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ANNEX B - RUNWAY 23 CONCEPT OF OPERATIONS

Glasgow Airport Standard Instrument Departures

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B. 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. This Annex to the Consultation Document provides an explanation of the concept of operations for aircraft departing Runway 23. Having described how the SIDs work as an array, each will be described in isolation focusing on any potential impact to the environment.

B.1. Overview

B.1.1. There are nine SIDs in the existing conventional departure array off Runway 23:

- 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).

B.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 It will be impossible to fly them by conventional means once the VOR has been withdrawn.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 are clearly shown by the NTK evidence in **Figure 1** overleaf affecting a very large part of the region.

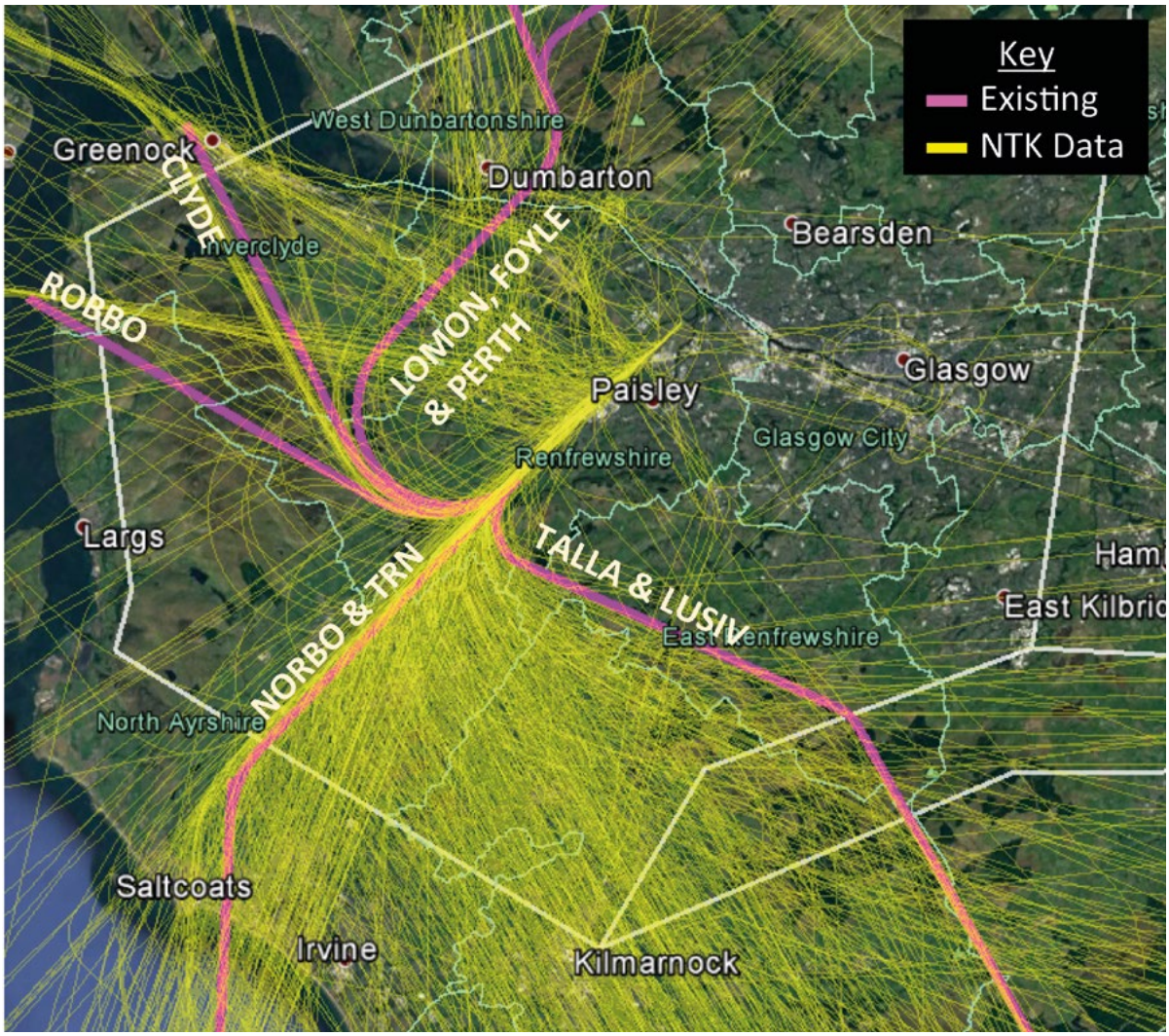

Figure 1: NTK evidence from 11-17 June 2017 Sample vs Existing Runway 23 SIDs

B.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. For example, in **Figure 1** above, it was not possible to replicate the 'S-Bend' on SID PERTH to the north of the Airport. Furthermore, as there was an opportunity for improvements to be made both operationally and environmentally; why would we not want to do that?
- **Redesign** – this option was considered the most favourable as there is a perceived opportunity to deliver significant environmental or operational benefits from the complete redesign of the array of departure procedures.

B.1.4. As is seen in **Figure 1** above, 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. Furthermore, owing to the prevailing winds affecting the region, Runway 23 is in use around 78% of the time for departures (and arrivals). **Figure 2** overleaf shows the percentage usage of the existing Runway 23 SIDs when in operation from 2016 data.

Figure 2: Existing SID Usage Runway 23

B.1.5. Figure 3 overleaf shows the existing array as compared to the proposed array. All the SIDs are contained within the controlled airspace delegated1 to Glasgow Airport. The proposed departures are fewer in number, as it was important to simplify and consolidate the array; they are also shorter, as they are truncated to the point at which aircraft 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, they are designed to route towards where aircraft operators wish to go (with ATM system requirements) whilst 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.

[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.

B.1.6. The blue lines below depict the SIDs 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.

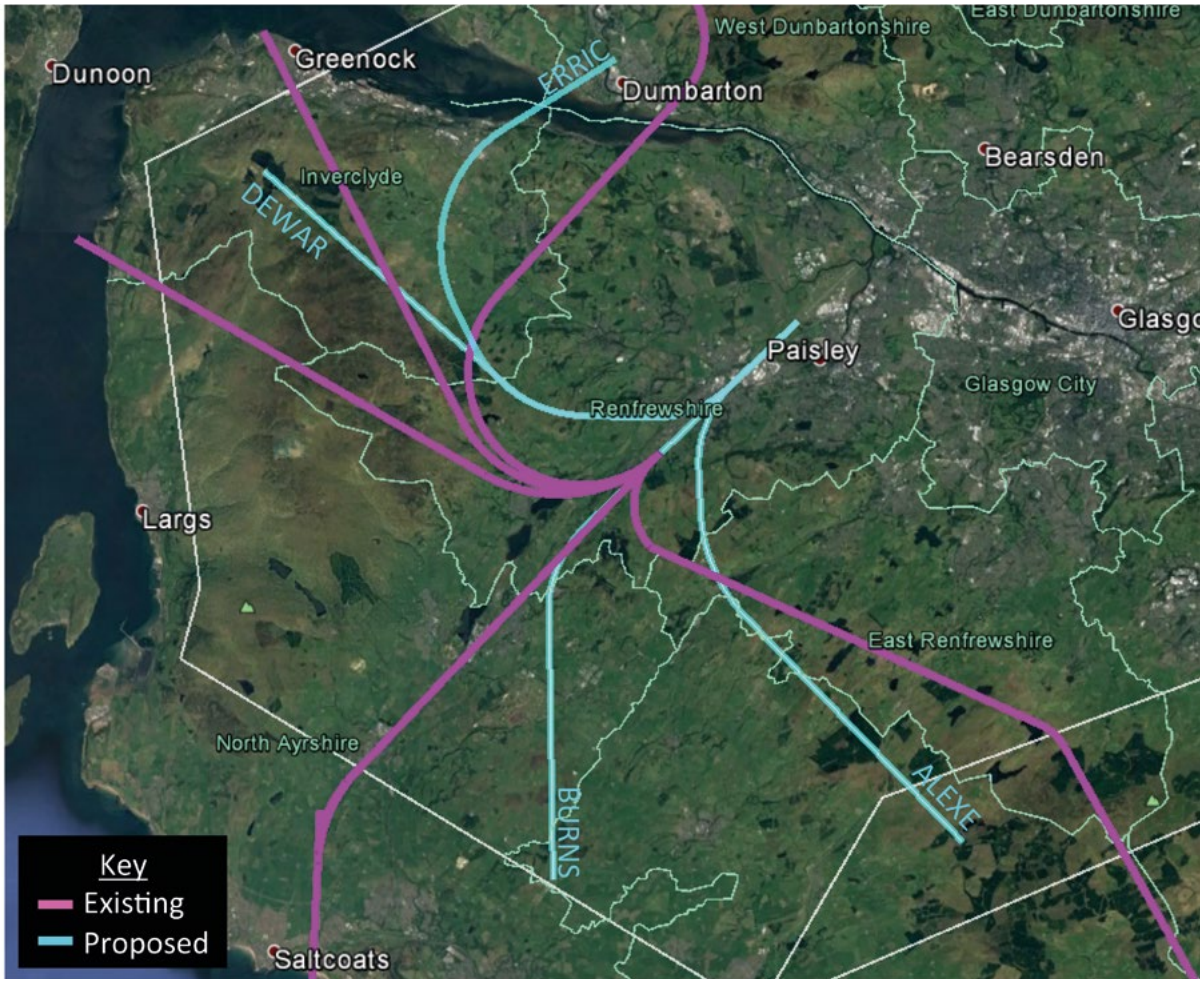

Figure 3: Runway 23 Existing vs Proposed Departure Array

B.1.7. As the proposed procedures are designed to RNAV-1 standard (required navigational tolerance of 1NM either side of the line) and they are designed with the operators desired routings in mind, the expected track adherence is anticipated 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.

B.1.8. 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.

B.1.9. The link routes beyond the end of the SIDs are out with 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** overleaf. This is further explained within the paragraphs specific to each SID.

[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

Figure 4: Runway 23 Proposed Departure Array extended to 7,000 feet

B.2. Concept of Operations

B.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 two 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. Furthermore, making SIDs DEWAR and ERRIC coincident in the first turn, enhances the opportunity to reduce the delays for southbound departure clearances by turning non-southbound traffic out to the right of the immediate climb-out lane earlier. The combination of limited airspace availability, design regulations and the presence of other procedures limit the options available to us. However, priority has been given to limiting the environmental impact of the SIDs (in terms of the noise impact) through avoiding communities where possible. The procedures are also shorter and more direct, resulting in reduced fuel burn and CO_2 emissions.

B.2.2. A statistical 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 the southbound SIDs as possible.

B.2.3. 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 determines which route was filed for 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. SID DEWAR was designed to meet the needs of operators currently using SIDs CLYDE and ROBBO whilst SID ERRIC was designed to meet the needs of those currently using SIDs PERTH, LOMON and FOYLE. 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 altered should there be sufficient reason to do so. **Table 1** shows the concept of operations for Runway 23.

B.2.4. Unlike Runway 05, there is no 'Respite' SID in the Runway 23 proposed array as there was not the perceived need to design one.

SID	TIMES (LOCAL)	USAGE
ALEXE	0600-0959	LAKEY (Jets) and TALLA departures (All types).
	1000-0559	All southbound types except those for TRN.
BURNS	0600-0959	LAKEY (Non-Jets) and SUBUK (All types).
	1000-0559	As required.
	24/7	All TRN departures.
DEWAR	24/7	All ROBBO and CLYDE departures.
ERRIC	24/7	All FOYLE, LOMON and PERTH departures.

Table 1: Runway 23 SID Proposed Concept of Operations

B.2.5. To put this in perspective, we have apportioned a full years' worth of movements from 2016 assuming that Runway 23 was in use 70% of the time. **Figure 5** overleaf shows an averaged 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 routes, year-on-year, averages around 6% out to 2029.

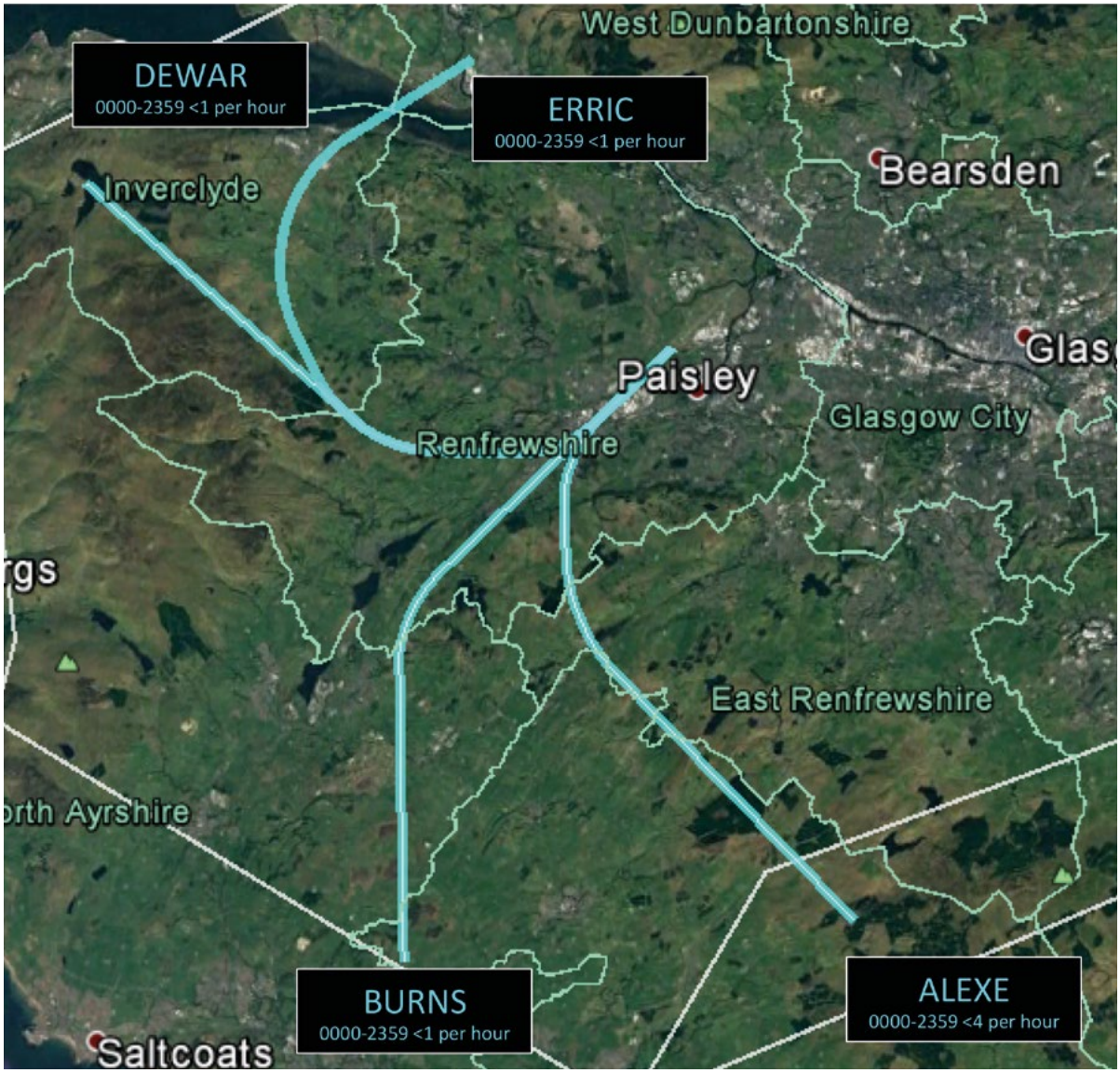

Figure 5: Average SID Usage (per hour) based on 2016 data

B.3. SIDs ALEXE and BURNS

B.3.1. SIDs ALEXE and BURNS are the proposed southbound SIDs designed to route over 80% of departing traffic when Runway 23 is in use. As is shown in **Figure 6** overleaf, the existing departure tracks begin to diverge at the 5NM point (i.e. once NAPs have been satisfied) and proceed to fan out over a large swathe of North and East Ayrshire. The existing SIDs, as depicted by the magenta lines, no longer meet the requirements of the operators or the ATM operation and this when combined with the inferior navigation standards achievable by conventional means, result in a broad swathe.

B.3.2. The procedures are coincident until SID ALEXE turns left at approximately 3NM from the Airport. SID BURNS is designed to continue straight ahead to approximately 7NM from the Airport before it too turns left. The tracks need to diverge from each other and meet route spacing and separation criteria and, along with environmental considerations related to potential community disturbance, is instrumental in the development of the designs proposed.

B.3.3. These two SIDs, designed to meet the needs of the southbound traffic, are more direct. It is also perceived that the proposed SIDs are an improvement from a community noise nuisance perspective for the communities of Beith and Stewarton as compared with that experienced today. It is recognised that the southern part of Johnston will be directly overflown owing to the earlier left turn but this is a trade-off that provides some relief to Howwood (can be seen in **Figure 7**, page 13).

Attempts to avoid Uplawmoor were made, however, it was not possible to achieve the required route spacing without directly affecting the remainder of the SID array. Any such amendment to ALEXE would have come at the expense of Beith or Kilbirnie as the knock-on implication would have been the requirement to move SID BURNs further west. Design criteria made it impossible to turn any earlier or tighter to route SID ALEXE to the east of Uplawmoor.

B.3.4. 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.

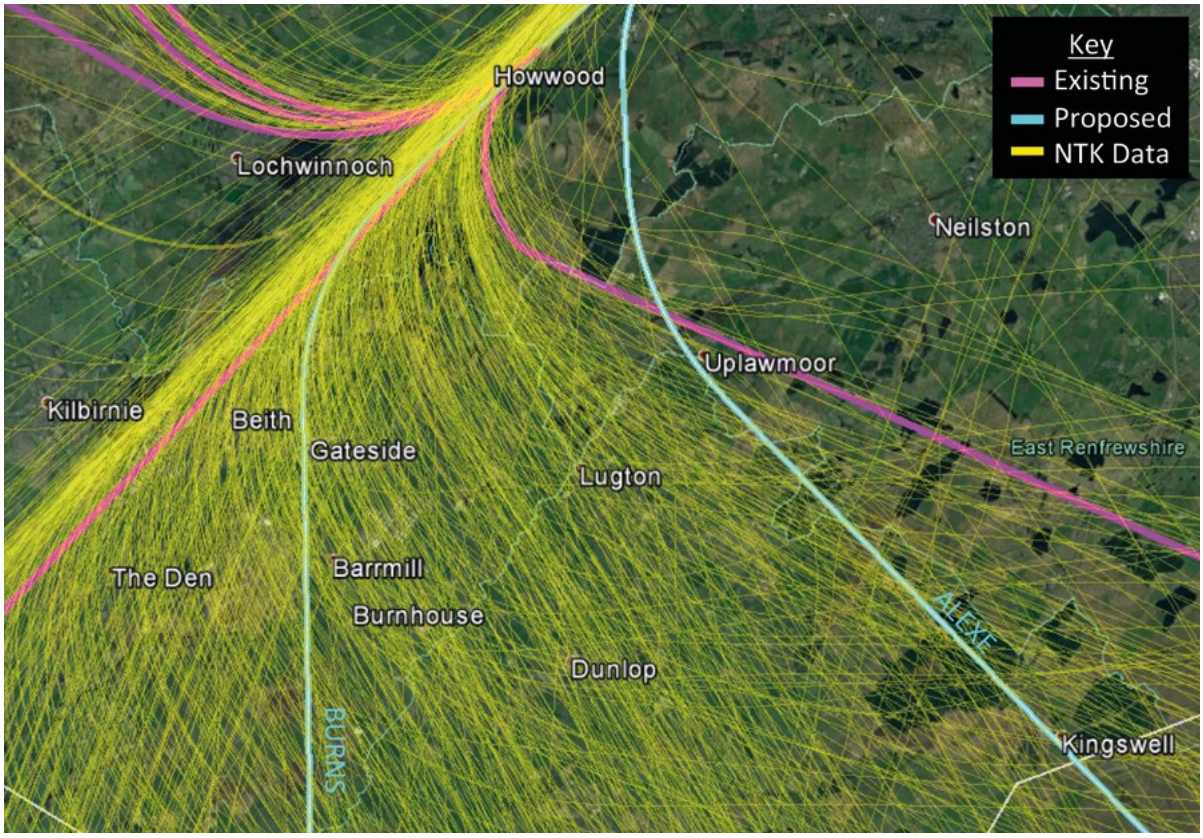

Figure 6: SIDs ALEXE and BURNS against Existing SIDs and NTK data from 11-17 June 2017

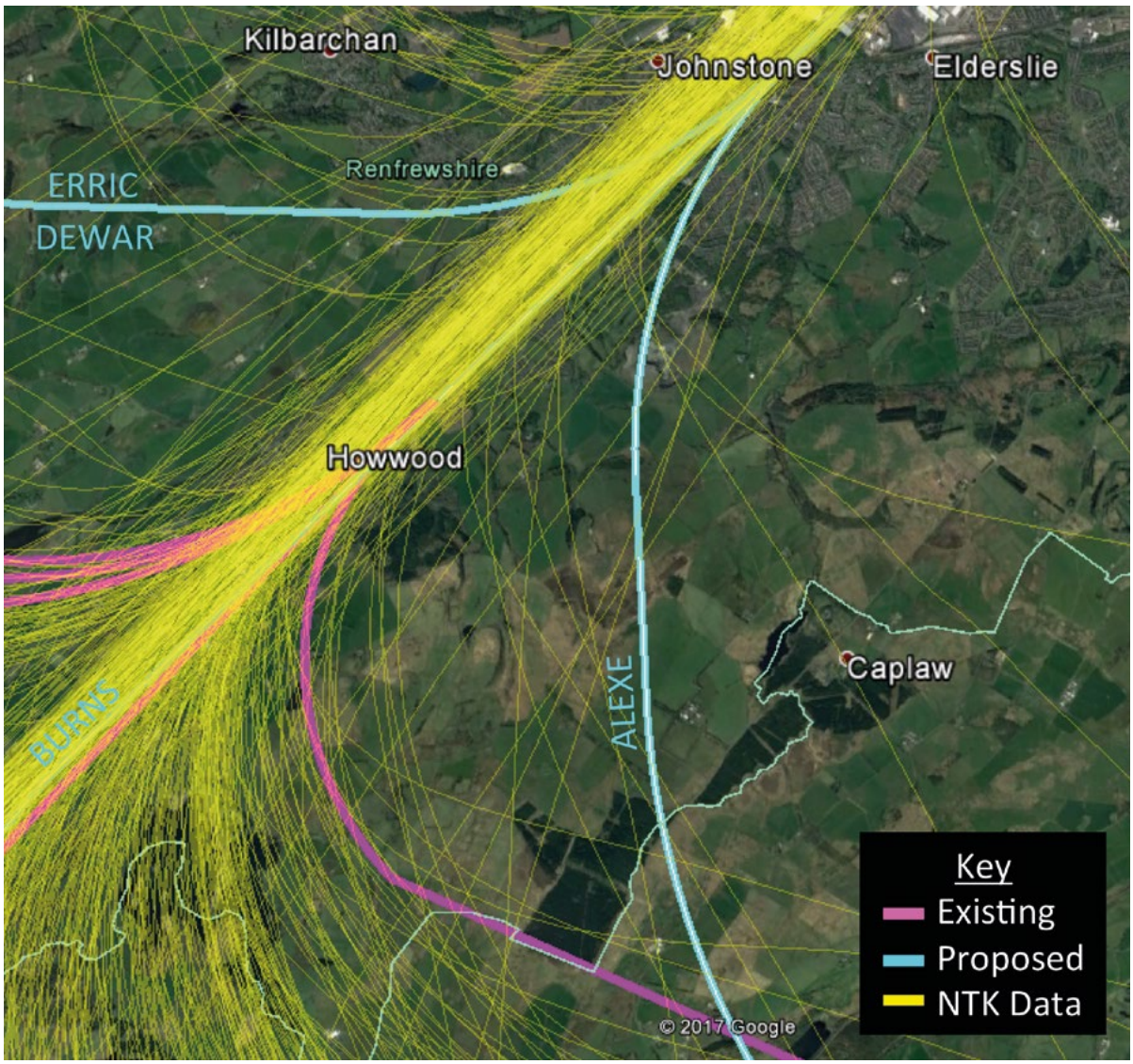

Figure 7: SID ALEXE turn at 3nms

Image © 2017 Google

B.3.5. Based on 2017 summer usage, it is expected that of the 80% of Runway 23 southbound traffic, those using SID ALEXE would make up over 55%, with the remainder on SID BURNS.

B.3.6. Figure 8 overleaf shows 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] Therefore, 6,000 feet is the lowest aircraft will be by the end of the SID.

B.3.7. Based on actual 2016 usage, it is expected that of the Runway 23 traffic, those using SID ALEXE would make up 69%, with 14% on SID BURNS (Note: In the period 0600-0959 this is much closer to a 50%/50% split of the southbound traffic). SID DEWAR would take 8% of the traffic and SID ERRIC would accommodate 9%

[3] Trials of each of the SIDs in a Boeing 737-800 simulator demonstrated that aircraft would typically be passing between 3,500ft and 4,000ft in the vicinity of Uplawmoor on SID ALEXE and aircraft would typically be passing between 4,000ft and 5,000ft before turning south on SID BURNS.

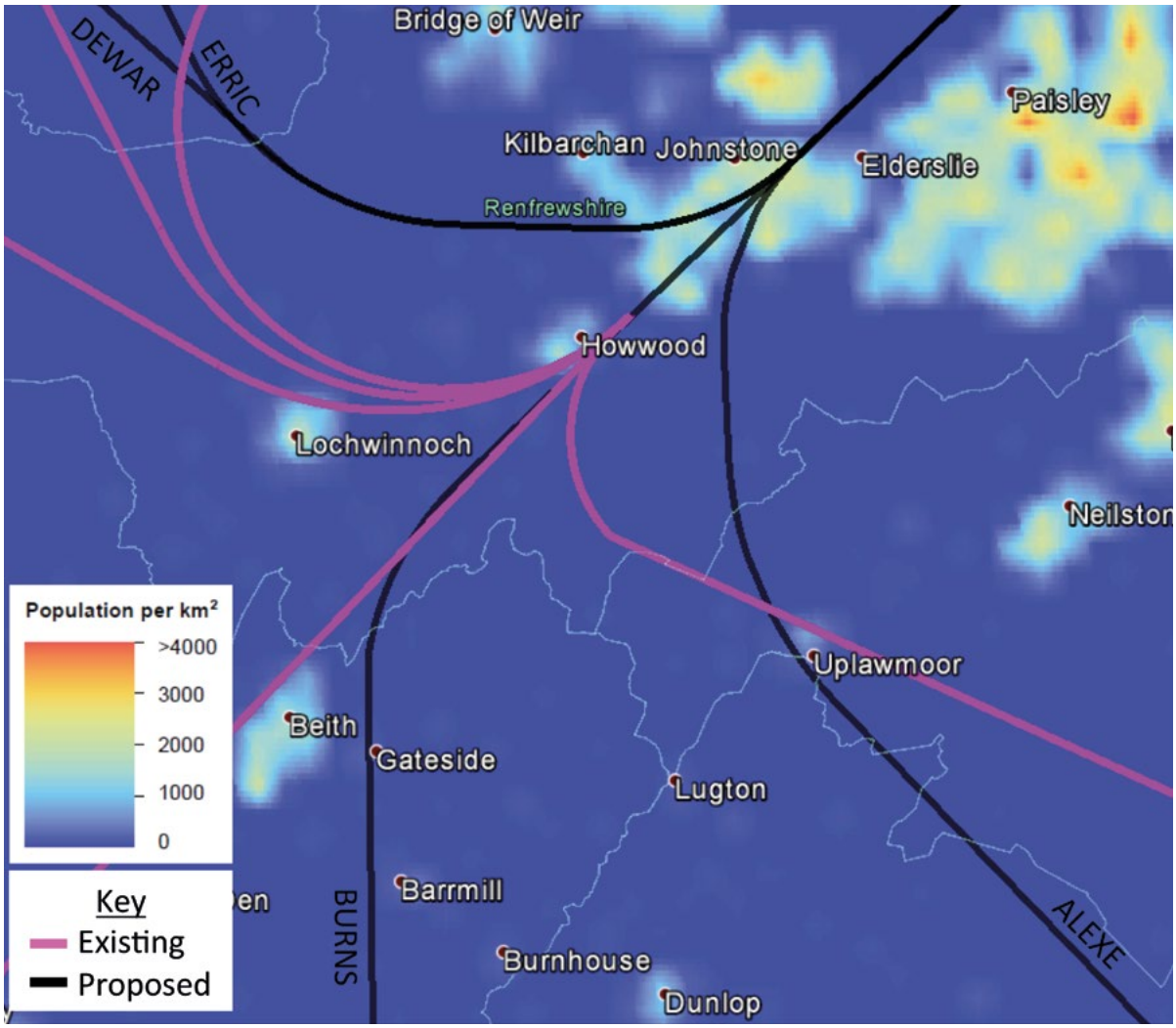

Figure 8: SIDs ALEXE and BURNS with 2011 Census Population Heat Map with 2017 CACI Population Data

B.4. SIDs DEWAR and ERRIC

B.4.1. SIDs DEWAR and ERRIC are the proposed SIDs designed to route the remaining 15-20% of departing traffic when Runway 23 is in use. As with the southerly SIDs, there was a broad swathe presented in the NTK evidence (shown in Figure 9 overleaf), impacting much of western Renfrewshire including communities such as Bridge of Weir, Brookfield and Kilmacolm. The existing SIDs, as depicted by the magenta lines, are not as direct as preferred by the operators or the ATM operation and this, when combined with the inferior navigation standards achievable by conventional means, results in a broad swathe. Note: Also, evident on this graphic are tracks from locally-based light aircraft not following the existing SIDs. These typically turn away from the climb-out lane shortly after take-off.

B.4.2. These proposed procedures are coincident through the first turn at approximately 3NM from the Airport. SID ERRIC then continues a right turn towards the North-East whereas SID DEWAR continues North-West through Inverclyde. The tracks needed to diverge sufficiently from SID BURNS to meet route spacing and separation criteria and this, along with environmental considerations related to potential community disturbance, was instrumental in the development of the designs presented.

B.4.3. SID DEWAR, which is designed to meet the needs of the traffic currently routing via CLYDE and ROBBO is more direct than the SIDs it is designed to replace. SID ERRIC turns earlier than the existing LOMON, FOYLE and PERTH SIDs and in so doing avoids Lochwinnoch. It then routes further north than the existing SIDs to avoid overflying Kilmacolm. SID ERRIC terminates just north of the heavily populated areas of Dumbarton and aircraft can be expected to be well above 6,000ft in most cases by this point.

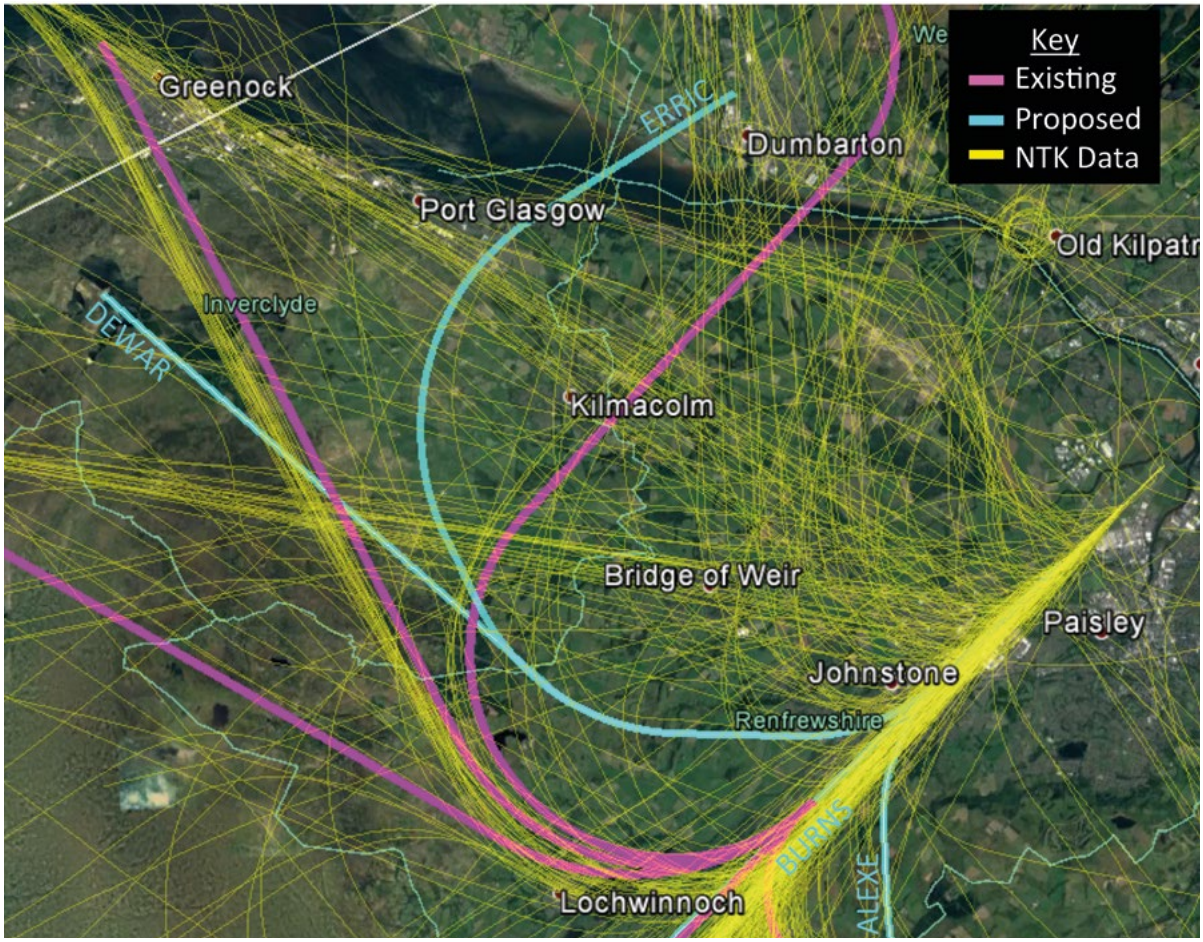

Figure 9: SIDs DEWAR and ERRIC against Existing SIDs and NTK data from 11-17 June 2017

B.4.4. It is perceived that the proposed tracks are an improvement from a community noise nuisance perspective for the communities of Bridge of Weir, Kilbarchan, Brookfield, Lochwinnoch, Houston and Kilmacolm in particular as compared with that experienced today. It is recognised that the western part of Johnston is now directly overflown owing to the earlier right turn but this is a trade-off that provides some relief to Howwood (as can be seen in **Figures 7 and 8**). **Figure 10** shows the proposed procedures against a Population Heatmap created using the 2011 Census Data.

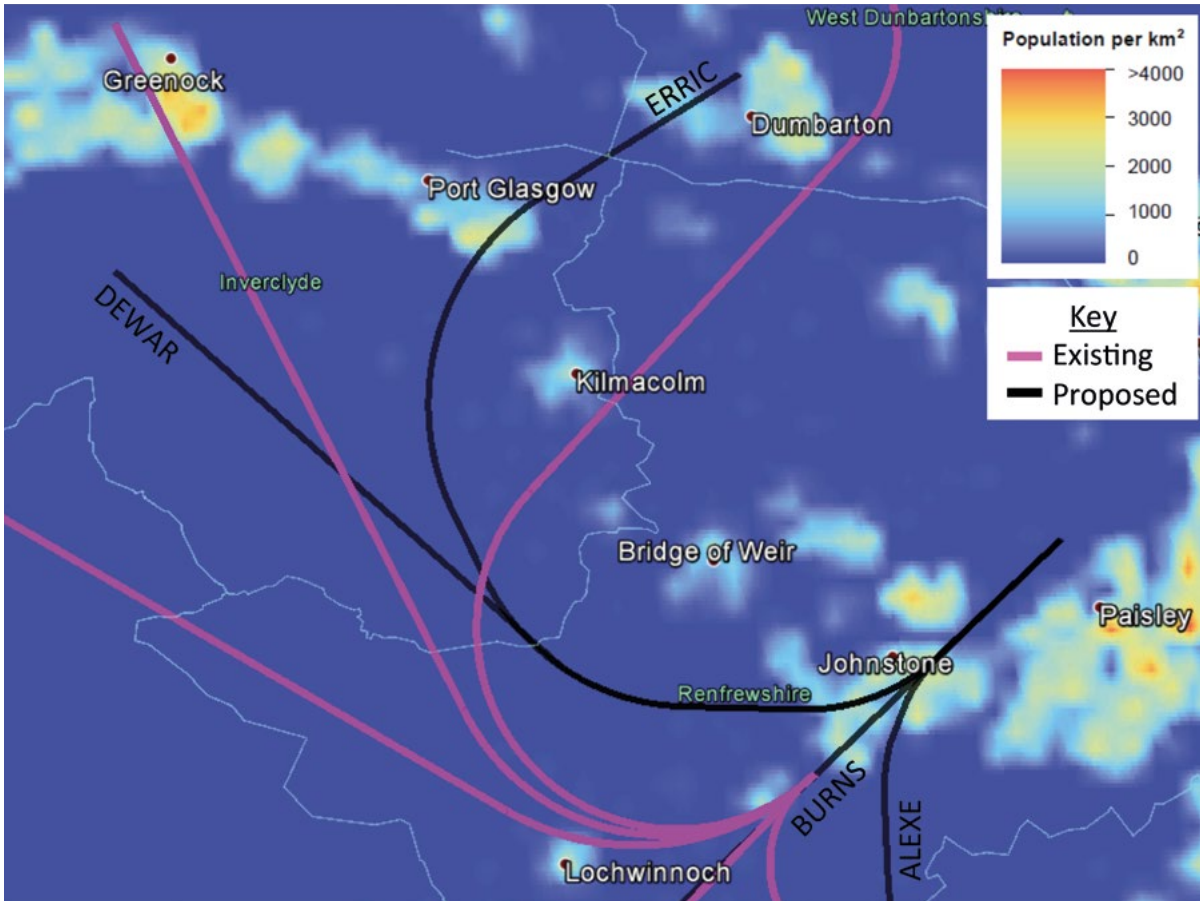

Figure 10: SIDs DEWAR and ERRIC with 2011 Census Population Heat Map with 2017 CACI Population Data

B.4.5. Although the graphics present the point at which the procedures are designed to reach 6,000ft, it is highly likely that the aircraft will out-perform the required climb gradient.[4]

B.5. Navigational Accuracy

B.5.1. All the proposed SIDs will utilise a higher navigational standard. RNAV-1 criteria requires that 95% of all traffic be within 1NM of the blue lines. 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.

B.5.2. **Figures 11, 12 and 13** can be downloaded as separate documents from our website - www.glasgowairport.com/airspace and can also be seen below. They indicate a 1NM swathe either side of the proposed SIDs against an Ordnance Survey background. **Figures 12 and 13** also depict the expected usage of these five departure procedures when Runway 23 is in use, expressed as a percentage.

[4] Trials of each of the SIDs in a Boeing 737-800 simulator resulted in an altitude of 9,500ft being reached by the end of SID DEWAR and over 12,000ft being reached by the end of SID ERRIC.

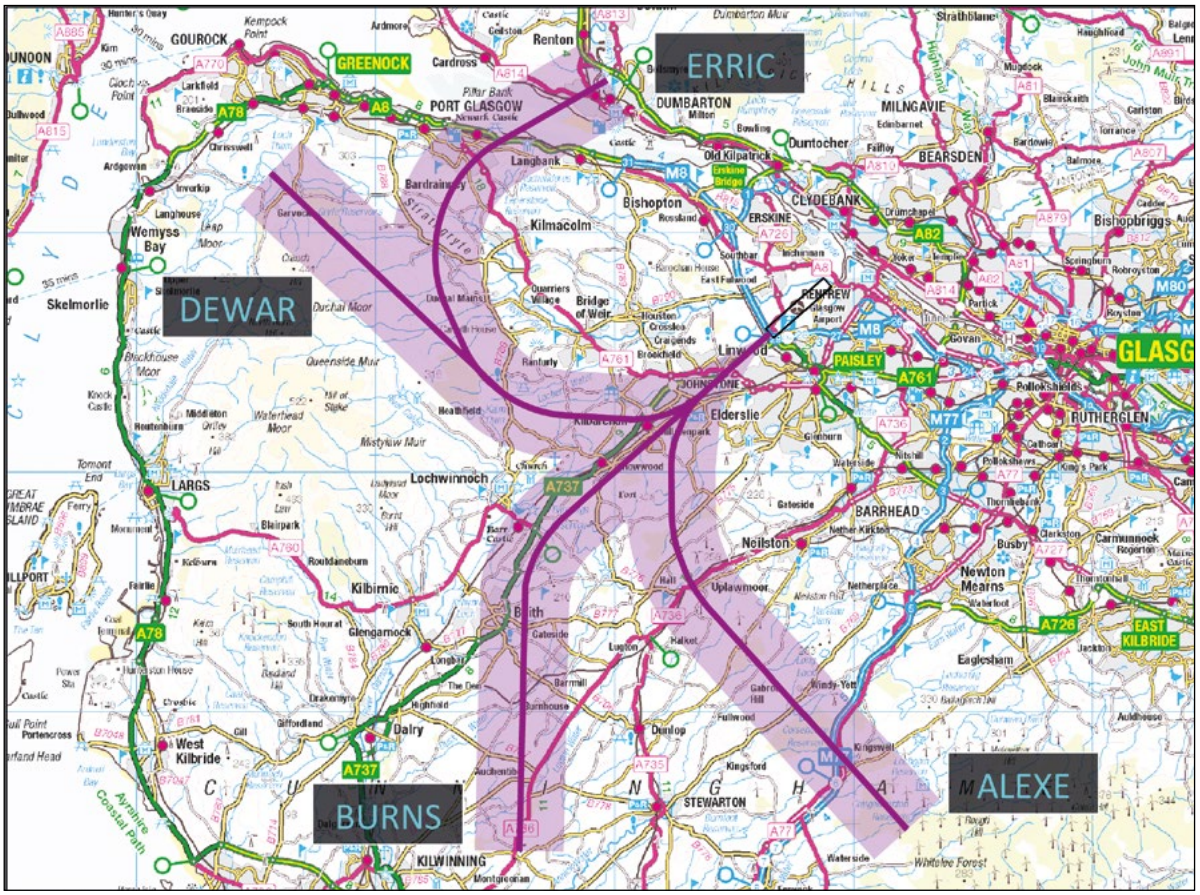

Figure 11: Runway 23 Proposed SID Array RNAV-1 Swathe

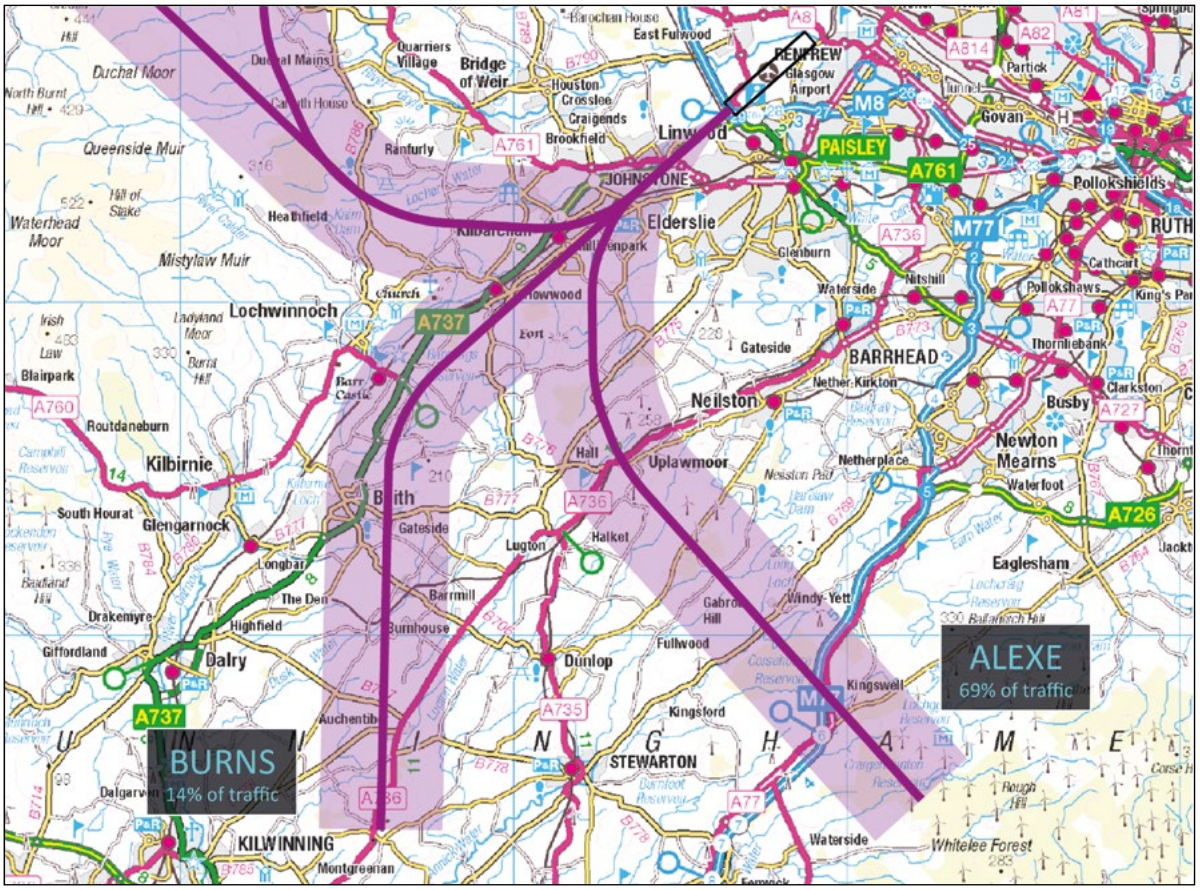

Figure 12: SIDs ALEXE and BURNS RNAV-1 Swathe

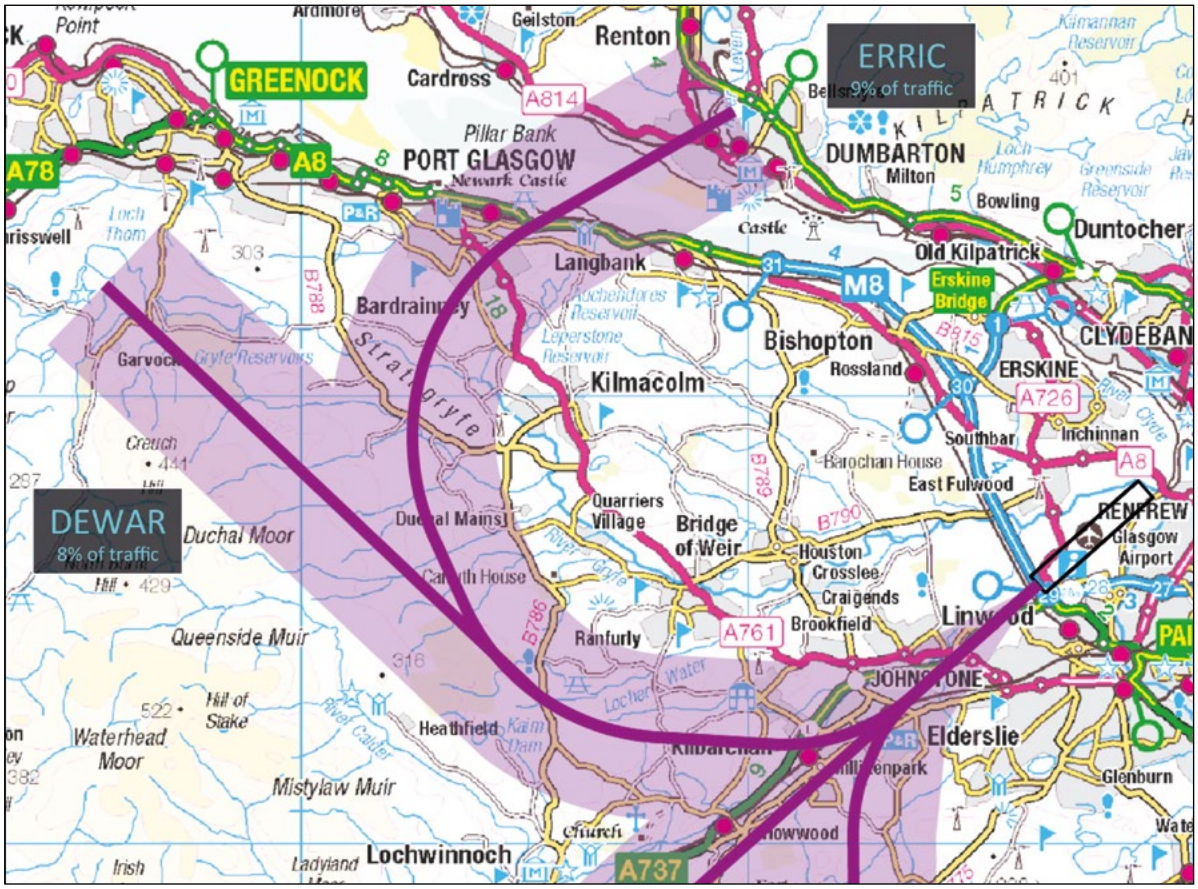

Figure 13: SIDs DEWAR and ERRIC RNAV-1 Swathe

B.6. Environmental Impact Assessment

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

B.7. Summary

B.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.

B.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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