ANNEX E TO PIR REPORT DATED APRIL 2017

RNAV 1 SID route design for Route 4 in strong south to south-westerly winds

This section discusses the performance of the modified RNAV 1 SID under strong south to south-westerly wind conditions when compared to the performance of the initial RNAV 1 SID. It also reports on discussions held at two Gatwick Airport Limited hosted Flight Operations Performance and Safety Committee meetings held on 25 May 2016 and 27 July of 2016 and consideration of a 190KIAS speed limited SID to counter this wind effect. Finally, this section comments on the GAL letter dated 20 December 2016 titled Conclusion of the Route 4 RNAV 1 SID Monitoring Period, where the airport discusses the 190KIAS speed limited SID option.

Background

As discussed in the original CAA Post Implementation Review CAP 1346 Annex 3, PIR Operational and Technical Report, the initial RNAV 1 SID had issues of resilience under strong southerly wind conditions. The effect of such wind conditions leads to a significant increase in groundspeed as the aircraft turn north. Although the initial RNAV 1 SID was speed constrained at 220KIAS[1], the addition of a >40 knot wind vector at between 2,000 feet and 3,000 feet led to the examples of aircraft ballooning to the north of downwind track, leading on occasions to phenomena such as waypoint bypass and even turn reversals. It was this SID behaviour that the modified RNAV 1 SID was intended to address, providing a degree of rigour in terms of aircraft performance under such strong southerly wind conditions.

The modified SID retains the 220KIAS speed constraint in the wrap-around turn, but the route construction has been simplified in order to avoid the potential of waypoint bypass. Rather than the two fly-by turns at KKW04 followed by KKN06 used in the initial SID design – see Figure 1, the modified RNAV 1 SID – see Figure 2, commences a Course to Fix (CF) turn onto the downwind track, having over flown KKW02, a waypoint located 2.0NM along the runway track from the departure end of Runway 26L. The CF path terminator leg type provides a natural dispersion of aircraft tracks, taking as it does, account of aircraft weight, speed and bank angle authority in order to compute the path steering command to complete

[1] Within the Instrument Flight Procedure (IFP) design, the 220KIAS (Knots Indicated Air Speed) constraint is designed as a maximum speed. Within the aircraft Flight Management System on a climb procedure this is interpreted as a “target speed”, as the aircraft seeks to accelerate into a clean and efficient configuration.

the turn onto the downwind track of 078 degrees before reaching the next waypoint at KKE09.

The advantage of this design construction is that there is no minimum stabilisation distance to infringe between consecutive fly-by waypoints. The stabilisation distance is the distance the aircraft Flight Management System (FMS) requires in order to ensure completion of one fly-by turn before commencement of the next. The disadvantage of the modified RNAV 1 SID design is that it is left to individual FMS and aircraft manufacturers to compute the path from the commencement of the course change through to the downwind leg capture.

Figure 1 - Initial RNAV1 SID (LAM 1X)

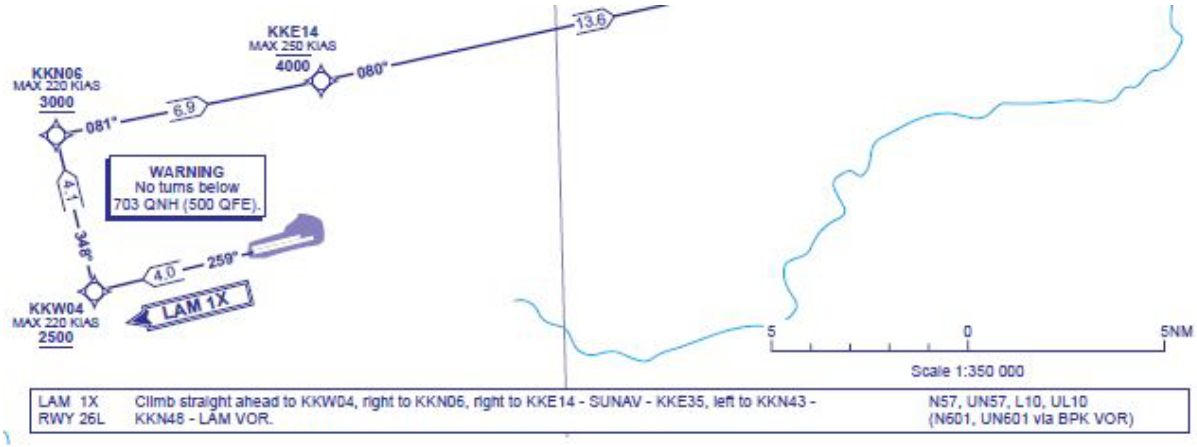
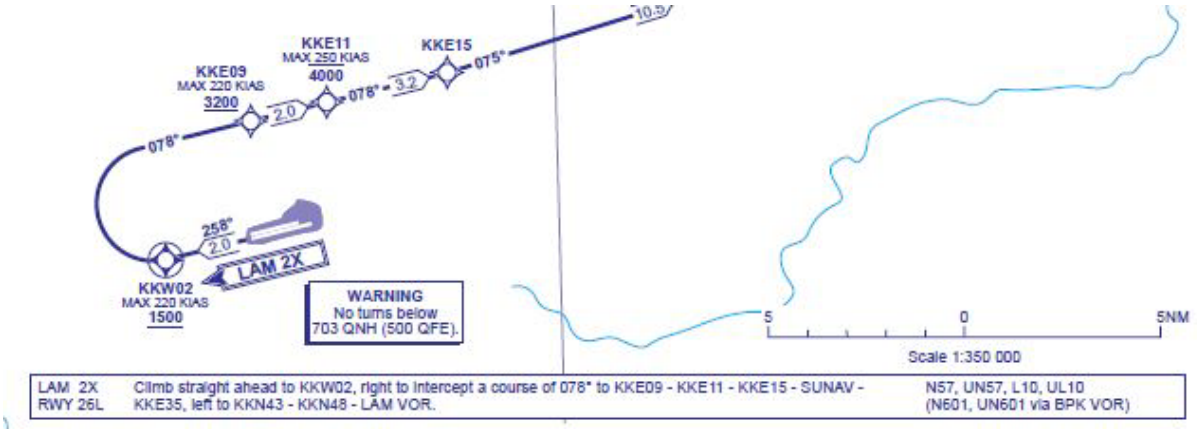


Figure 2 – Modified RNAV 1 SID (LAM 2X)



With a 220KIAS speed constraint and average wind conditions, the aircraft tracks remain spread within the Noise Preferential Route – see Figure 3. This accounts for the equipment and aircraft variability, and to a degree, the Standard Operating Procedures (SOP) applied by the Gatwick operators. However, as we've noted in Section 9, a slow speed coupled with high rate of climb as associated with certain A380 departures, can result in a very tight turn towards the capture for KKE09. And this is the difficulty with the CF path terminator, its natural dispersion can only be controlled through aircraft speed and that has to factor the effect of wind on groundspeed.

Effect of a Strong South to south-westerly wind on the LAM 2X RNAV 1 SID

A strong southerly to south westerly wind translates as a cross wind prior to KKW02 to a tailwind afterwards. Despite the 220KIAS speed constraint, aircraft ground speed can pick up an additional 20 to 30 knots and the FMS uses this to compute the required angle of bank in order to make the capture of the downwind leg. At a given point, depending on aircraft weight, speed and available bank angle authority, the bank angle limits and the aircraft will drift outside of the turn. This is evident in Figure 4.

The only option is to avoid the ground speed from becoming too high, which means that as the wind is a constant, aircraft speed has to be kept below the speed constraint in order to provide speed margin and continued bank angle authority around the turn.

It should be noted that the procedure design is not at issue, rather the speed at which aircraft undertake the wrap-around turn. The aircraft speed management is under the control of the flight crew and the Standard Operating Procedures (SOP) which they adhere to. The Course to Fix (CF) path terminator used in the modified RNAV 1 SID design is a non-deterministic path terminator i.e., the path will vary depending on the input parameters, including wind. It does provide dispersion, but this dispersion is difficult to manage when aircraft and SOPs call for maximum use of automation.

Other options could include a version of the RNAV 1 SID with a slower speed constraint or use of an alternative procedure design using a more deterministic path terminator such as the Radius to Fix (RF) which allows for greater bank-angle authority. The first option is discussed below in the response from GAL, the second option would require further study, due the inherent track concentration afforded by the RF.

Path terminators were discussed in detail in Post Implementation Review CAP 1346 Annex 3, PIR Operational and Technical Report.

Figure 3 - Aircraft Tracks relative to NPR on Modified RNAV 1 SID (LAM 2X) 25th November – 1st December 2016

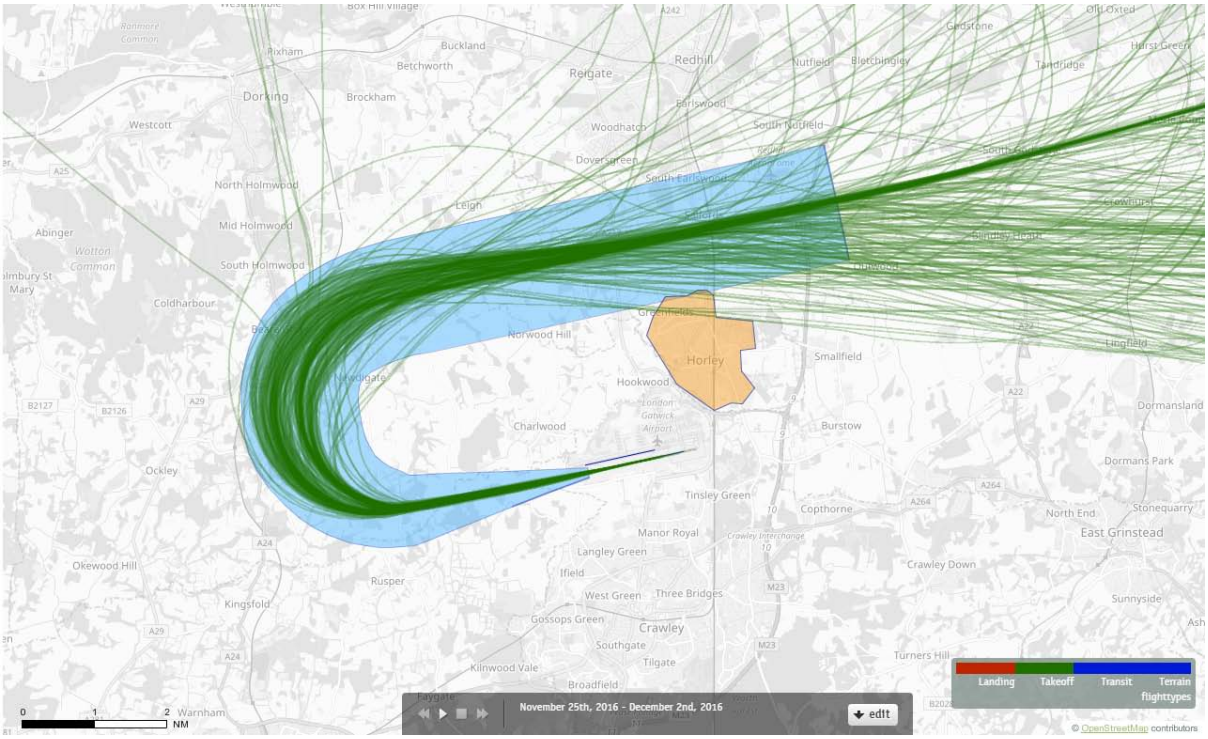
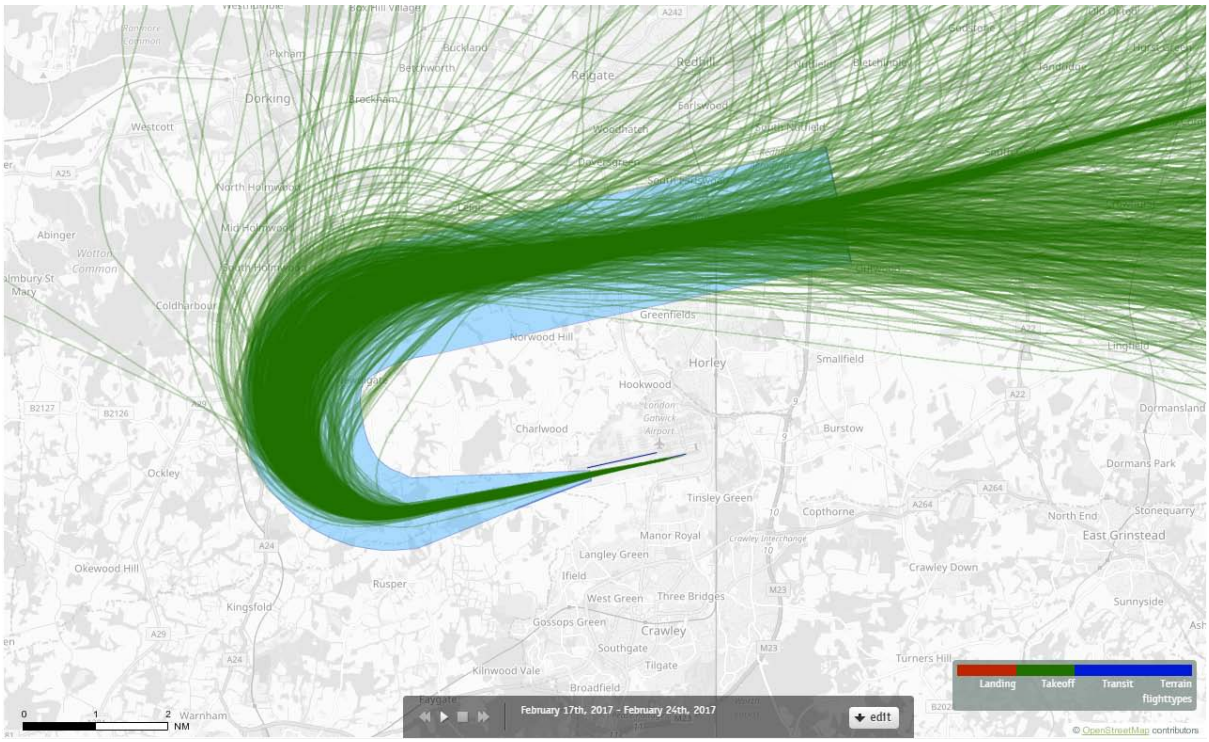


Figure 4 - Aircraft Tracks relative to NPR on Modified RNAV 1 SID (LAM 2X) 17th – 23rd February 2017, including strong southerly wind days



GAL Flight Operations Performance and Safety Committee Meetings

The CAA attended as an observer to two of the Flight Operations Performance and Safety Committee meetings chaired by the airport and with the major operators and the ATS provider amongst attendees. The following are notes taken by CAA.

Wednesday 25 May 2016

GAL mentioned the problem of the strong southerly wind effect and consideration of a 190KIAS version of the new wrap-around SID design. Initial response was not favourable, neither from the operators present or the ATS provider. Both communities expressed concerns with potential non-standard operations and catch-up and the loss of 1 minute splits affecting runway throughput. GAL requested feedback by the time of the next FLOPSC Meeting at the end of July, on the 190KIAS design concept and any other thoughts.

Wednesday 27 07.2016

CAA was expecting an update on the question of a slower (190KIAS) SID, but there was no mention of this. CAA queried this with GAL after the meeting and was advised that the option was not under active consideration with efforts turning instead to making the current procedure work.

At the meeting, an airline made an interesting comment on their NPR performance. Having received violations, the Base Captain went back into the simulator and has developed the following flight crew procedure:

On the ground he has now instructed his flight crews to set the first turn speed constraint to 190kts. Then the flight crews are encouraged to use SPD Intervene and “bug-up” i.e., increase speed in accordance with track conformance. He has even instructed his navigation data base manager to have the wraparound procedures coded at 190kts. The effect of this policy is that if forces LNAV to turn at the tightest angle of bank. The problem with the CF leg is that on some FMS systems it can be quite lazy and will not use all of the available bank-angle authority. As the groundspeed changes and the re-computation requires more bank angle, the aircraft is playing catch-up.

Extract from Letter from GAL dated 20 December 2016, Conclusion of the Route 4 RNAV 1 SID Monitoring Period

The follow is an extract from the GAL letter, detailing their position on the strong southerly wind effects.

As part of the process to ensure sufficient operational compliance GAL initially considered whether an alternate RNAV 11 SID design option should be included to be used in strong south-westerly wind conditions. It transpired through discussions with operators that the windy day option would require the aircraft to be configured in such a way (i.e., extended flaps and increased thrust) that it would likely result in increased noise thus negating any perceived benefit from improved track keeping especially as the existing levels of compliance are relatively high (i.e., circa 94% over the monitoring period). Moreover given the added complexity of activating a 'windy day' SID we do not consider that this option would add significantly to the operational performance on this route. Therefore, unless there is a requirement, our intention is to withdraw this proposal.

GAL has, and continues to, engage directly with some operators to aid compliance including to help shape airline standard procedures but also in the case of one airline to support simulator fly-ability checks.

Summary

We note the work undertaken by GAL and the outcome of discussions with both their ATS provider and the operators. The CAA recognises the difficulty in designing a departure procedure that provides dispersion (non-deterministic path) but yet is susceptible to wind effects such as the strong southerly wind. The primary objective from having a modified RNAV 1 SID design was to ensure that the procedure did not "break" under those strong wind conditions i.e., waypoint bypass or turn reversals. In this respect, the modified RNAV 1 SID is more robust. The CAA is concerned by the degree of deviation to the north of the NPR, especially with respect to Gatwick to Heathrow positioning flight departures, but again recognises that it is a very small proportion of the flights operating on the LAM 2X. Our belief is that NPR compliance under strong southerly wind conditions can best be controlled through flight crew SOP and recognition of the need to monitor and adjust speed in accordance with track conformance. Any future studies might also investigate the use of the Radius to Fix (RF), in particular as London Gatwick is one of the UK airports included within the scope of Implementing Regulation (EU) 716/2014 - Pilot Common Project Supporting the Implementation of the EATM Master Plan. The Pilot Common Project (PCP) requires the Gatwick to implement RNP 1 and RF procedures from 01 January 2024.