPLE FLIGHT TRACKS FROM THE RNAV-1 FLIGHT TRIAL AT 220KTS USED TO FORECAST THE IMPACT OF THE CHANGE – TRACK DISPERSION PLOT - APRIL 2014 STAKEHOLDER CONSULTATION DOCUMENT PAGE 20 FIG 9:

Departures climb straight ahead until passing 1030ft amsl (500ft above aerodrome elevation) then turn left towards the southwest. Departures form a concentrated traffic pattern along the runway extended centreline before the turn, then the main core of departures form two patterns along the NPR centreline, one towards the M1 Junction 10 (J10) and a second smaller pattern flying slightly wider than the main core of departures and over Slip End.

After the M1 J10, most aircraft continue along the NPR centreline on a south-westerly track, and some departures fly slightly to the west of noise monitor NMT 02 and fly over the eastern extremity of Markyate.

After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans and Sandridge. Departures fly a more concentrated traffic pattern around the inside (left hand side) of the NPR swathe, flying between Redbourn in the north and Hemel Hempstead to the south. There are no flights directly over Flamstead and Redbourn, and in this sample, only a single departure is apparent over the north of Hemel Hempstead.

After passing Hemel Hempstead and the M1, aircraft complete the turn onto an easterly track in a more concentrated traffic pattern, which, continues towards Sandridge then routing to Hatfield. Radar vectoring is apparent after passing the A5183 from St Albans to Redbourn, and a widespread traffic pattern is evident. Some departures are still flying over the northern parts of St Albans, and vectoring towards the northern part of Hatfield remains evident and extends towards Welwyn Garden City.

Table 1 – CAA Track Analysis of the Track Dispersion Plots July 2015 Conventional SID Vs July 2016 RNAV-1 SID - Track Dispersion Plots for Departures in Altitude Bands in 1000ft Intervals Up To 7000ft

CAA Web Ref Procedure & AIP Chart Ref	Segment / Stage / Phase of SID & Waypoint	Path Terminator Employed	Pre-implementation Conventional SID Traffic pattern [in Blue is a description of the expected traffic pattern based on the 2014 Trial]	New RNAV-1 SID traffic pattern	Comparison of the new RNAV-1 SID <u>vertical profile</u> with the pre-implementation Conventional SID	Expected traffic pattern achieved?	SID Flown As designed (Yes/No)? SID Design Acceptable/Not- Acceptable?
(Col 1)	(Col 2)	(Col 3)	(Col 4)	(Col 5)	(Col 6)	(Col 7)	(Col 8)
Conventional SID JULY 2015 (2482 departures) v RNAV-1 SID (+Conv SID) JULY 2016 (3020 departures) Notes: 1. The traffic samples only show departures routing to Brookmans Park (which is the subject of this PIR) and do not show the Compton and Olney SIDs, which, also fly a similar route as far as the A5 between Markyate and Flamstead. 2. The July 2016 sample shows RNAV-1 departures and approximately 500 conventional departures.							
Annex H	Up to 1000ft	CA up to 1030ft	Slide 3: July 2015 Departures climb straight ahead forming a concentrated traffic pattern along the runway extended centreline. Forecast pattern: Departures climb straight ahead and form a concentrated traffic pattern along the runway extended centreline before the turn.	Slide 4: July 2016 The traffic pattern is similar to the 2015 pattern before the change. For the RNAV-1 SID, departures climb straight ahead forming a concentrated traffic pattern along the runway extended centreline.	Slide 3 Vs Slide 4 Some departures are evident for a slightly longer distance in this altitude band.	Yes. The traffic pattern is generally as expected, except, some departures appear to fly a slightly longer distance in this band (i.e. climb less well).	Yes SID Design is Acceptable
Annex H	1000ft to 2000ft	CA up to 1030ft DF to GWS 01 TF to all following waypoints	Slide 5: July 2015 Departures form a concentrated traffic pattern along the runway extended centreline and follow the NPR centreline during the turn towards the M1 Junction 10 (J10).	Slide 6: July 2016 The traffic pattern is similar to the 2015 pattern before the change. Departures form a concentrated traffic	Slide 5 Vs Slide 6 Some departures are evident for a slightly longer distance in this altitude band extending beyond the M1.	The traffic pattern is generally as expected, except, some departures appear to fly a slightly longer distance in this band (i.e. climb less well).	SID not flown by all aircraft types as designed. Therefore, SID design not acceptable. Boeing aircraft experienced some flyability issues with this

CAA Web Ref Procedure & AIP Chart Ref	Segment / Stage / Phase of SID & Waypoint	Path Terminator Employed	Pre-implementation Conventional SID Traffic pattern [in Blue is a description of the expected traffic pattern based on the 2014 Trial]	New RNAV-1 SID traffic pattern	Comparison of the new RNAV-1 SID vertical profile with the pre-implementation Conventional SID	Expected traffic pattern achieved?	SID Flown As designed (Yes/No)? SID Design Acceptable/Not- Acceptable?
(Col 1)	(Col 2)	(Col 3)	(Col 4)	(Col 5)	(Col 6)	(Col 7)	(Col 8)
			Forecast Pattern: Departures are dispersed across the NPR swathe, most departures fly towards the western side and several departures on the eastern side of the NPR centreline. The main core of departures forms two patterns, one centred along the NPR centreline to the M1 J10; and a second less dense pattern (with fewer aircraft) over Slip End, with some departures flying slightly wider than the main core of departures on the western extremity of the NPR swathe.	pattern along the runway extended centreline and during the southwest turn near the M1 J10, the main core of departures starts to form two patterns. Departures are dispersed across the NPR swathe, most tracks fly towards the western side and several departures on the east side of the NPR centreline.			segment of the SID. To address these, a minor modification (change GWS01 from a FO to FB WP) was made before being validated and then implemented in the AIP in February 2017.
Annex H	2000ft to 3000ft	DF to GWS 01 (FO WP) TF to all following waypoints	Slide 7: July 2015 As before to the M1. After the M1 J10, the pattern reduces in width and as it passes the A5 between Markyate and Flamstead, the pattern starts to become concentrated along the NPR centreline.	Slide 8: July 2016 Departing traffic is more dispersed compared with the conventional SID. As before to the M1. After the M1 J10, aircraft continue along a south-westerly track along the NPR centreline.	Slide 7 Vs Slide 8 A similar profile is evident with the RNAV-1 SID.	No; some aircraft are wider during the initial turn to the southwest turn than was expected, and around NMT02, some departures fly slightly outside the NPR swathe. It should be noted that due to the 2016 sample containing samples of conventional SID	No Not acceptable As the resultant traffic pattern provided is more widespread to the west than was intended, this may be due to the GWS01 flyover waypoint. It is difficult to be certain of this at this point due to the 2016 sample

CAA Web Ref Procedure & AIP Chart Ref	Segment / Stage / Phase of SID & Waypoint	Path Terminator Employed	Pre-implementation Conventional SID Traffic pattern [in Blue is a description of the expected traffic pattern based on the 2014 Trial]	New RNAV-1 SID traffic pattern	Comparison of the new RNAV-1 SID vertical profile with the pre-implementation Conventional SID	Expected traffic pattern achieved?	SID Flown As designed (Yes/No)? SID Design Acceptable/Not- Acceptable?
(Col 1)	(Col 2)	(Col 3)	(Col 4)	(Col 5)	(Col 6)	(Col 7)	(Col 8)
			After passing the A5 between Markyate and Flamstead, departures continue straight ahead, for approximately 1km, following the NPR centreline before commencing the left turn towards St Albans and Sandridge. Some departures remain within this altitude band (i.e. below 3000ft) as they commence the left turn towards St Albans. Forecast Pattern: After the M1 J10, aircraft continue along the NPR centreline on a south-westerly track, although there are some departures flying slightly to the west of noise monitor NMT 02 and flying over the eastern extremity of Markyate. After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans and Sandridge; the traffic pattern is more concentrated around the inside (left hand side) of the NPR swathe.	The departures form a dispersed pattern across the NPR swathe, with some departures flying slightly to the west of noise monitor NMT 02 and flying over the eastern extremity of Markyate. After passing the A5 between Markyate and Flamstead, aircraft turn left towards Sandridge in a similar traffic pattern but just slightly further to the east on the inside of the NPR centreline.		departures, it is difficult to form an accurate assessment of whether the desired outcome is achieved.	containing both conventional and RNAV SID departures. Boeing aircraft experienced some flyability issues with this segment of the SID. To address these, a minor modification (change GWS01 from a FO to FB WP) was made before being validated and then implemented in the AIP in February 2017.

CAA Web Ref Procedure & AIP Chart Ref	Segment / Stage / Phase of SID & Waypoint	Path Terminator Employed	Pre-implementation Conventional SID Traffic pattern [in Blue is a description of the expected traffic pattern based on the 2014 Trial]	New RNAV-1 SID traffic pattern	Comparison of the new RNAV-1 SID vertical profile with the pre-implementation Conventional SID	Expected traffic pattern achieved?	SID Flown As designed (Yes/No)? SID Design Acceptable/Not- Acceptable?
(Col 1)	(Col 2)	(Col 3)	(Col 4)	(Col 5)	(Col 6)	(Col 7)	(Col 8)
Annex H	3000ft to 4000ft	DF to GWS 01 (FO WP) TF to all following waypoints	Slide 9: July 2015 As before to the A5. After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans and Sandridge and fly a wide dispersed turn. The dispersion covers the southern extremities of Redbourn to the northern extremities of Hemel Hempstead. On the inside of the turn, some departures are flying over Flamstead. After passing Hemel Hempstead, aircraft complete the turn onto an easterly track towards Sandridge and Hatfield. Forecast Pattern: After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans and Sandridge. Departures fly a concentrated traffic	Slide 10: July 2016 As before to the A5. After passing the A5 between Markyate and Flamstead, aircraft fly a more concentrated traffic pattern during the left turn towards Sandridge. The main core of departures routes between Redbourn and Hemel Hempstead, with a few flights over Flamstead and Redbourn. Some departures also fly over the north of Hemel Hempstead. After passing Hemel Hempstead, aircraft complete the turn onto an easterly track in a more concentrated traffic pattern, which, continues towards Sandridge and Hatfield. In this sample, three departures leave the	Slide 9 Vs Slide 10 A similar profile is evident with the RNAV-1 SID.	The traffic pattern is generally as expected, however some departures fly over the north of Hemel Hempstead which was not expected. It should be noted that due to the 2016 sample containing samples of conventional SID departures, it is difficult to form an accurate assessment of whether the desired outcome is achieved.	No, as some aircraft fly over Hemel Hempstead. Not acceptable but see Column 7. Boeing aircraft experienced some flyability issues with this segment of the SID. This caused some of these aircraft to fly closer Hemel Hempstead than expected. To address these issues, a minor modification (change GWS01 from a FO to FB WP) was made before being validated and then implemented in the AIP in February 2017.

CAA Web Ref Procedure & AIP Chart Ref	Segment / Stage / Phase of SID & Waypoint	Path Terminator Employed	Pre-implementation Conventional SID Traffic pattern [in Blue is a description of the expected traffic pattern based on the 2014 Trial]	New RNAV-1 SID traffic pattern	Comparison of the new RNAV-1 SID <u>vertical profile</u> with the pre-implementation Conventional SID	Expected traffic pattern achieved?	SID Flown As designed (Yes/No)? SID Design Acceptable/Not- Acceptable?
(Col 1)	(Col 2)	(Col 3)	(Col 4)	(Col 5)	(Col 6)	(Col 7)	(Col 8)
			pattern around the inside (left hand side) of the NPR swathe, flying between Redbourn in the north and Hemel Hempstead to the south. There are no flights directly over Flamstead and Redbourn, and in this sample, only a single departure is apparent over the north of Hemel Hempstead. After passing Hemel Hempstead, aircraft complete the turn onto an easterly track in a concentrated traffic pattern, which, continues towards Sandridge and Hatfield. After passing the A5183, radar vectoring becomes apparent from St Albans to Redbourn, and a widespread traffic pattern is evident. Some departures are still flying over the northern parts of St Albans, and vectoring remains evident towards the northern part of Hatfield, which, extends over Welwyn Garden City.	NPR swathe early and fly over Harpenden.			

CAA Web Ref Procedure & AIP Chart Ref	Segment / Stage / Phase of SID & Waypoint	Path Terminator Employed	Pre-implementation Conventional SID Traffic pattern [in Blue is a description of the expected traffic pattern based on the 2014 Trial]	New RNAV-1 SID traffic pattern	Comparison of the new RNAV-1 SID vertical profile with the pre-implementation Conventional SID	Expected traffic pattern achieved?	SID Flown As designed (Yes/No)? SID Design Acceptable/Not- Acceptable?
(Col 1)	(Col 2)	(Col 3)	(Col 4)	(Col 5)	(Col 6)	(Col 7)	(Col 8)
Annex H	4000ft to 5000ft	DF to GWS 01 (FO WP) TF to all following waypoints	Slide 11: July 2015 As before to the A5. After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans and Sandridge and fly a wide dispersed turn. The dispersion covers the southern extremities of Redbourn to the northern extremities of Hemel Hempstead. On the inside of the turn, some departures fly over Flamstead. After passing Hemel Hempstead, aircraft complete the turn onto an easterly track, in a wide dispersed traffic pattern, routeing towards St Albans and Sandridge then Hatfield and Welwyn Garden City. Widespread vectoring is apparent after passing Redbourn. Forecast Pattern: After passing the A5 between Markyate and Flamstead, aircraft turn left towards St Albans and Sandridge. Departures fly a	Slide 12: July 2016 As before to the A5. After passing the A5 between Markyate and Flamstead, aircraft fly a dispersed left turn towards Sandridge. The main core of departures fly between Redbourn and Hemel Hempstead. In addition to the main core, several departures also fly over the southern part of Redbourn and the north of Hemel Hempstead. Some aircraft fly over Flamstead and a greater number of aircraft fly over Redbourn than in the lower altitude band up to 4000ft. After passing Hemel Hempstead, aircraft complete the turn onto an easterly track and are dispersed across the NPR swathe. The dispersal is most likely due to radar vectoring by ATC.	Slide 11 Vs Slide 12 A similar profile is evident with the RNAV-1 SID.	No, as after the left turn towards Sandridge, aircraft form a dispersed pattern. It should be noted that due to the 2016 sample containing samples of conventional SID departures, it is difficult to form an accurate assessment of whether the desired outcome is achieved.	While less aircraft are seen over Redbourn as expected, the number of aircraft over Hemel Hempstead is more than expected. But it should be noted that due to the 2016 sample containing samples of conventional SID departures, it is difficult to form an accurate assessment of whether the desired outcome is achieved. Therefore, SID design is not acceptable.