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ANNEX A - RUNWAY 05 CONCEPT OF OPERATIONS

Glasgow Airport Standard Instrument Departures

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A. INTRODUCTION

An array of Standard Instrument Departures (SIDs) have been designed for each runway with the expectation that each SID serves a specific purpose in terms of the operator's intended destination, the aircraft type and its performance. Additionally, the SIDs have been designed to be used at specific times to provide respite at night whilst enhancing capacity during the day. This Annex to the Consultation Document provides an explanation of the concept of operations for aircraft departing Runway 05. Having described how the SIDs work as an array, each will be described in isolation focusing on any potential impact to the environment. The figures used in this annex in relation to the proportion of traffic using the existing and proposed departure procedures have been derived from 2016 data as there was a full years' worth of data. We have calculated growth in the region of 3% for the year 2017.

A.1. Overview

A.1.1. There are nine SIDs in the existing conventional departure array off Runway 05:

- CLYDE (Trans-Atlantic and the islands);
- ROBBO (Westbound departures);
- NORBO (Southbound Jet departures);
- TURNBERRY (South-Westbound Non-Jet departures);
- LOMON (North-Westbound traffic);
- FOYLE (Northbound traffic);
- PERTH (North-Eastbound traffic);
- TALLA (East South-Eastbound Traffic); and
- LUSIV (South-Eastbound Non-Jet departures).

A.1.2. The conventional array has developed over time and is overly complex. It will be impossible to fly them by conventional means once the VOR has been withdrawn. Furthermore, the SIDs no longer meet the needs of many of our airline customers and, as a result, they are not being fully flown with aircraft turning earlier upon satisfying the Noise Abatement Procedures. ATC can re-route aircraft tactically onto more expeditious routings against other traffic within the airspace. The swathes that resulted from a combination of the limitations of conventional navigation technology and the lack of track adherence (brought about by ATC instructions) are clearly shown by the NTK plots in Figure 1 below affecting a very large part of the region.

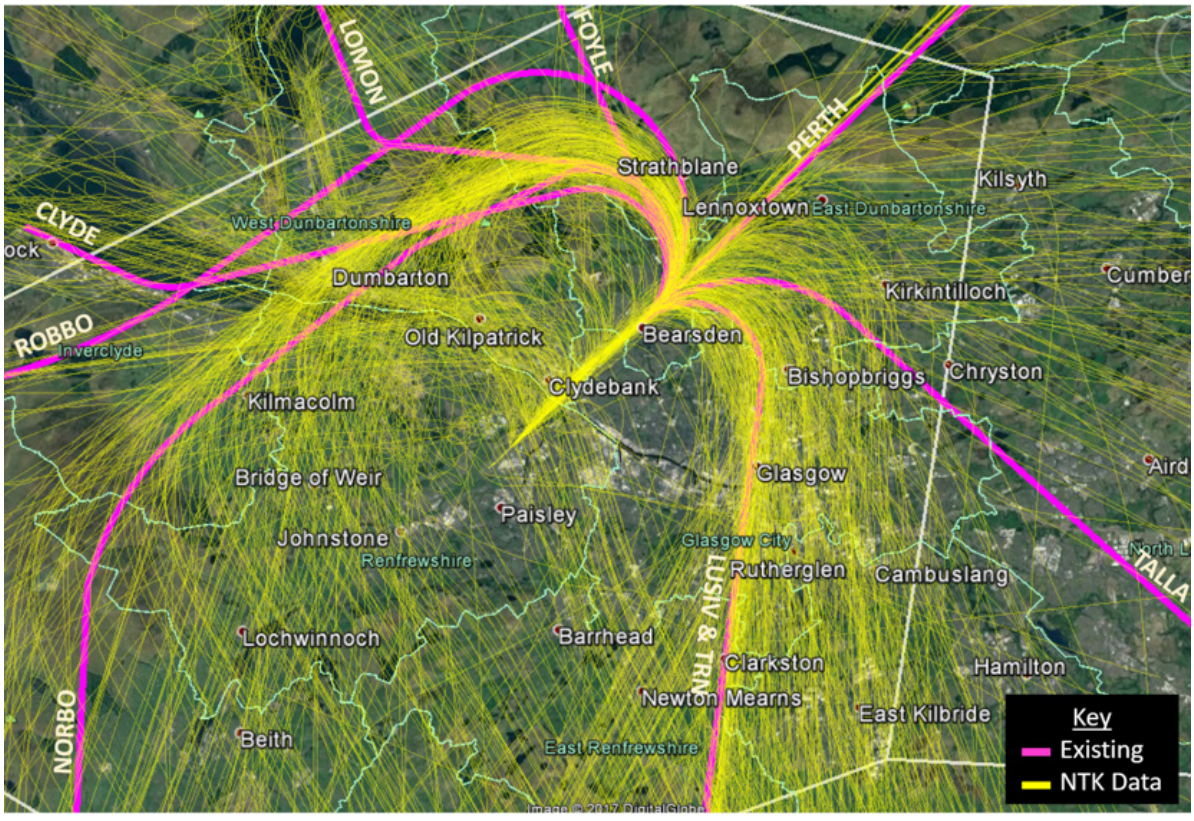

Figure 1: NTK evidence from 1-7 May 2017 Sample vs Existing Runway 05 SIDs

A.1.3. It was considered that realistically there were only three available options; Do Nothing, Replicate or Redesign:

- **Do Nothing** – this option is simply not available because the navigational aid that the current procedures rely upon is being withdrawn.
- **Replicate** – although on face-value this may seem the obvious choice, it is not always possible to replicate conventional procedures accurately owing to the differing parameters involved in the design and approval of RNAV procedures. Furthermore, as there was an opportunity for improvements to be made both operationally and environmentally; why would we not want to do that? The existing array can be rationalised to reduce its complexity and, as stated already, these SIDs are not aligned with our customers' needs meaning that any replication exercise would simply result in a replication of today's issues.
- **Redesign** – this option is considered the most favourable as there is an opportunity to deliver significant environmental and operational benefits from the complete redesign of the array.

A.1.4 As can be seen in **Figure 1**, much of the traffic departing Glasgow Airport (over 80%) requires a southbound SID. For this reason, a minimum of two southbound SIDs are required to split the traffic in a manner that allows aircraft to depart as safely and expeditiously as possible from the runway. Owing to the prevailing winds affecting the region, Runway 05 is only in use around 22% of the time for departures (and arrivals).

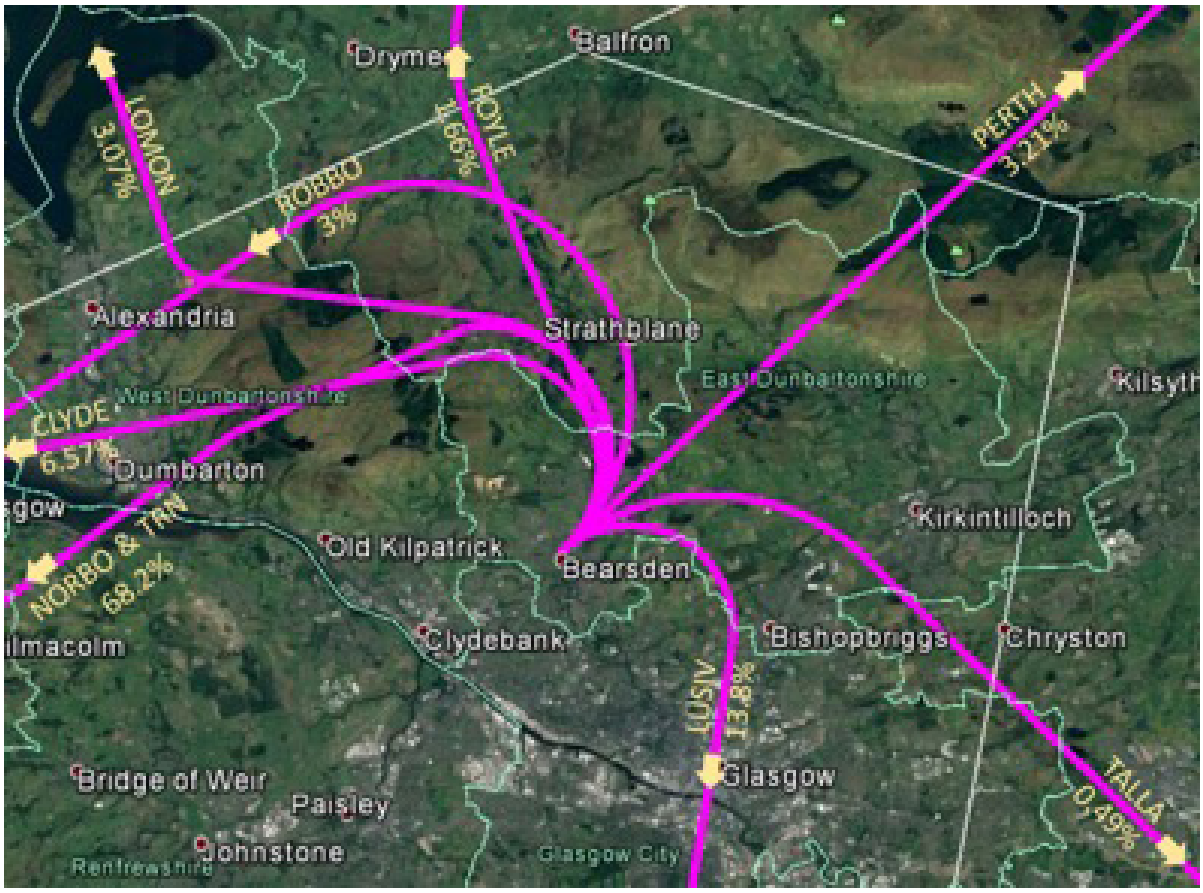

Figure 2: Existing SID Usage from Runway 05

A.1.5. **Figure 2** shows the percentage usage of the existing Runway 05 SIDs when in operation from 2016 data.

A.1.6. **Figure 3** overleaf shows the proposed array overlaid on the existing array of Runway 05 departures. All the departure procedures are contained within the controlled airspace delegated[1] to Glasgow Airport. The proposed departures are fewer in number, as it is important to simplify and consolidate the array. The SIDs are also shorter, as they are truncated to the point at which aircraft would reach 6,000 feet above mean sea level (amsl) (see para 3.11.6 of the main Consultation Document for an explanation of altitude) and are designed to route towards where aircraft operators wish to go (within ATM System requirements) whilst

[1] Glasgow Airport does not own the airspace, it is delegated to the Airport by the CAA and the Airport acts as a custodian of this airspace.

considering the communities that may be affected. Truncating the procedure back to point at which aircraft reach 6,000 feet (as opposed to an arbitrary point further along the route) reduces the fuel that airlines need to carry as they do not need to plan for having to stop their climb at a lower level where fuel burn is comparatively greater.

A.1.7. The blue lines below depict the procedures up to the point that they reach 6,000 feet. Aircraft have different performance characteristics and therefore climb at different rates. The SIDs have been designed using a climb gradient that is achievable by most aircraft that would wish to use them but some will outperform the climb requirements and reach 6,000 feet early. In all likelihood, they will be given further climb instructions from ATC and be well above 6,000 feet by the end of the blue lines as depicted.

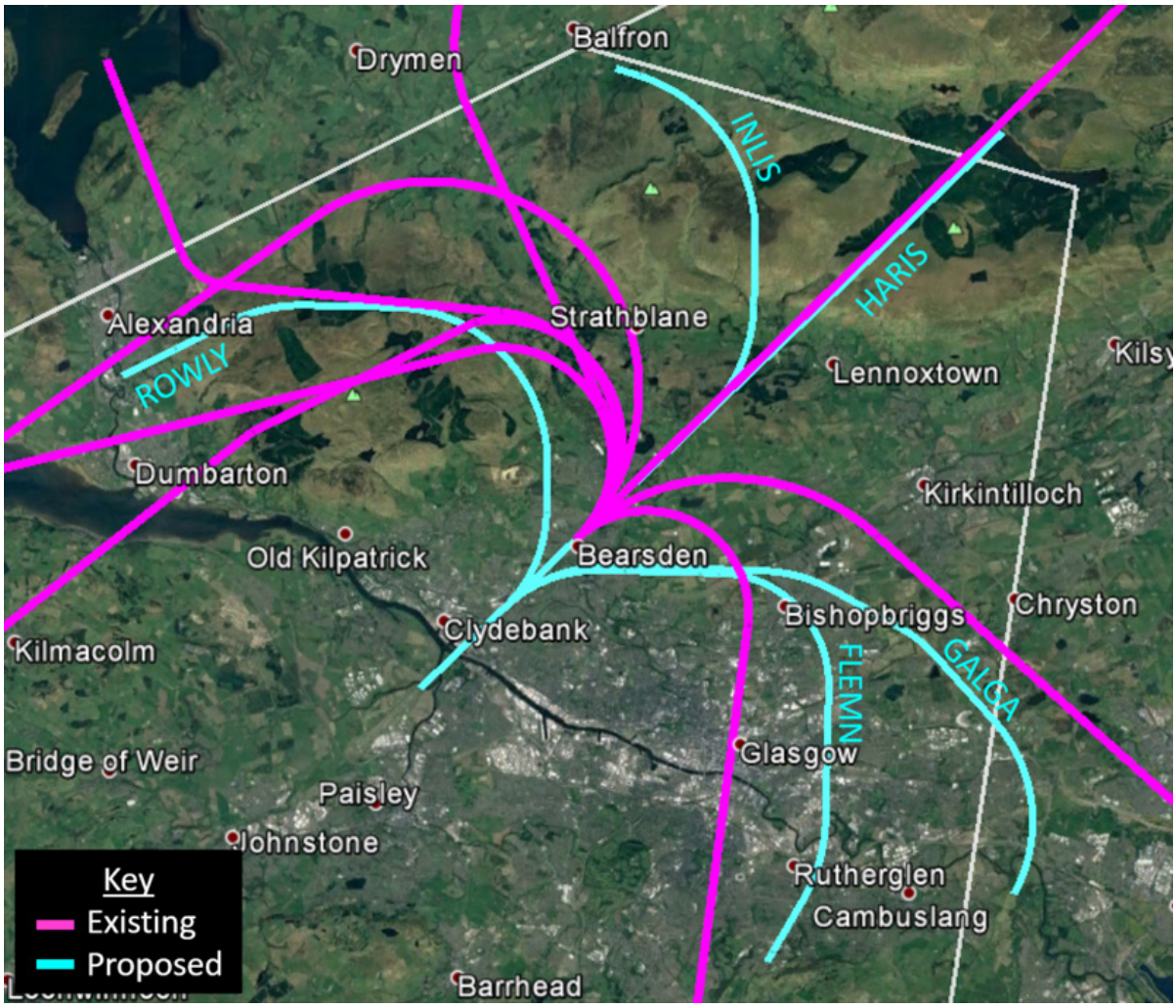

Figure 3: Runway 05 Existing vs Proposed Departure Array

Image © 2017 Google

A.1.8. As the proposed procedures are designed to RNAV-1 standard, with optimum routing in mind, the expected track adherence is expected to be very close to that depicted. Even once the proposed NAP of passing 4,000 feet has been satisfied, there should be little need to deviate from the tracks as shown.

A.1.9. The airlines, aircraft operators, the ATM and Environmental communities have participated in the iterative and evolving development of these proposals through a series of Focus Groups and we believe that we have reached an optimum solution of balancing a variety of needs.

A.1.10. The link routes (the means of getting from the end of the SID to the Route Network or Airways) beyond the end of the SIDs are beyond the control of the Airport as the aircraft are under the control of PC. Despite the SIDs terminating at 6,000 feet, the DfT and the CAA require that we consult on the changes up to 7,000 feet in keeping with the Government's Altitude Based Priorities[2] (see para 2.8.5 of the main Consultation Document). For this reason, we have tried to depict a cone of where aircraft are likely to go within 1,000 feet of the end of the SID as shown in Figure 4 below. This is further explained within the paragraphs specific to each SID.

A.2. Concept of Operations

A.2.1. The primary issue that the new array needs to address is to adequately split the southbound traffic evenly during the peak periods of the day to enable an efficient flow that reduces delays on the ground. The southbound SIDs need to be adequately separated to reduce the time separation between departures to the most expeditious possible whilst maintaining a safe operation within regulations. The combination of limited airspace availability, design regulations and the presence of other procedures limits the options available to us. Despite efforts to fit in two southbound SIDs that could be used simultaneously, there was insufficient room. Consequently, the two right

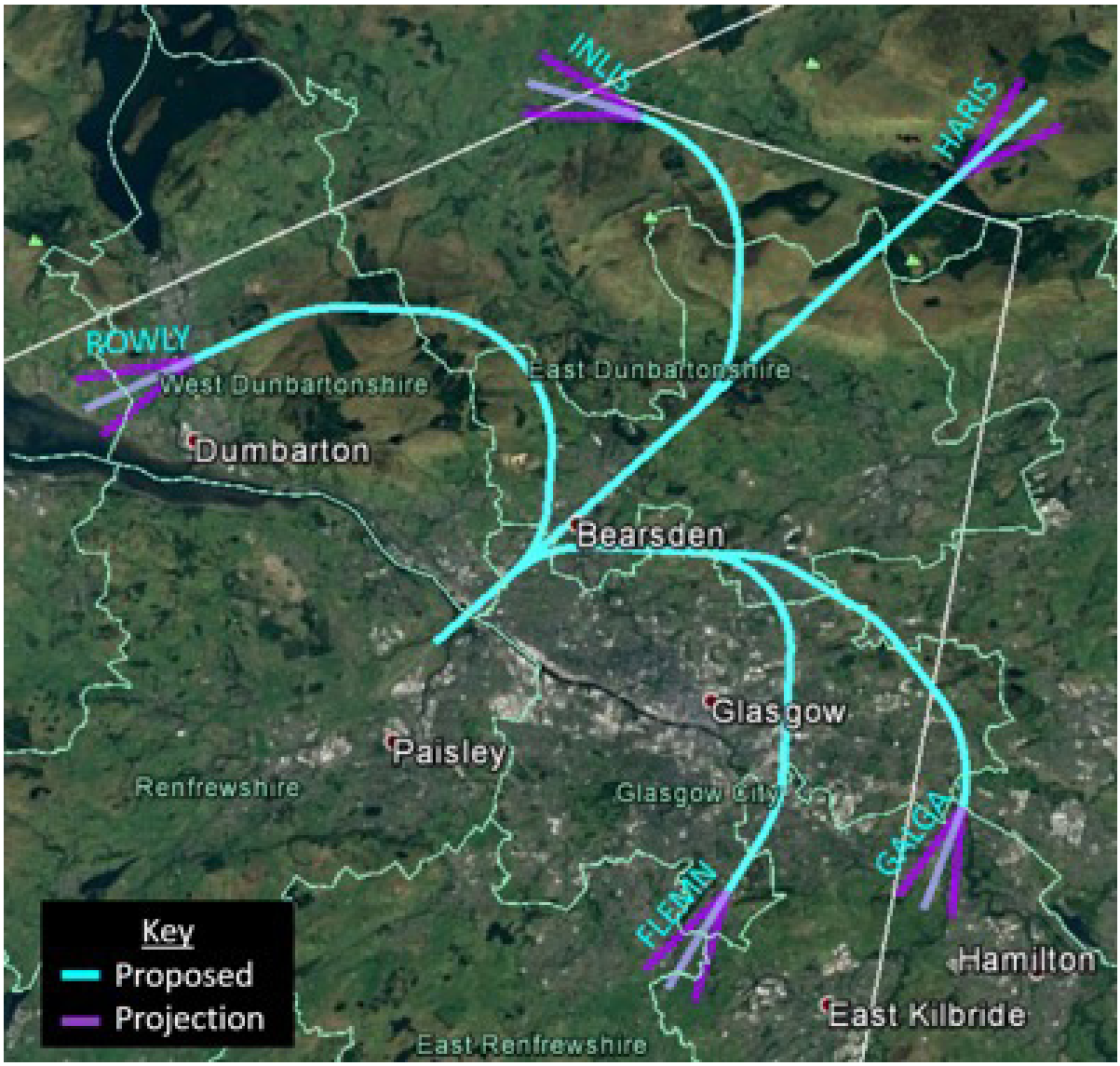

Figure 4: Runway 05 Proposed Departure Array extended to 7,000 feet

[2] For more detail on the Altitude Based Priorities, see the Department for Transport Air Navigation Guidance document at the following link: www.gov.uk/government/uploads/system/uploads/attachment_data/file/653978/air-navigation-guidance-2017.pdf

turns presented above are for use at different times of day and will not be used in tandem. This does however provide us the opportunity to deliver respite to certain communities, i.e. planned periods of noise relief. The other proposed southbound route (ROWLY) turns left as the existing NORBO SID does but does not go as far to the west as NORBO does.

A.2.2. Priority has been given throughout the process to limit the environmental impact of the procedures (in terms of noise) through avoiding communities where possible. The SIDs are in most cases shorter and more direct, resulting in reduced fuel burn and CO_2 emissions.

A.2.3. An analysis was undertaken to establish the existing SID usage in terms of destination, route, aircraft propulsion type (jet/non-jet) and time. This analysis enabled us to look at ways to achieve as close to a 50/50 split on southbound traffic volume on the southbound SIDs as possible.

A.2.4. Further south, the aircraft have been routing via either SUBUK, LAKEY (both in Cumbria), TALLA (in the Scottish Borders) or Turnberry (TRN, Ayrshire); these are reporting points on the existing route network. The ultimate destination of the aircraft determined which route was chosen by the airline. The chosen ATS route reporting points, combined with the aircraft propulsion type enabled us to split this southbound traffic as close to a 50/50 split as possible. SIDs ROWLY, FLEMN and GALGA were all designed to meet the southbound traffic needs. The period of 0600-0959 (Local) was not chosen at random, it was perceived appropriate to meet the capacity demands of the busy first wave or 'spike' and it also aligned with the plans at EDI thus making it easier for the en-route ATS provider to coordinate. The times can be reconsidered should there be sufficient reason to do so.

A.2.5. The existing array of southbound SIDs required jet aircraft to turn left rather than right from Runway 05. However, in reality many were given a right turn when they got airborne if ATC could accommodate them. What is proposed here is that the southbound jet aircraft will routinely turn right from Runway 05. So, in the peak morning rush most jets will turn right and all non-jets and some jets will turn left. **Table 1** shows the concept of operations for Runway 05.

SID	TIMES (LOCAL)	USAGE
FLEMN	0600-0959	LAKEY (Jets) and TALLA departures (All types).
	1000-2259	All southbound types except those for TRN.
	2300-0559	Not in use.
GALGA (Respite)	0600-2259	Not in use.
	2300-0559	All southbound types except those for TRN.
HARIS	24/7	All PERTH departures.
INLIS	24/7	All FOYLE and LOMON departures.
ROWLY	0600-0959	LAKEY (Props) and SUBUK (All types).
	1000-2259	As required, principally ROBBO, CLYDE and TRN.
	2300-0559	As required, principally ROBBO, CLYDE and TRN.
	24/7	All ROBBO, CLYDE and TRN.

Table 1: Runway 05 SID Proposed Concept of Operations

A.2.6. To put this in perspective, we have apportioned a full years' worth of movements from 2016 and assessed the numbers against the proposed SIDs with the assumption that Runway 05 was in use 30% of the time. Figure 5 below shows an average number of movements per hour that would have been on each of the proposed SIDs using the concept of operations above. Note: The forecast growth for these SIDs, year-on-year, does not exceed 6% out to 2029.

Figure 5: Average Proposed SID Usage (per hour) based on 2016 data

Image © 2017 Google

A.3. SIDs FLEMN, GALGA and ROWLY

A.3.1. These three procedures are the proposed southbound SIDs designed to route over 80% of departing traffic when Runway 05 is in use. SID ROWLY will also route traffic to the west and north-west as it is designed to replace SIDs CLYDE and ROBBO. As is shown in Figure 6, the majority of the existing departure tracks (as depicted by the magenta lines) begin to diverge at the 5NM point (i.e. once existing NAPs have been satisfied) and proceed to fan out over a large swathe of East and West Dumbartonshire, Stirlingshire and Glasgow City. The existing SIDs were no longer meeting the requirements of the operators or the ATM operation and, when combined with the inferior navigation standards in use (achievable by conventional means), resulted in a broad swathe.

A.3.2. SIDs FLEMN and GALGA as proposed, are more direct than experienced by much of the jet traffic today. The existing array requires that the jet traffic depart on a left turn via SID NORBO and only non-jets turn right via SID LUSIV. This arrangement is no longer working and many of the jet operators are seeking a right turn whenever ATC can accommodate them. In the event that the NORBO SID is issued, aircraft are not typically following the whole procedure and are looking for a more expeditious southbound turn as soon as can be offered. As a consequence, there is a broad swathe of southbound tracks spread across much of Renfrewshire.

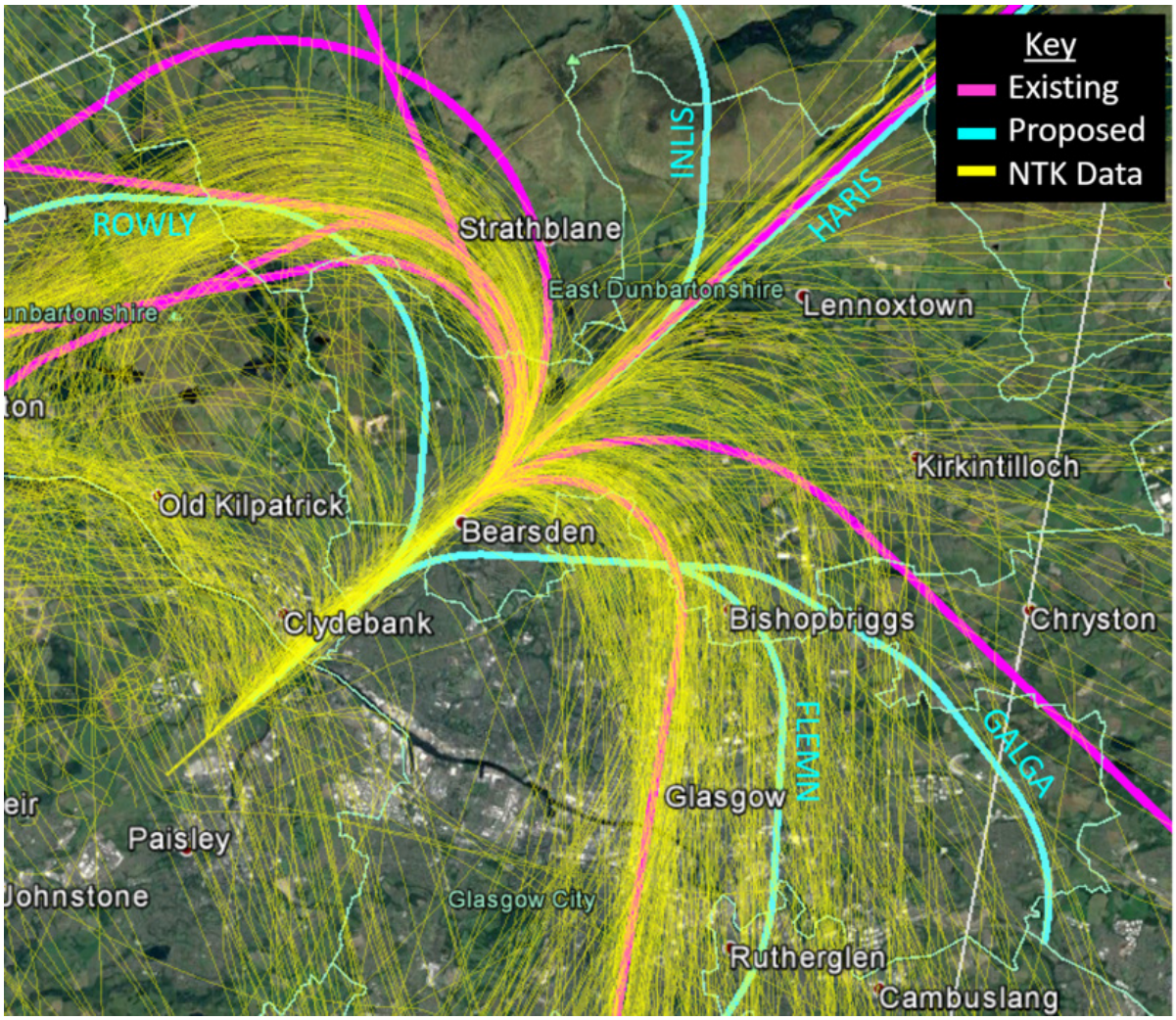

Figure 6: SIDs FLEMN, GALGA and ROWLY against Existing SIDs and NTK data from 1-7 May 2017

A.3.3. In comparison, the proposed SIDs FLEMN, GALGA and ROWLY array involve earlier turns at approximately 3NM from the Airport (requiring an amendment to Noise Abatement Procedures). The tracks are required to diverge from each other and meet route spacing and separation criteria and together with environmental considerations related to potential community disturbance, is instrumental in the development of the designs presented.

A.3.4. SID FLEMN (as depicted in **Figure 6**) tracks further east of the Glasgow city centre area than the existing SID LUSIV track (magenta line) thereby reducing the population density overflown. SID FLEMN turns right earlier (at 3NM) than the existing SID, thereby providing relief to the north-eastern part of the Bearsden area who experience all the arrivals under the approach path when Runway 23 is in operation, (see **Figure 7**).

A.3.5. **Figures 7 and 8** show the proposed procedures against a Population Heatmap created using the 2011 Census Data. Although the graphics present the point at which the procedures are designed to reach 6,000 feet, it is highly likely that the aircraft will out-perform the required climb gradient.[3]

[3] Trials of these SIDs in a Boeing 737-800 simulator demonstrated that aircraft would typically be passing over 5,000ft in the vicinity of Bishopbriggs on both SID FLEMN and SID GALGA. In the case of SID ROWLY, the aircraft was typically through at least 4,000ft by a point west-abeam Strathblane. The aircraft was reaching altitudes above at least 8,000ft by the end of each of these SIDs.

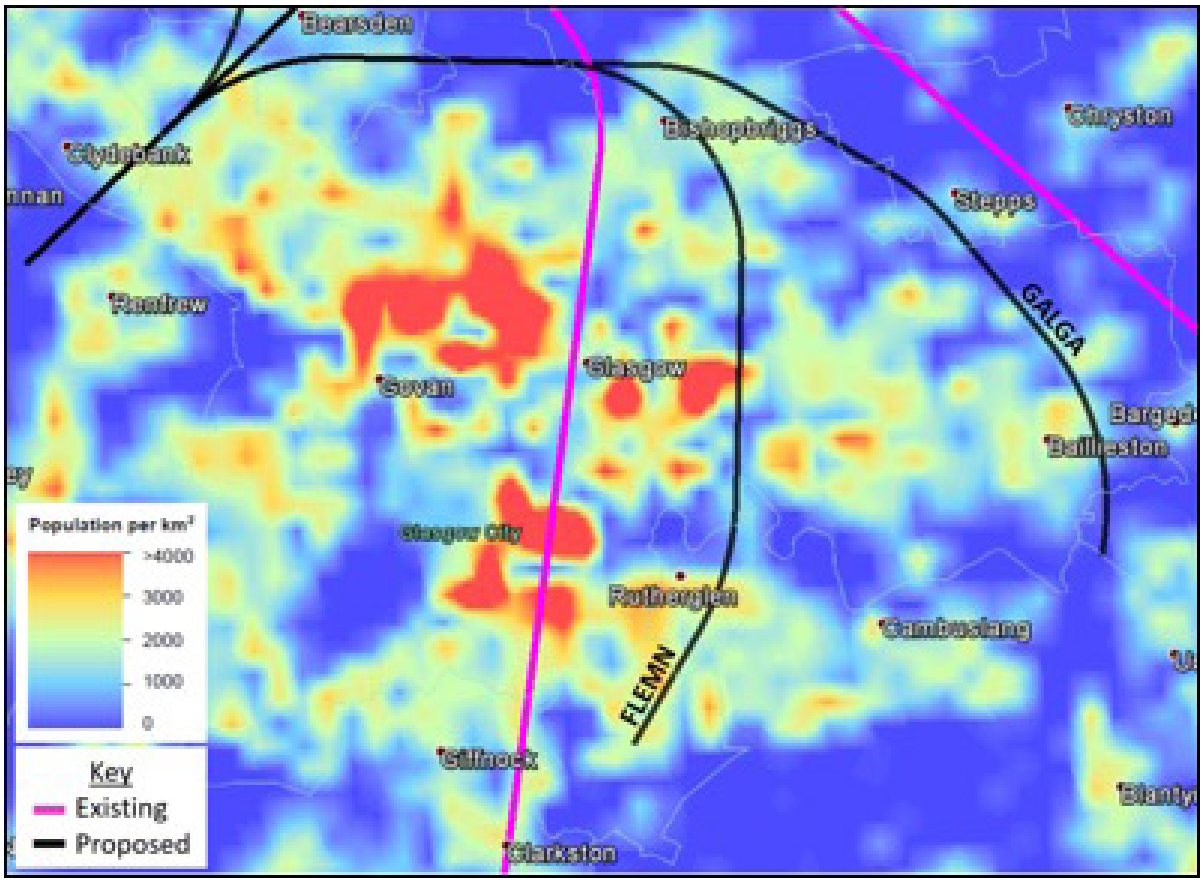

Figure 7: SIDs FLEMN and GALGA with 2011 Census Population Heat Map and CACI 2017 Population Data

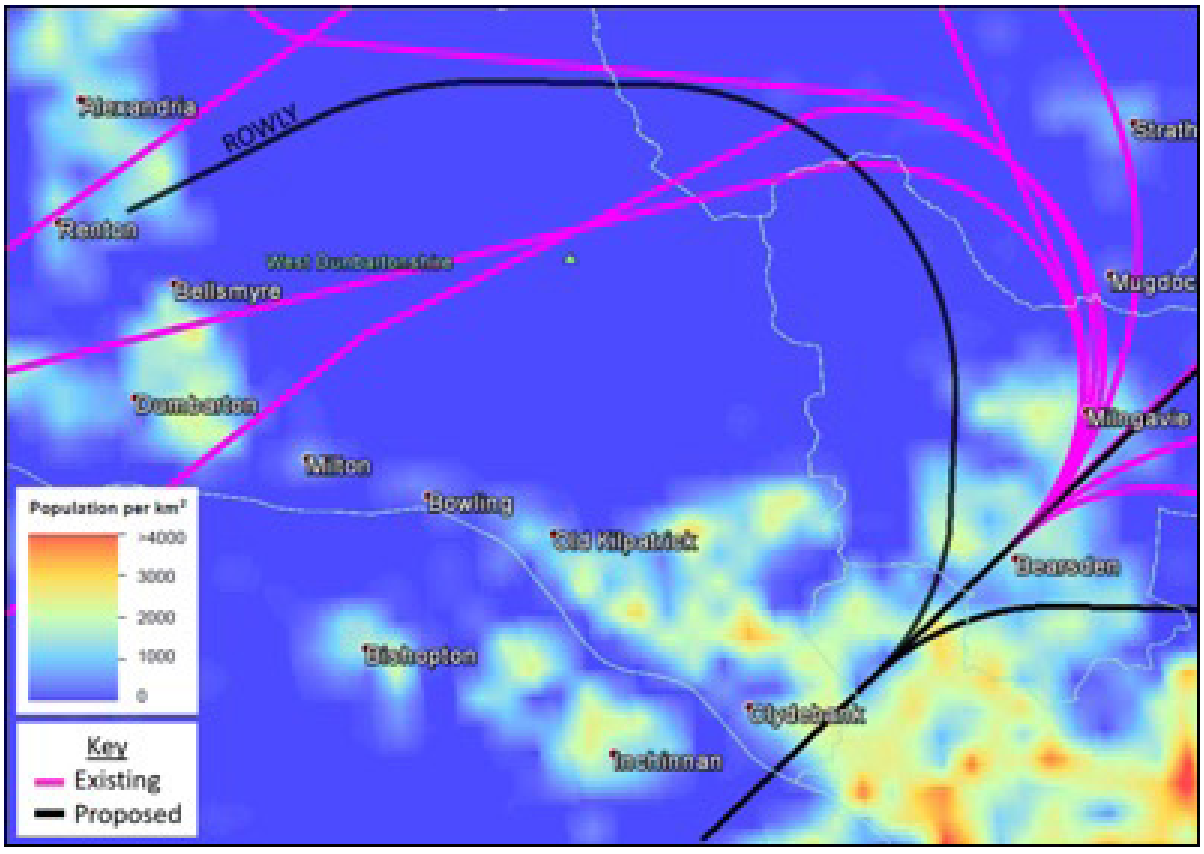

Figure 8: SID ROWLY with 2011 Census Population Heat Map and CACI 2017 Population Data

A.3.6. Based on 2016 usage, it is expected that of the Runway 05 traffic, those using SID FLEMN would make up roughly 53%, with 26% on SID ROWLY (in the period 0600-0959 this would amount to a 47%/53% split in favour of SID ROWLY). SID GALGA would accommodate 4% of the traffic (between 2300 and 0559 only). The remainder of the traffic would be shared between SIDs HARIS (5%) and INLIS (11%). The 50/50 split deemed desirable for southbound traffic volumes is achievable with this concept of operation.

A.4. SIDs HARIS and INLIS

A.4.1. These SIDs are designed for use by the remaining 10% of departing traffic. Although, the existing LOMON and FOYLE SIDs shared little traffic, the tracks are essentially co-incident with the other left turns (NORBO, CLYDE and ROBBO) resulting in the communities of Milngavie, Mugdoch and to some extent, Strathblane, being affected by all of the left turning departures. The proposed array, as can be seen in Figure 9, divides this traffic east and west of these communities.

A.4.2. The SIDs are coincident until SID INLIS turns left at approximately 7NM from the Airport. SID HARIS continues North-East towards Stirling as the PERTH SID does today.

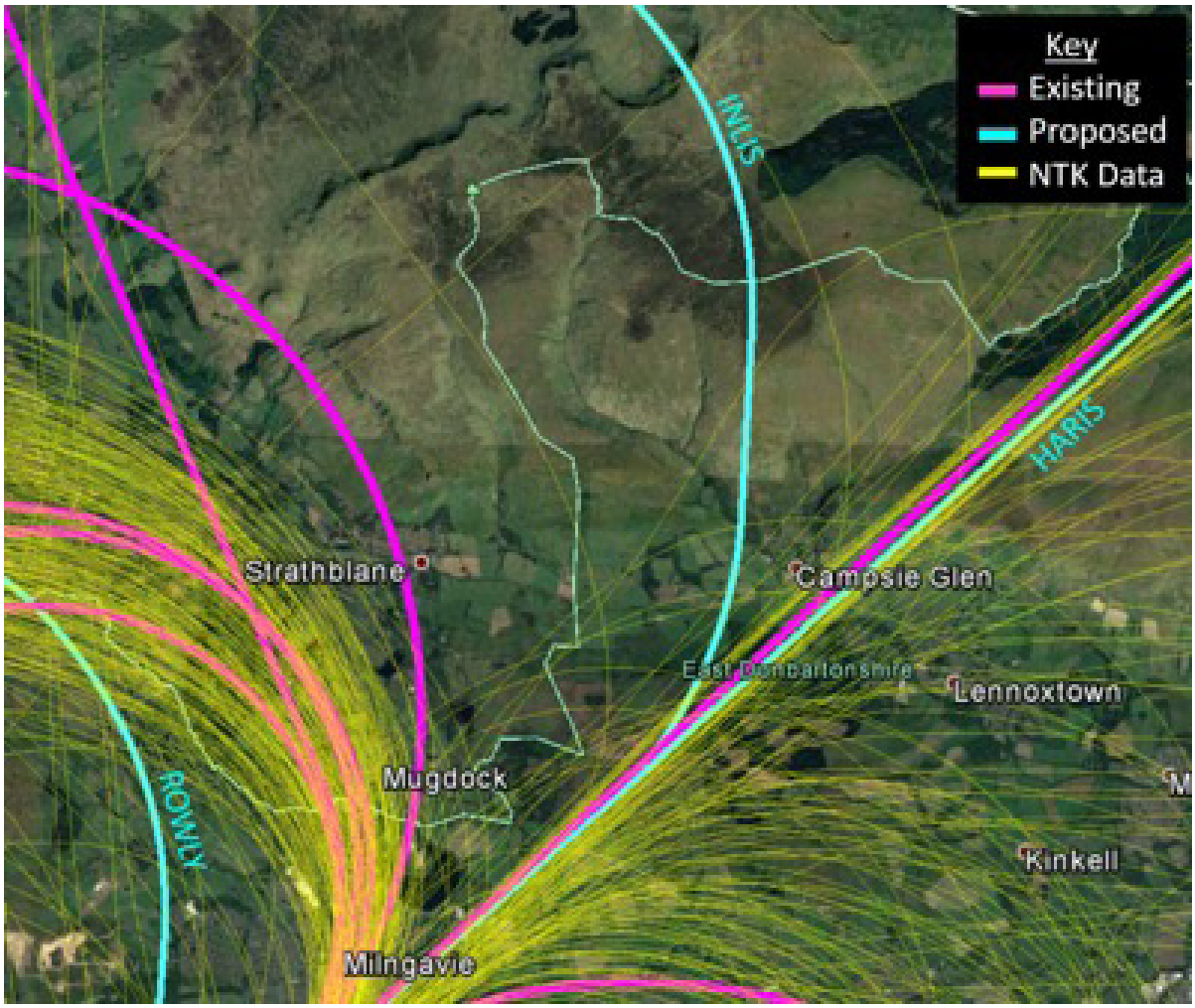

Figure 9: SIDs INLIS and HARIS against Existing SIDs and NTK data from 1-7 May 2017

A.4.3. The proposed SIDs are intended to improve noise for the communities such as Milngavie, Mugdoch and Strathblane as compared with that experienced today. Figure 10 shows the proposed procedures against a Population Heatmap.

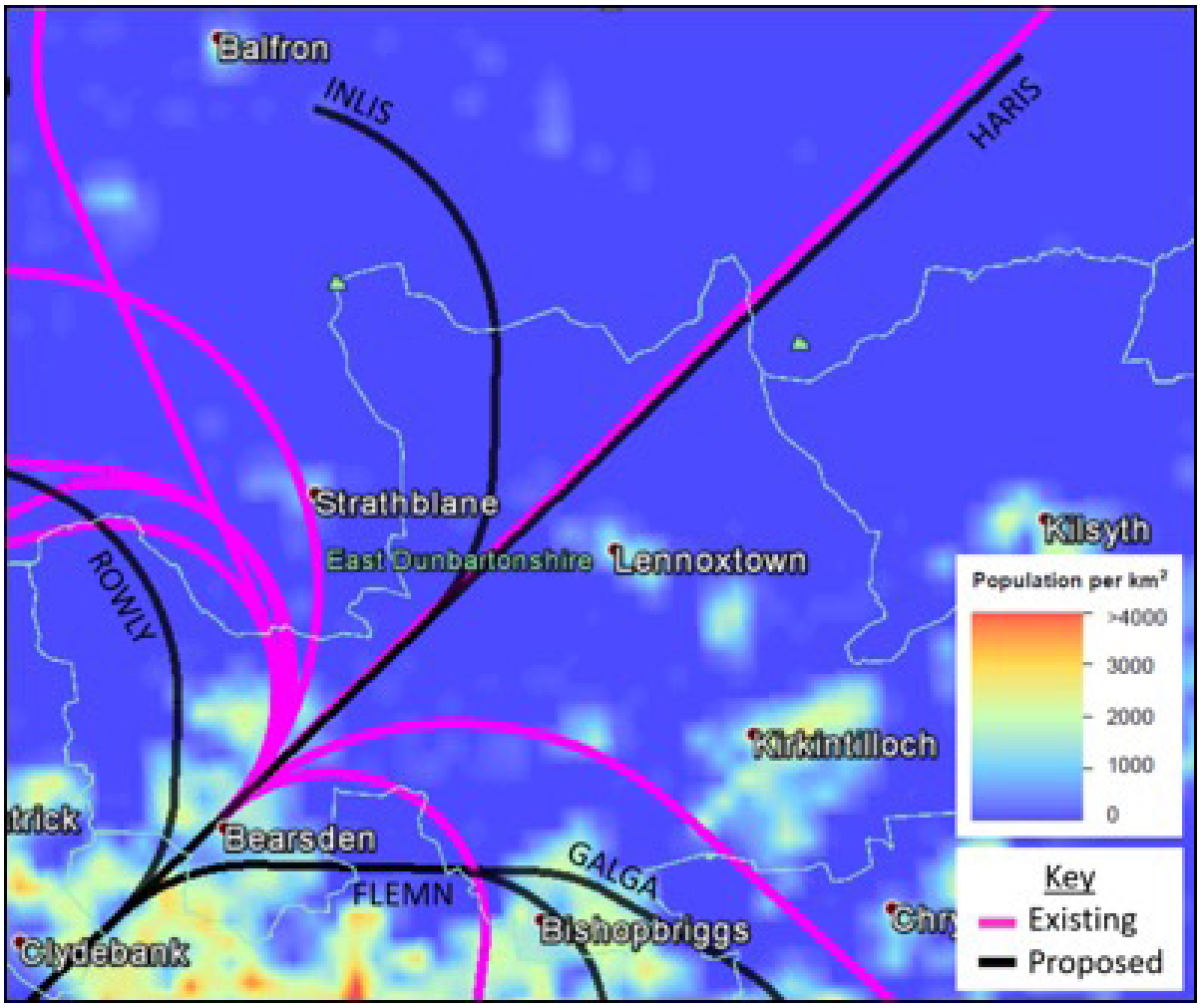

Figure 10: SIDs INLIS and HARIS with 2011 Census Population Heat Map and CACI 2017 Population Data

Image © 2017 Google

A.4.4. Although the graphics present the point at which the procedures are designed to reach 6,000 feet, it is highly likely that the aircraft will out-perform the required climb gradient.[4]

A.5. Navigational Accuracy

A.5.1. All the proposed SIDs will utilise a higher navigational standard. RNAV-1 criteria require aircraft to be within 1NM of where they should be 95% of the time. Navigational accuracy of RNAV-1 has proved to be far more accurate than the allowable tolerance and track adherence is therefore expected to be much tighter.

A.5.2. **Figures 11, 12 and 13** can be downloaded as separate documents from our website and can also be seen overleaf. They indicate a 1NM swathe either side of the proposed tracks against an Ordnance Survey background. **Figures 12 and 13** also depict the expected usage of these five departure procedures when Runway 05 is in use, expressed as a percentage.

[4] Trials of SID INLIS in a Boeing 737-800 simulator resulted in an altitude of at least 4,000ft being passed before Lennoxtown and at least 8,000ft being reached by the end of the SID. SID HARIS was not tested owing to the simplistic straight-ahead nature of the departure.

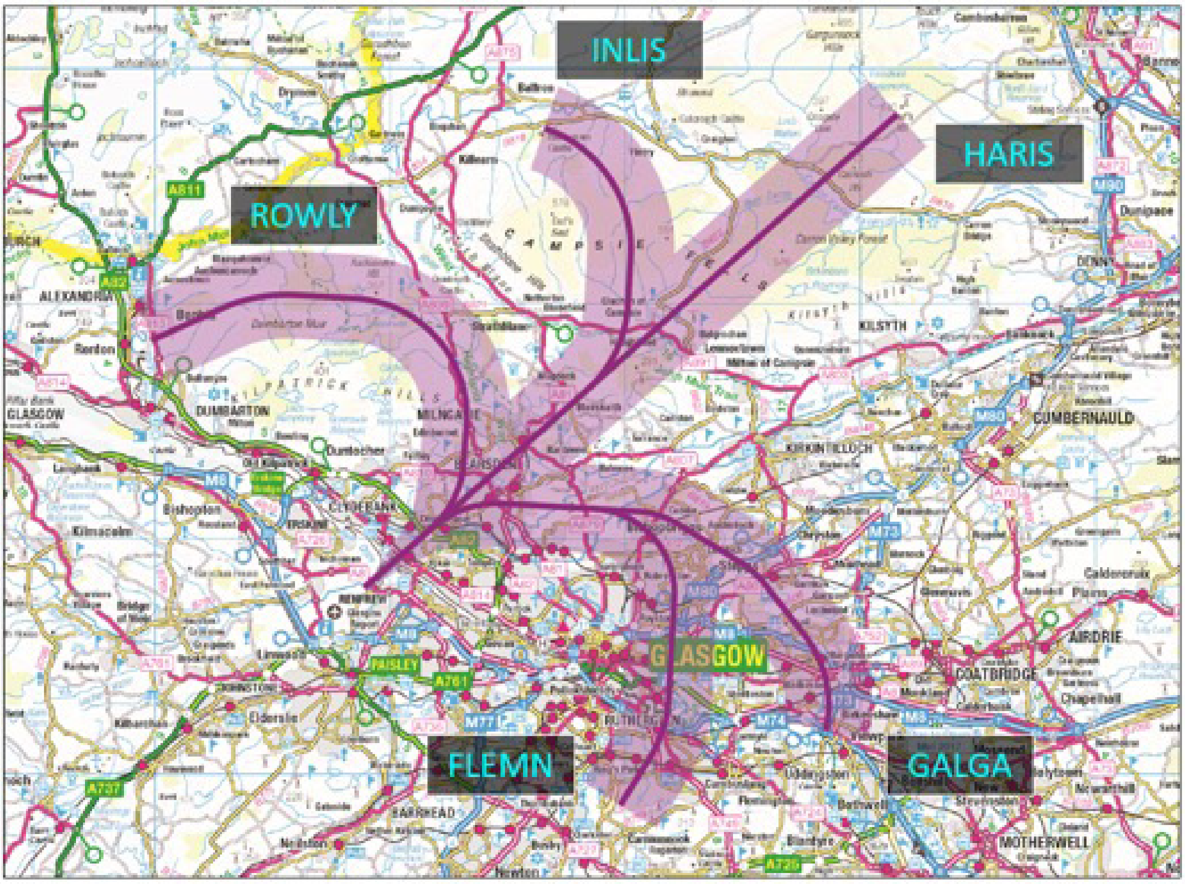

Figure 11: Runway 05 Proposed SID Array RNAV-1 Swathe

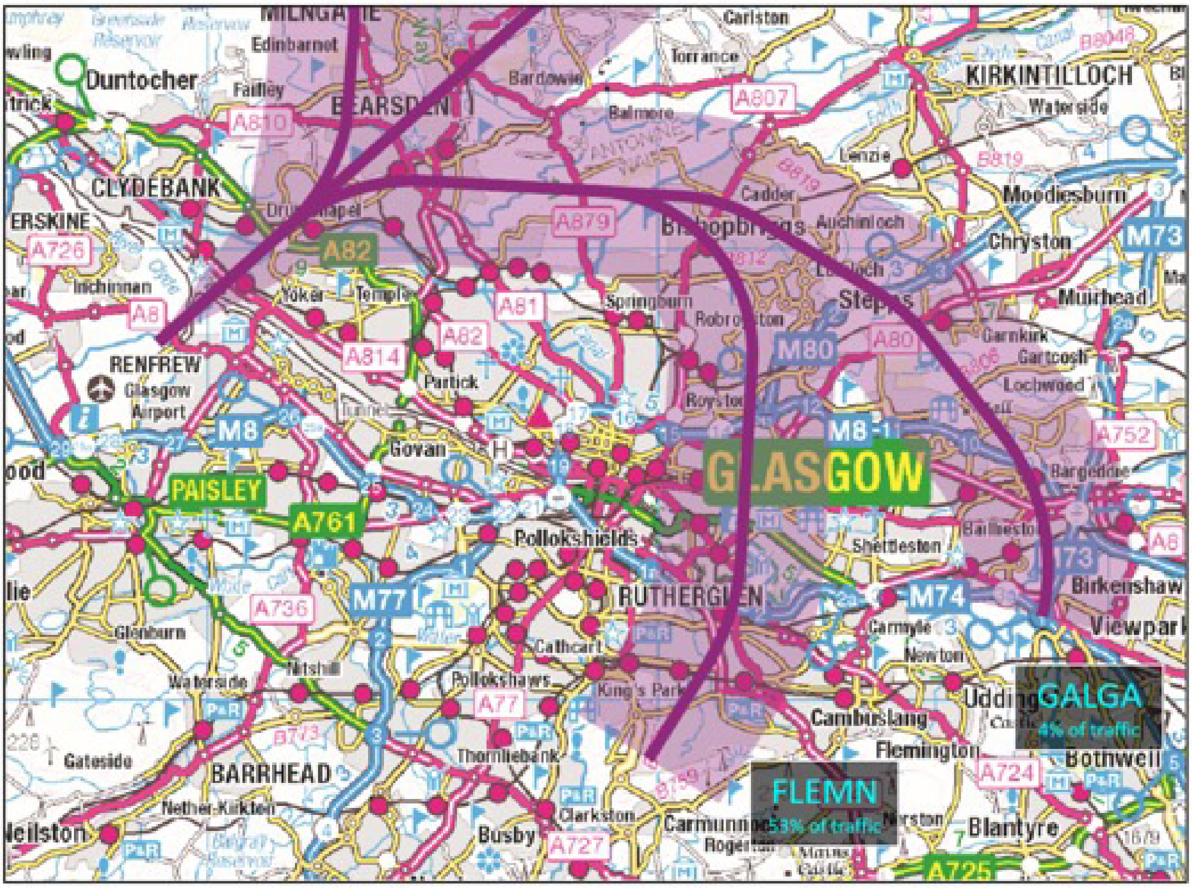

Figure 12: SIDs FLEMN and GALGA RNAV-1 Swathe

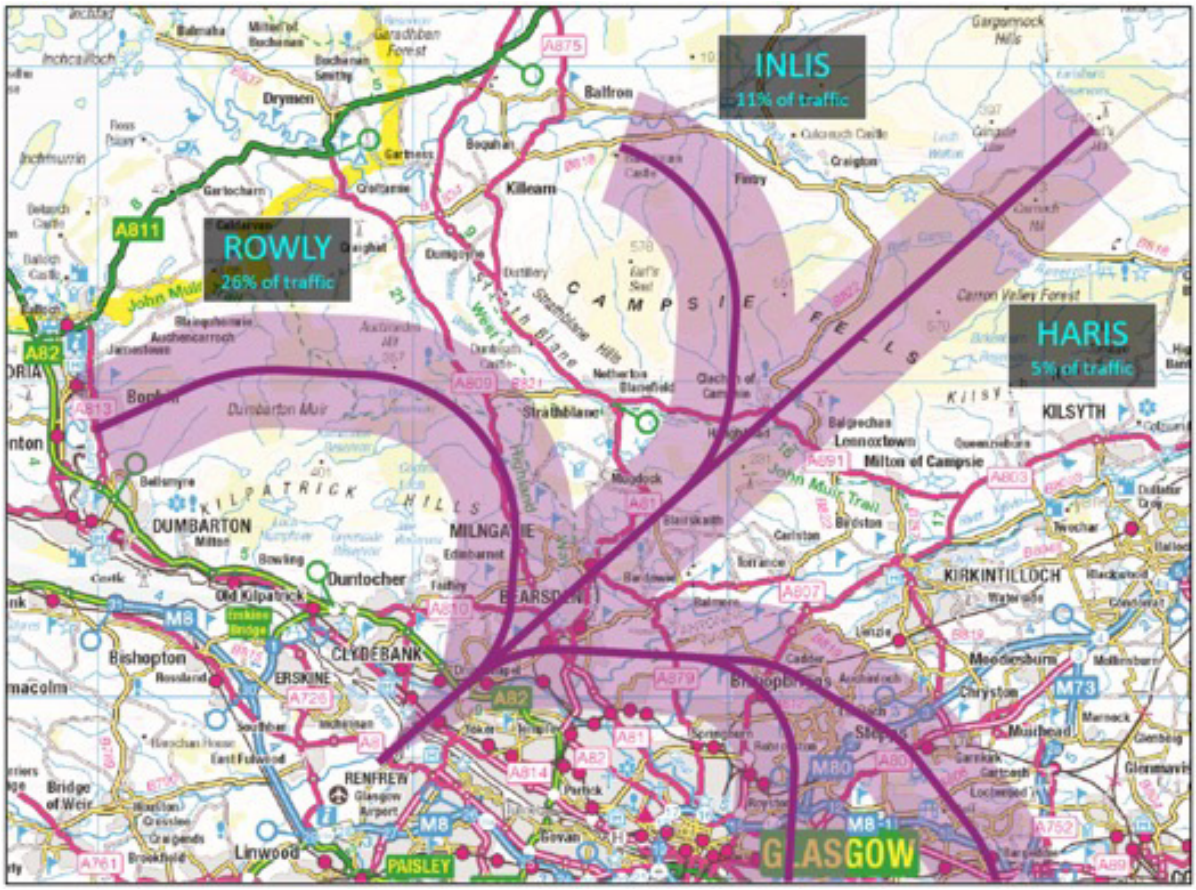

Figure 13: SIDs HARIS, INLIS and ROWLY RNAV-1 Swathe

A.6. Environmental Impact Assessment

A.6.1. **Part 3** of the main Consultation Document provides an assessment of the environmental impact.

A.7. Summary

A.7.1. In the development of these SIDs we have sought to improve the operational and environmental impact of departing aircraft as far as has been practicable. What is presented is a rationalised array of departure procedures designed to meet the needs of the environment, (by limiting the effects felt by people on the ground and through reduced emissions) and the needs of our operators by providing shorter routings that reduce fuel burn. These procedures have all been designed based upon the capabilities and requirements of the operators at Glasgow Airport, they have been simulated by a Boeing 737-800 and have been proven to be flyable as stand-alone procedures.

A.7.2. Should you wish to express your views on that which is proposed, we would very much welcome your feedback. Feedback can be provided via post, email or online form as detailed in **Part 1** of our main **Consultation Document.**

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