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GEORGE BEST BELFAST CITY AIRPORT

2022 ANNUAL REPORT

Report to

George Best Belfast City Airport
Sydenham By-Pass
Belfast
BT3 9JH

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29 March 2023

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1.0 INTRODUCTION

The planning agreement[1] between Belfast City Airport Limited (BCA) and the Department for Infrastructure dated 22 July 2019 sets out regular reporting that the airport is required to make. The required reporting includes an Annual Performance Report (APR) which is to be submitted annually on 31 March. The content of the APR is detailed in paragraphs 6.7.1 to 6.7.15 of *PART II The Covenants* of the agreement.

Bickerdike Allen Partners LLP (BAP) have been retained by George Best Belfast City Airport (GBBCA) to produce some of the information required for the APR, specifically the information related to the following paragraphs:

- 6.7.1 Noise exposure contours
- 6.7.2 Comparison of noise contour areas
- 6.7.3 Air traffic movements the contours are based on
- 6.7.6 The Quota Count for the previous year
- 6.7.7 A record of movements by aircraft types not permitted to use the airport in the previous year (those only marginally compliant with Chapter 3)
- 6.7.14 (Partial) An evaluation of the data reported, specifically that we are preparing.

Noise contours have been produced for 2022 based on the actual aircraft movements over the 92 day summer period, and for 2023 and 2024 based on forecasts provided by GBBCA. All of the noise contours have been produced using the Federal Aviation Administration's prediction software, the Integrated Noise Model (INM) version 7.0d. This methodology has been validated for the key aircraft types operating at the airport, using results from the Noise Monitoring Terminals (NMTs) installed at GBBCA.

Section 2 of this report gives details of the air traffic movements used to produce the noise contours. Section 3 gives details of the methodology used to produce the noise contours. Section 4 reports the areas of the noise contours and compares them with the 57 dB $L_{Aeq,16h}$ noise contour area limit. Population counts for the key noise exposure contours are also provided. Section 5 reports the results of the quota count assessment for 2022. Section 6 gives details of movements in 2022 by aircraft types that were only marginally compliant with Chapter 3.

[1] Agreement Pursuant to Section 77(1)(a) of the Planning Act (Northern Ireland) 2011

A glossary of acoustic terms can be found in Appendix 1 and Appendix 2 contains details of BAP's noise contour validation exercise.

2.0 AIRCRAFT MOVEMENTS

The basis for the 2022 noise contours are the actual movements during the 92 day summer period, 16 June to 15 September inclusive. Detailed information was provided by GBBCA for all aircraft movements during this period. Although a small proportion of movements occur early in the morning between 6:30 and 7:00 or late in the evening between 23:00 and 00:00 over the 92 day period, for the production of the noise contours all movements have been modelled as taking place within the "daytime period" of 07:00 to 23:00.

The actual movements in 2022 include 40 movements by helicopters. Historically helicopters have not been modelled at GBBCA, as they typically comprise less than 1% of the total movements, and this was also the case in 2022. Their continued omission is not considered significant to the overall contours due to their small number of movements and maintains consistency with previous contouring.

Compared to 2021, there has been an increase in movements from 4,568 to 8,223 in 2022 although this remains less than the 9,745 movements in 2019. This increase comes alongside a significant change in fleet mix compared to 2021, with passenger turboprop aircraft now comprising the majority of movements.

Forecasts of summer movements have been provided for 2023 and 2024. Total summer movements are forecast to remain similar at 8,197 in 2023. Summer movements in 2024 are forecast to increase by around 3% to 8,426. The forecasts include an allowance for general aviation (GA) movements, without specifying particular aircraft types. These movements have been modelled based on the GA types which operated in summer 2022.

The INM software includes noise information for many common aircraft types, but as with all noise modelling software, it does not include every aircraft type. This means that substitutions are required, where an alternative aircraft type is used to model the actual type. For larger aircraft this generally does not involve a change but for the smaller types, and in particular the general aviation aircraft, substitutions occur. Where INM has no guidance, an aircraft type has been assigned based on the aircraft size and engine details. Table 1 below shows the aircraft movements by aircraft type in summer 2022 and those forecast for 2023 and 2024. It also includes the INM type used for each aircraft type in the modelling. "n/a" is shown where a type performed fewer than 10 movements or for the forecast movements was not specifically included in the forecast. Movements by these types have been grouped under "other."

Aircraft Type	INM Type(s)	Summer Fixed Wing Movements		
		2022 Actual	2023 Forecast	2024 Forecast
Airbus A319	A319-131[1]	448	794	865
Airbus A320ceo	A320-211[1]	862	1,089	1,320
Airbus A320neo	A320-211[1]	86	400	471
Airbus A321neo	A321-232	n/a	17	17
ATR 42	DO328	140	53	0
ATR 72	DO328/DHC6[1]	3,240	4,489	4,258
Beechcraft Super King Air	CNA441	12	n/a	n/a
Cessna CitationJet CJ2	CNA525C	10	n/a	n/a
Cessna Citation Excel	CNA560XL	32	n/a	n/a
Diamond DA-62	BEC58P	10	n/a	n/a
De Havilland Canada DHC-8	SD330/DHC6[1]	1,662	0	0
Embraer E135	EMB145	12	n/a	n/a
Embraer E145	EMB145	369	158	158
Embraer E175	EMB175/737500[1]	600	0	0
Embraer E190	EMB190[1]	532	916	1,048
Embraer Legacy 500	CNA55B	14	n/a	n/a
Embraer Phenom 300	CNA510	10	n/a	n/a
Eclipse 500	ECLIPSE500	12	n/a	n/a
Hawker 800	LEAR35	12	n/a	n/a
Pilatus PC-12	CNA208	18	n/a	n/a
Other (less than 10 movements)	Various	142	282	290
Total[2]		**8,223**	**8,197**	**8,426**

[1] INM type modified based on results of a validation exercise.

[2] Forecast totals may not match due to rounding.

Table 1: 2022, 2023 and 2024 Summer Fixed Wing Movements

3.0 NOISE CONTOUR METHODOLOGY

3.1 General

The aircraft movement data, provided by GBBCA, has been assessed in relation to aircraft type, departure and arrival route, flight profiles and runway usage to enable input into the noise computation program, the Integrated Noise Model (INM). This section of the report describes how this information has been compiled in a form suitable for analysis purposes.

3.2 Runway Usage

The overall split of movements by runway during the 2022 summer period is given in Table 2, and is compared with the long term average (2018-2022). For the 2022 actual contours, the actual runway usage for each individual movement was used. For the 2023 and 2024 forecast contours the long term average modal split has been used.

Runway	% of Summer Movements			
	2022		2018-2022 Average	
	Arrivals	Departures	Arrivals	Departures
04	41%	45%	35%	39%
22	59%	55%	65%	61%

Table 2: 2022 and Long Term Average Summer Modal Split

The usage of the runways is dependent on the direction of the wind, therefore some variation is to be expected between individual years. Compared to the long term average there was around 6% more usage of runway 04 by both arrivals and departures in 2022, with corresponding decreases in the usage of runway 22.

3.3 Flight Tracks

For each runway there is a single modelled arrival route, which follows the runway centreline. There is one modelled initial departure route on runway 22, but four modelled initial departure routes on runway 04.

A validation exercise was undertaken in 2011 to validate the flight tracks used in the INM software. The details of this exercise are shown in Appendix B of the BAP report Ref: A9443-R01-NW dated November 2011. The resulting main departure tracks are shown in Figure 01 and have been used for the contours as there have been no changes to the published routes since 2011.

The method of determining the split of aircraft between the routes from runway 04 takes into account both aircraft type and destination. Where the destination is in Scotland or in Northern Europe (Iceland, Norway, etc.) the initial route heading in a north easterly direction is used. The remaining traffic is split amongst the three routes which turn south. The particular route depends on the distance at which the aircraft type involved is expected to have achieved one of a set of specific altitudes, as required by the airport's noise abatement procedures. These altitudes are 1,500 ft for small propeller aircraft (maximum takeoff weight of up to 13,000 kg); 2,000 ft for large propeller aircraft; and 3,000 ft for jet aircraft.

3.4 Dispersion

Aircraft on departure are allocated a departure route to follow. In practice, this route is not followed precisely by all aircraft. To allow for this the INM software was used to generate a mean track for each of the five initially distinct routes, and these mean tracks were then dispersed as described below.

The dispersion model has the common assumption that there are five "dispersed" tracks associated with each departure route; these comprise the mean track of each route and two sub-tracks either side, as the actual pattern of departing aircraft is dispersed about the route's centreline. The degree of dispersion is normally a function of the distance travelled by an aircraft along the route after take-off and also on the form of the route.

When considering many departures, it is commonly found that the spread of aircraft approximates to a "normal distribution" pattern. A simplified mathematical model can be adopted to represent a normal distribution of events, based on standard deviations. Five "dispersed" tracks associated have been used to model each departure route; these comprise the mean track of each route and two sub-tracks either side. The resulting allocation of movements to each track is as follows:

- 53.3% departures along the main track;
- 22.2% departures split equally along two inner sub tracks either side of the main track and offset by a distance of 1.355 standard deviations;
- 1.15% departures split equally along two outer sub tracks either side of the main track and offset by a distance of 2.71 standard deviations.

This dispersion model has been used in the INM software, which generates the sub-tracks with distances supplied by the user. The distances and percentages used have been determined by BAP from analysis of similar activity at other airports.

3.5 Flight Profiles

For departure movements the INM software offers a number of standard flight profiles for most aircraft types, particularly for the larger aircraft types. These relate to different departure weights which are greatly affected by the length of the flight, and consequently the fuel load. In the INM software this is referred to as the stage length. The stage length increases in increments of 500 nmi up to 1,500 nmi and then in increments of 1,000 nmi. As the stage length increases, the aircraft has to depart with greater fuel, and so its flight profile is slightly lower than when a shorter stage length is flown.

For the 2022 contours, destination airports were given with the actual movements. Stage lengths have been assigned, where INM offers the option, based on the distance of these airports from GBBCA.

For the forecast 2023 and 2024 contours GBBCA have provided information on the expected destinations served by most aircraft types. For these, stage lengths have been assigned where INM offers the option based on the distance of these airports from GBBCA. The other movements without a destination are generally by general aviation. All of these other movements have been modelled as stage length 1, which in most cases is the only option available in the INM for the aircraft type.

3.6 INM Model

All contours and population counts have been determined using the Integrated Noise Model (INM) version 7.0d software. GBBCA data relevant to the INM study is taken from the latest edition of the UK Aeronautical Information Package. A 3.0° approach angle has been used for all aircraft and the ground topography has been assumed to be flat. The INM default headwind of 14.8 km/h has been assumed.

Results from the airport's Noise Monitoring Terminals (NMTs) from the period September 2021 to September 2022 have been used in the 2022 validation exercise to review the INM assumptions for the key aircraft types operating at GBBCA.

The 2022 validation exercise included reviewing seven key aircraft types, to better model their operations at GBBCA. The result is that the modelled noise characteristics of some of these aircraft have been adjusted by modifying the INM aircraft used and/or the noise level of the INM aircraft types as necessary. Where modifications have been made to the noise levels, this has been by applying a factor to the number of movements. These adjustments are detailed in Table 3 below.

Aircraft Type	Default INM Type	Modification to INM Assumptions	
		Arrivals	Departures
Airbus A319ceo	A319-131	A319-131 × 0.7	A319-131 × 1.2
Airbus A320ceo	A320-211	A320-211 × 1.0	A320-211 x 1.0
Airbus A320neo	-	A320-211 × 0.6	A320-211 x 0.4
ATR 72	DO328	DO328 × 0.5	DHC6 × 1.0
Bombardier Dash 8	-	SD330 × 1.1	DHC6 × 0.5
Embraer E175	EMB175	EMB175 × 0.7	737500 × 1.1
Embraer E190	EMB190	EMB190 × 1.0	EMB190 × 1.8

Table 3: Modifications to INM Assumptions Used for the Contours

Some changes have been made to the modifications compared to those used for the 2021 contours. In particular, the Airbus A319ceo has a smaller reduction on arrival, whereas the ATR 72 has a greater reduction on arrival.

The Boeing 737-800 has been removed, as there were no movements by this aircraft type in the 2022 summer period. The Bombardier Dash 8 and Embraer E175 have been included since they now constitute a larger proportion of movements. They were last previously validated in 2020. Full details of the 2022 validation exercise are given in Appendix 2.

4.0 NOISE CONTOURS

Noise contours for 2022, 2023 and 2024 in terms of the $L_{Aeq,16h}$ metric have been produced for the 16 hour daytime period, 07:00 to 23:00; although they also include the movements that occur between 06:30 and 07:00 and the small number that occurred between 23:00 and 00:00. They are based on the actual movements for the 92 day summer period in 2022 and the forecasts provided for 2023 and 2024 as detailed in Section 2. The areas of the noise contours are given in Table 4, where they are compared with the 57 dB $L_{Aeq,16h}$ contour area limit.

The 2022 actual, 2023 forecast and 2024 forecast noise contours are shown in Figures 02, 03 and 04 respectively at values from 54 to 69 dB $L_{Aeq,16h}$ in 3 dB steps. The 57 dB contours for all three years are compared in Figure 05.

Contour Level (dB $L_{Aeq,16h}$)	Area of Daytime Air Noise Contours (km^2)			Contour Area Limit $(km)^2$
	2022	2023	2024	
54	5.08	5.96	6.43	-
57	2.61	3.12	3.40	5.2
60	1.38	1.63	1.77	-
63	0.78	0.92	0.99	-
66	0.47	0.54	0.58	-
69	0.29	0.34	0.36	-

Table 4: 2022, 2023 and 2024 Noise Contour Areas

The area of the 2022 57 dB $L_{Aeq,16h}$ contour area is 2.61 km^2, which is well below the contour area limit of 5.2 km^2. The areas of the noise contours for 2022 have decreased slightly compared to 2021. This is due to the change in fleet mix, with the much greater use of quieter turboprop aircraft types countering the overall increase in movements. The contour areas also remain smaller than in 2019.

The noise contour areas are forecast to increase over the next two years. The 57 dB contour areas are forecast to remain below the contour area limit in 2023 and 2024. The increase in contour area is due to changes in the fleet, with increased movements by passenger turbofan types more than offsetting the absence of movements by the quieter Bombardier Dash 8. The latter due to the collapse of FlyBe.

4.1 Population and Dwelling Counts

The population and dwelling data has been derived from a 2022 postcode database supplied by CACI Ltd. Population counts for the 2022, 2023 and 2024 $L_{Aeq,16h}$ daytime contours are given in Table 5 and Table 6 below, the corresponding dwelling counts are given in Table 7 and Table 8.

Contour Level (dB $L_{Aeq,16h}$)	2022 Population	2023 Population	2024 Population
54	8,544	10,992	12,656
57	1,295	2,792	3,438
60	0	0	20
63	0	0	0
66	0	0	0
69	0	0	0

Table 5: Comparison of 2022, 2023 and 2024 Population Counts – Cumulative Totals

Year	Population by Contour Band (dB $L_{Aeq,16h}$)						Total
	> 69	69 – 66	66 – 63	63 – 60	60 – 57	57 – 54	
2022	0	0	0	0	1,295	7,249	8,544
2023	0	0	0	0	2,792	8,200	10,992
2024	0	0	0	20	3,418	9,218	12,656

Table 6: Comparison of 2022, 2023 and 2024 Population Counts

Contour Level (dB $L_{Aeq,16h}$)	2022 Dwellings	2023 Dwellings	2024 Dwellings
54	3,988	5,151	5,976
57	588	1,257	1,548
60	0	0	11
63	0	0	0
66	0	0	0
69	0	0	0

Table 7: Comparison of 2022, 2023 and 2024 Dwelling Counts – Cumulative Totals

Year	Dwellings by Contour Band (dB $L_{Aeq,16h}$)						Total
	> 69	69 – 66	66 – 63	63 – 60	60 – 57	57 – 54	
2022	0	0	0	0	588	3,400	3,988
2023	0	0	0	0	1,257	3,894	5,151
2024	0	0	0	11	1,537	4,428	5,976

Table 8: Comparison of 2022, 2023 and 2024 Dwelling Counts

The number of people and dwellings within each contour has reduced compared to 2021 and remains less than in 2019. The 2023 contours contain more people and dwellings than the 2022 contours, due to increase in the area of the 2023 contours. The number of people and dwellings in the contours is forecast to increase further in 2024, due to the increase in contour area.

There were no people or dwellings within the 63 – 60 dB $L_{Aeq,16h}$ contour band in 2022. This is forecast to remain the same in 2023. In 2024 there are forecast to be 20 people and 11 dwellings within this contour band.

5.0 QUOTA COUNT

As part of their planning agreement BCA are required to report the quota count for the year just completed. The quota count is based on the aircraft movements in the 92 day summer period and is limited to 4,665.

The quota count production methodology is described in paragraphs 6.4 to 6.6 of *PART II The Covenants* of the agreement. In summary, the method requires the certification data for the aircraft type, which is then processed and compared to a scale to determine the quota count for the aircraft type when arriving, and separately when departing.

For the aircraft that operated, the noise certification data has been obtained either from the noise certificate of the specific aircraft, or for those registered in the UK from the CAA G-INFO database[2] and those registered in Switzerland from the FOCA Swiss Aircraft Register[3]. Where certification data was not available, quota count values have been taken from the tables in the latest UK AIP Supplement[4]. In some cases the tables offer more than one value for an aircraft type, in these cases the expected QC value based on available information has been used, and where only limited information is available the higher QC value has been taken.

The resulting quota count total for summer 2022 was 1,640.875, which is less than the limit of 4,665. Table 9 below gives details of how the quota count for summer 2022 has been calculated, including the specific arrival and departure quota count values used for the key aircraft types. Where more than one quota count value has been used for an aircraft type based on the individual noise certificates, both values are shown.

[2] https://siteapps.caa.co.uk/g-info/
[3] https://app02.bazl.admin.ch/web/bazl/en/#/lfr/search
[4] https://www.aurora.nats.co.uk/htmlAIP/Publications/2022-09-22/pdf/EG-eSUP-2022-058-en-GB.pdf

Aircraft Type	Arrivals	Arr. QC	Departures	Dep. QC	QC Total
Airbus A319	223	0.25	210 15	0.25 0.5	115.750
Airbus A320ceo	432	0.25	430	0.5	323.000
Airbus A320neo	43	0.125	43	0.125	10.750
ATR 42	70	0.125	70	0	8.750
ATR 72	1,621	0.125	1,619	0.125	405.000
Beechcraft Super King Air	6	0	6	0	0.000
Cessna CitationJet CJ2	3 2	0 0.125	3 2	0 0.125	0.500
Cessna Citation Excel	15 1	0.125 0.25	16	0	2.125
Diamond DA-62	5	0	5	0	0.000
Bombardier Dash 8	832	0.25	830	0.125	311.750
Embraer E135	6	0.125	6	0.125	1.500
Embraer E145	184	0.125	185	0.125	46.125
Embraer E175	300	0.25	18 282	0.25 0.5	220.500
Embraer E190	266	0.125	49 217	0.25 0.5	154.000
Embraer Legacy 500	6 1	0 0.125	6 1	0 0.125	0.250
Embraer Phenom 300	5	0	5	0	0.000
Eclipse 500	6	0	6	0	0.000
Hawker 800	5 1	0.25 0.5	5 1	0.125 0.25	2.625
Pilatus PC-12	9	0	9	0	0.000
Other[1]	92	Various	90	Various	38.250
Total	**4,134**	**-**	**4,129**	**-**	**1,640.875**

[1] Includes 40 movements by helicopters

Table 9: Summer 2022 Quota Count

6.0 MARGINALLY COMPLIANT CHAPTER 3 AIRCRAFT MOVEMENTS

As part of their planning agreement BCA are required to accept in respect of jet aircraft, only those air traffic movements that comply with the certificate limits, as laid down in Chapter 3 of Annex 16, of the standards adopted by the International Civil Aviation Organisation Council and which are not Marginally Compliant Aircraft. In the agreement these are defined as:

> 11. 'Marginally Compliant Aircraft' means civil subsonic jet aeroplanes, that meet the certification limits as laid down in Chapter 3 of Annex 16 by a cumulative margin of not more than 5 EPNdB, whereby the cumulative margin is a figure expressed in EPNdB obtained by adding the individual margins at each of the three reference noise management points as defined in Chapter 3 of Annex 16

BCA are required to report any movements in the year just completed by any aircraft not permitted to use the airport.

For the aircraft that operated in 2022, the noise certification data has been obtained either from the noise certificate of the specific aircraft, or for those registered in the UK from the CAA G-INFO database[2] and those registered in Switzerland from the FOCA Swiss Aircraft Register[3]. Where specific certification data was not available, certification values have been taken from the latest EASA Approved Noise Levels[5].

In some cases, the EASA database offers more than one possible classification for an aircraft type. In these cases a worst case assumption has been made.

There were no movements in 2022 by jet or large propeller aircraft types that do not meet the requirements of Chapter 3 or are only marginally compliant with Chapter 3, as shown below in Table 10. The table also includes the number of movements that fully comply with Chapter 3 or comply with the more stringent Chapter 4 or Chapter 14. The certification of helicopters and light propeller aircraft is to different standards and so these aircraft have been separately recorded.

[5] https://www.easa.europa.eu/easa-and-you/environment/easa-certification-noise-levels

2022 Aircraft Movements					
Not Chapter 3 or Chapter 3 Marginally Compliant	**Chapter 3 Fully Compliant**	**Chapter 4**	**Chapter 14**	**Helicopters and Light Propeller Aircraft**	**Total**
0	669	13,721	10,695	411	25,496

Table 10: 2022 Aircraft Noise Classification

7.0 SUMMARY

$L_{Aeq,16h}$ noise contours and the associated population counts have been produced, based on the actual movements during the 92 day summer period in 2022, and the forecast summer movements for 2023 and 2024. The movements used to produce them have been reported in addition to the contours and the number of people they contain.

The area of the 2022 57 dB $L_{Aeq,16h}$ contour area at 2.61 km^2 is well below the contour area limit of 5.2 km^2. The noise contour areas are forecast to increase over the next two years. However, the area of the 57 dB contours for 2023 and 2024 are forecast to remain below the contour area limit.

The 2022 57 dB $L_{Aeq,16h}$ contour contains 588 dwellings and a population of 1,295. There are no dwellings in the 60 dB or higher contours. The number of people and dwellings within the contours is forecast to increase over the next two years, mainly due to the forecast increase in aircraft movements. In 2023 there are no dwellings forecast to be in the 60 dB or higher contours. In 2024 there are forecast to be 20 people and 11 dwellings in the 60 – 63 dB contour band, but no dwellings in the 63 dB or higher contours.

The quota count total for summer 2022 was 1,640.875, which is less than the limit of 4,665.

There were no movements in 2022 by jet or large propeller aircraft types that do not meet the requirements of Chapter 3 or are only marginally compliant with Chapter 3, in compliance with the restriction on the airport.

Mike Pau	**Duncan Rogers**	**David Charles**
for Bickerdike Allen Partners LLP	**Acoustic Consultant**	**Partner**

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LEGEND:

Initial Departure Routes

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Belfast City Airport
Regular Reporting

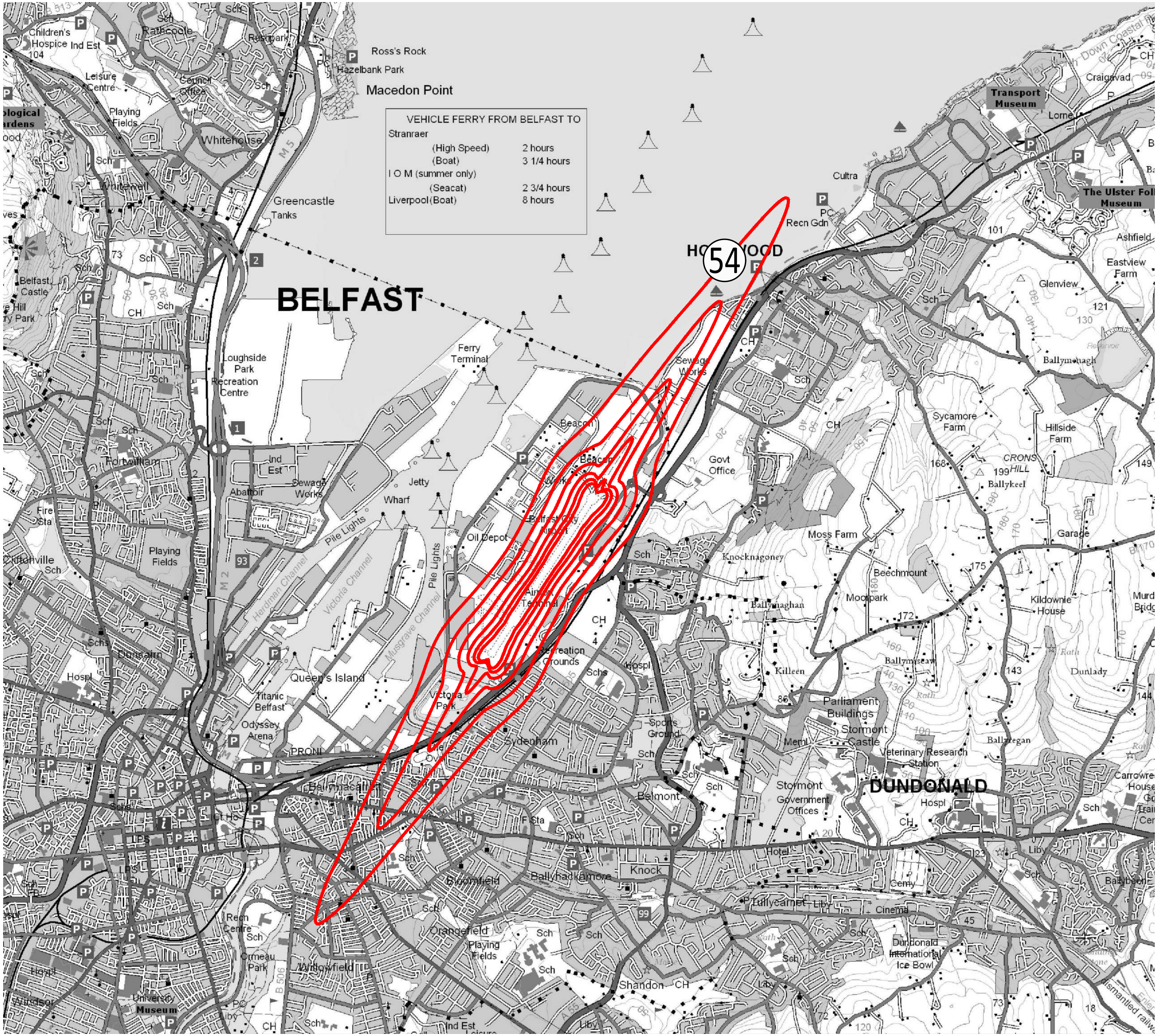
Figure 01
Initial Departure Routes

DRAWN: MP CHECKED: DR

DATE: November 2022 SCALE: 1:125,000@A4

FIGURE No:

A11298_11_DR001_1.0



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LEGEND:

Noise Contours,

54 to 69 dB $L_{Aeq,16h}$ in 3 dB steps

REVISIONS

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Belfast City Airport
Regular Reporting

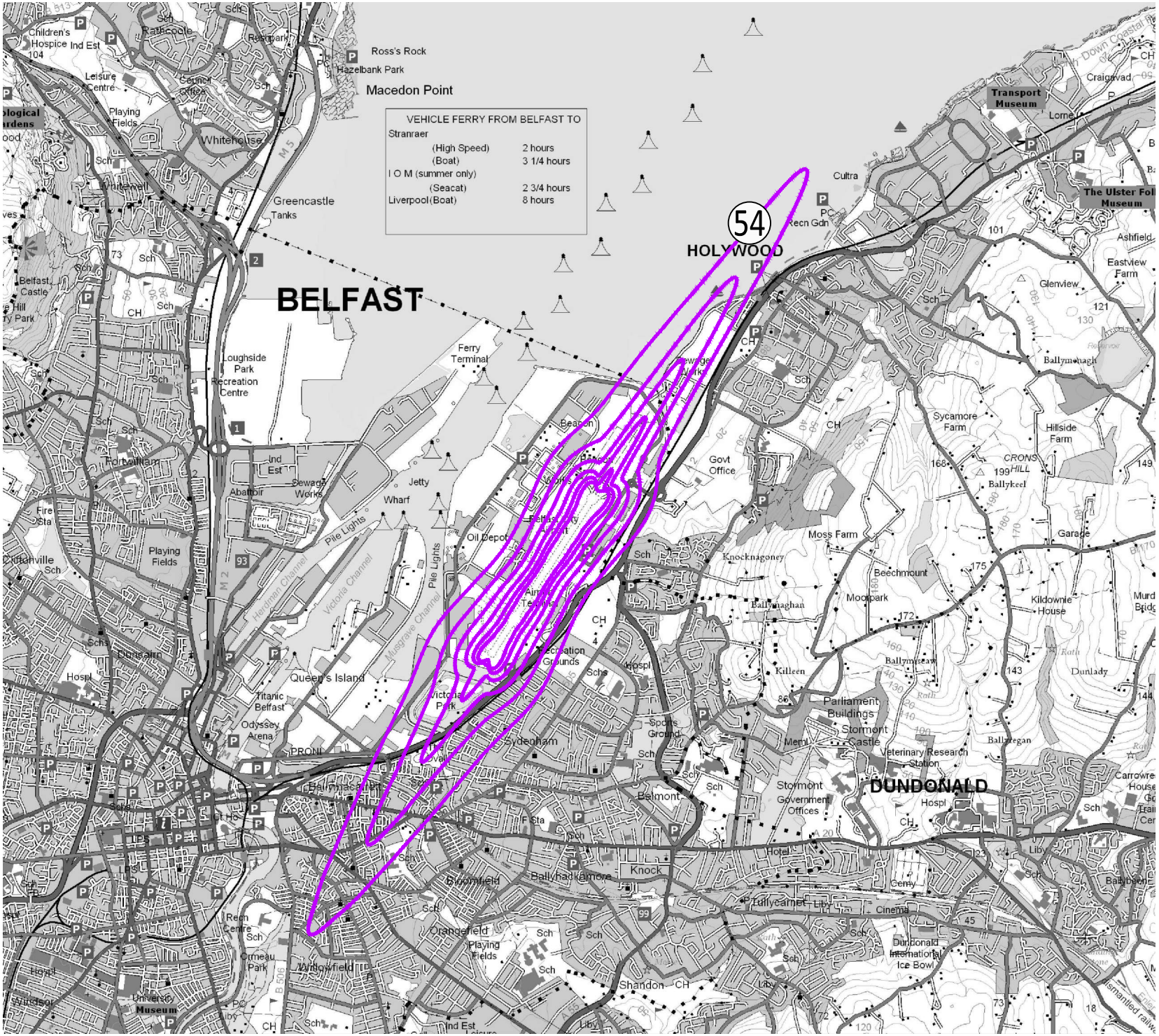
Figure 02
Summer Daytime Noise Contours
2022

DRAWN: MP CHECKED: DR

DATE: December 2022 SCALE: 1:50,000@A4

FIGURE No:

A11298_11_DR002_1.0



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LEGEND:

Noise Contours,
54 to 69 dB $L_{Aeq,16h}$ in 3 dB steps

REVISIONS

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Belfast City Airport
Regular Reporting

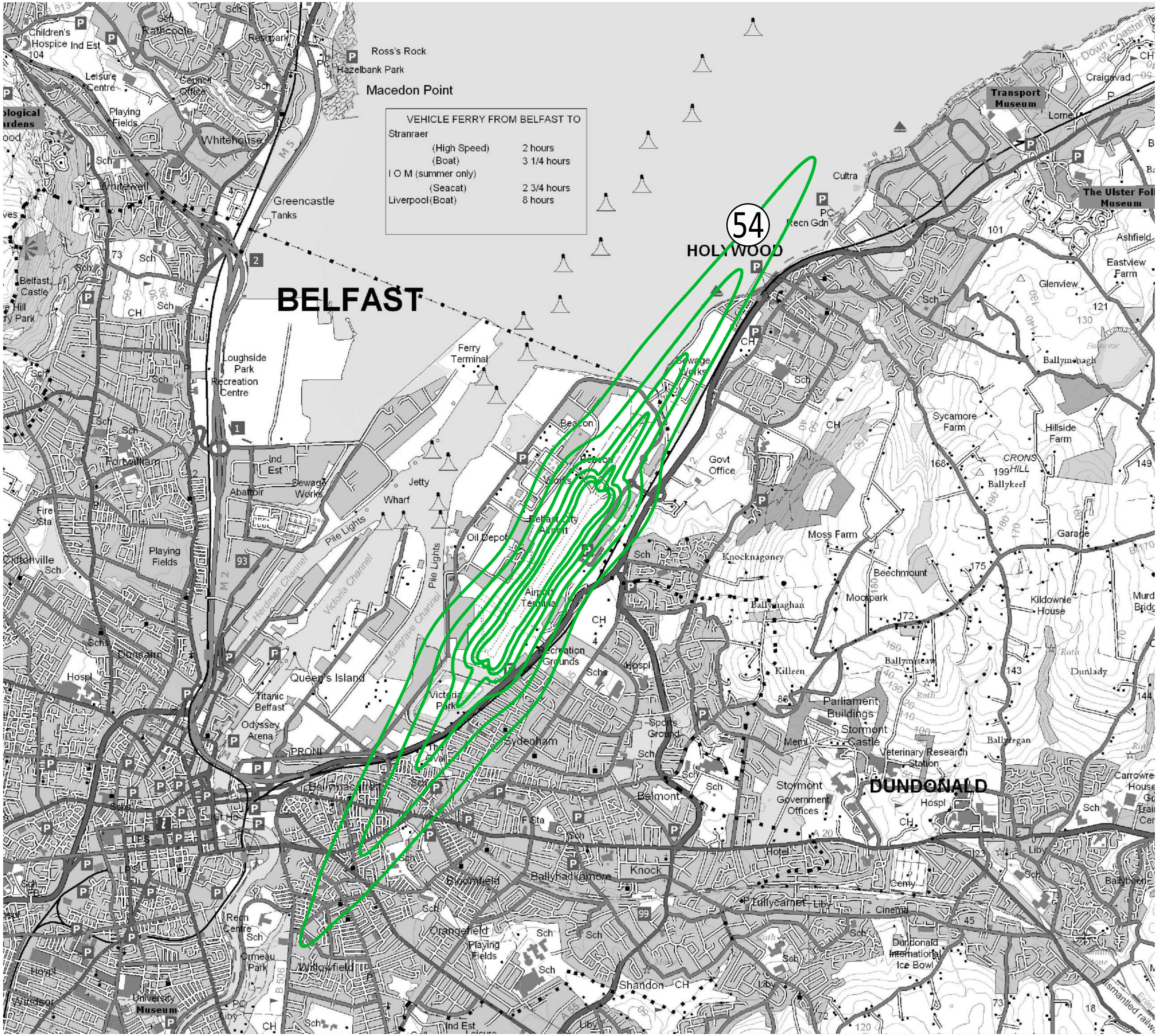
Figure 03
Summer Daytime Noise Contours
2023 Forecast

DRAWN: DR CHECKED: DC

DATE: March 2023 SCALE: 1:50,000@A4

FIGURE No:

A11298_11_DR003_2.0



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<u>LEGEND:</u>

Noise Contours,

54 to 69 dB $L_{Aeq,16h}$ in 3 dB steps

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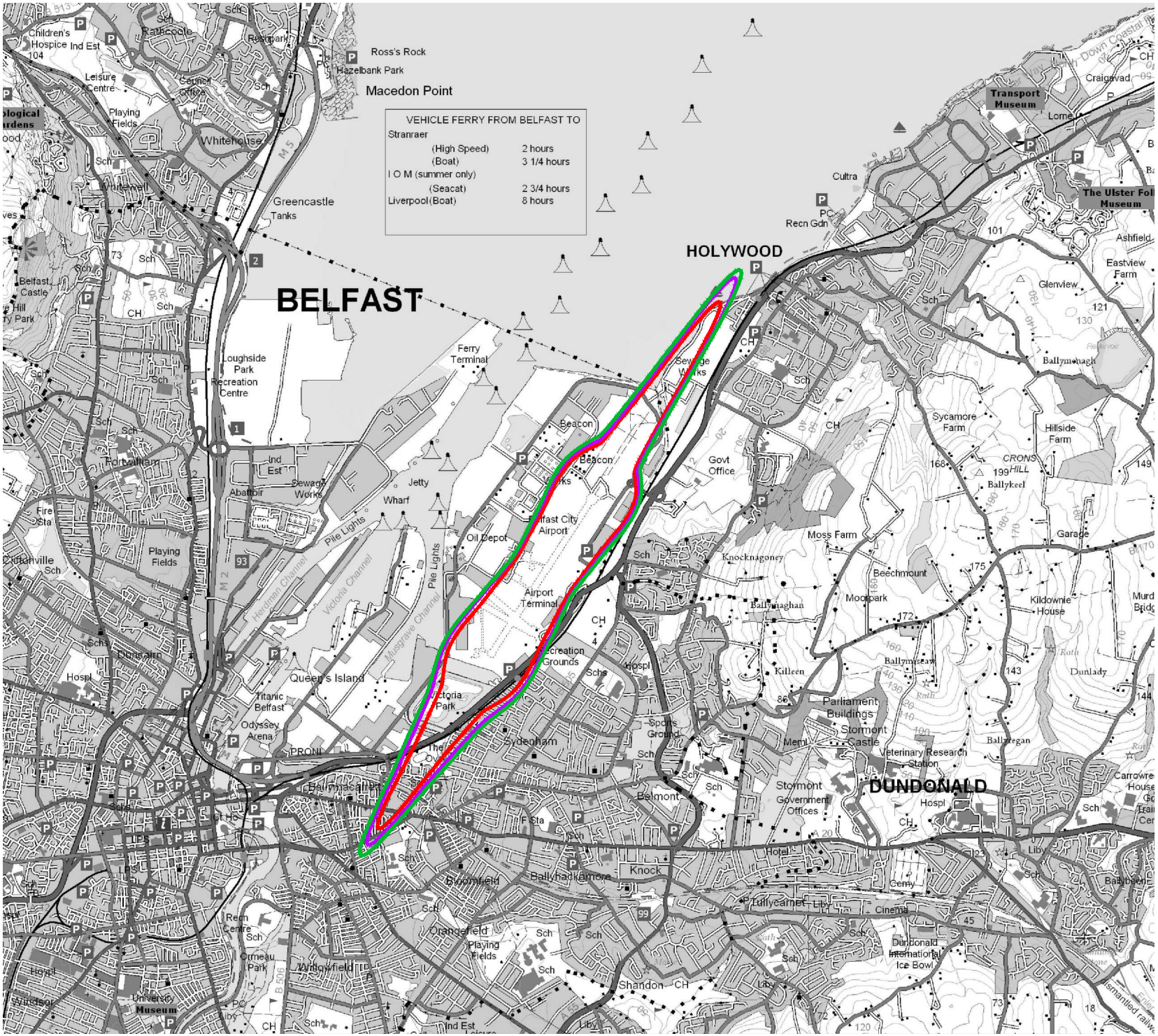
Figure 04
Summer Daytime Noise Contours
2024 Forecast

DRAWN: DR CHECKED: DC

DATE: March 2023 SCALE: 1:50,000@A4

FIGURE No:

A11298_11_DR004_2.0



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LEGEND:

Noise Contours,

- 2022
- 2023
- 2024

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Figure 05
Summer Daytime Noise Contours
2022, 2023 and 2024 57 dB $L_{Aeq,16h}$

DRAWN: DR CHECKED: DC

DATE: March 2023 SCALE: 1:50,000@A4

FIGURE No:

A11298_11_DR005_2.0

APPENDIX 1
GLOSSARY OF ACOUSTIC TERMINOLOGY

Sound

This is a physical vibration in the air, propagating away from a source, whether heard or not.

The Decibel, dB

The unit used to describe the magnitude of sound is the decibel (dB) and the quantity measured is the sound pressure level. The decibel scale is logarithmic and it ascribes equal values to proportional changes in sound pressure, which is a characteristic of the ear. Use of a logarithmic scale has the added advantage that it compresses the very wide range of sound pressures to which the ear may typically be exposed to a more manageable range of numbers. The threshold of hearing occurs at approximately 0 dB (which corresponds to a reference sound pressure of 2 x 10-5 Pascals) and the threshold of pain is around 120 dB.

The sound energy radiated by a source can also be expressed in decibels. The sound power is a measure of the total sound energy radiated by a source per second, in Watts. The sound power level, L_w is expressed in decibels, referenced to 10-12 Watts.

Frequency, Hz

Frequency is analogous to musical pitch. It depends upon the rate of vibration of the air molecules which transmit the sound and is measure as the number of cycles per second or Hertz (Hz). The human ear is sensitive to sound in the range 20 Hz to 20,000 Hz (20 kHz). For acoustic engineering purposes, the frequency range is normally divided up into discrete bands. The most commonly used bands are octave bands, in which the upper limiting frequency for any band is twice the lower limiting frequency, and one-third octave bands, in which each octave band is divided into three. The bands are described by their centre frequency value and the ranges which are typically used for building acoustics purposes are 63 Hz to 4 kHz (octave bands) and 100 Hz to 3150 Hz (one-third octave bands).

A-Weighting

The sensitivity of the ear is frequency dependent. Sound level meters are fitted with a weighting network which approximates to this response and allows sound levels to be expressed as an overall single figure value, in dB(A).

Effective Perceived Noise Level

Effective Perceived Noise Level (EPNL) is a measure used to express noise levels which analyses the frequency spectra of noise events as well as the duration of sound. The measurement unit for EPNL is EPNdB. This measure is used for the noise certification of aircraft, and the subsequent quota count determination.

Quota Count

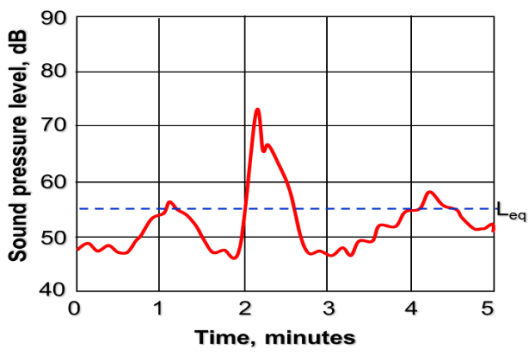
The value assigned to one take-off or to one landing by the aircraft in question, this number being related to its noise classification. The classification is determined from the noise level band in EPNdB, for take-off or landing, as the case may be, for the aircraft in question, as defined in the individual aircraft's noise certificate.

Environmental noise descriptors

Where noise levels vary with time, it is necessary to express the results of a measurement over a period of time in statistical terms. Some commonly used descriptors follow.

$L_{Aeq,T}$ The most widely applicable unit is the equivalent continuous A-weighted sound pressure level (LAeq,T). It is an energy average and is defined as the level of a notional sound which (over a defined period of time, T) would deliver the same A-weighted sound energy as the actual fluctuating sound.

This is shown in the graph below:



Noise Contour

A line which joins points on the ground which receive the same noise exposure from the nearby airborne aircraft; often for daytime studies the exposure is considered over a 16 hour period ($L_{Aeq,16h}$) and for night studies over a 8 hour period (LAeq,8h) with a range of levels used to express the different exposures.

Sound transmission in the open air

Most sources of sound can be characterised as a single point in space. The sound energy radiated is proportional to the surface area of a sphere centred on the point. The area of a sphere is proportional to the square of the radius, so the sound energy is inversely proportional to the square of the radius. This is the inverse square law. In decibel terms, every time the distance from a point source is doubled, the sound pressure level is reduced by 6 dB.

Meteorological effects

Temperature and wind gradients affect noise transmission, especially over large distances. The wind effects range from increasing the level by typically 2 dB downwind, to reducing it by typically 10 dB upwind – or even more in extreme conditions. Temperature and wind gradients are variable and difficult to predict.

Aviation terms

NPR

Noise preferential route – departure flight ground tracks to be followed by aircraft to minimise noise disturbance on the surrounding population.

Dispersion

Due to the effect of the wind, aircraft speed, and pilot choice differing aircraft tracks about the nominal track are flown; this is known as dispersion around a nominal track.

Start of Roll

The position on a runway where aircraft commence their take-off runs.

Threshold

The beginning of that portion of the runway usable for landing.

Radar Vectoring

Aircraft are provided by Air Traffic Control (ATC) with various instructions which result in changes of heading, altitude and speed. The controller affects safe separation from other traffic by use of radar.

Nominal Tracks

Using recognised international design techniques, tracks across the ground can be delineated for departing and arriving aircraft. These tracks are nominal because they can be influenced by the wind, ATC instructions, the accuracy of navigational systems and the flight characteristics of individual aircraft. In UK it is usual to permit a 1500m swathe to be established about the nominal track for the purposes of assessing whether an aircraft has stayed on track.

Altitude

Height of aircraft above sea level.

APPENDIX 2

GEORGE BEST BELFAST CITY AIRPORT

2022 NOISE CONTOUR VALIDATION

INTRODUCTION

Summer noise contours have been prepared for George Best Belfast City Airport (GBBCA) for a number of years. This has involved the use of the Federal Aviation Administration (FAA) prediction methodology, the Integrated Noise Model (INM).

The INM software has been used around the world in over 50 countries and consequently is flexible enough to allow local circumstances to be taken into account. This can be achieved by entering specific departure routes, operational profiles or weather conditions but also by creating or modifying specific noise information for aircraft types.

In order to improve the accuracy of the modelling at GBBCA, validation exercises have been conducted which compare predicted noise levels for individual aircraft movements with noise levels measured at Belfast. This is particularly useful for aircraft types where the INM does not have actual data and so suggests a substitute type.

VALIDATION

The validation exercises use the measured results from the permanent noise monitoring system at GBBCA. Specifically, the results from the Noise Monitoring Terminal (NMT) at Nettlefield Primary School (MP01) and at Kinnegar Army Camp (MP02). These NMTs are located approximately 4.5 km from the start of roll location of runway 22 and 3.9 km from the start of roll location of runway 04 respectively. The validation exercise for the 2022 actual and 2023 and 2024 forecast contours uses recent results from the NMTs. These include the results for the period September 2021 to September 2022, which comprise almost 5,000 individual aircraft measurements.

Seven aircraft types have been selected to be analysed in the validation exercise. These are the Airbus A319ceo, A320ceo and A320neo, the ATR 72, the Bombardier Dash 8, the Embraer E175 and E190. These aircraft types comprised around 90% of the summer period movements in 2022 and, except for the Bombardier Dash 8 and Embraer E175, were also selected for the 2021 validation.

The Boeing 737-800, which was previously validated, has not been validated this year as there were no movements by this aircraft type in the summer period.

The resulting average measured noise levels used for the 2022 validation exercise are given below in Table A2.1 for these aircraft types, where they are compared with the corresponding measured results used for the 2021 validation exercise. This shows that the average measured noise levels for these types have not generally varied by more than 1 dB compared to 2021. The exceptions are arrivals by the Airbus A319 which have increased by around 1 dB and arrivals by the ATR 72 which have decreased by around 1 dB.

Aircraft Type	Operation	2022 Validation Measured Noise Levels (SEL dB)		2021 Validation Measured Noise Levels (SEL dB)	
		Number	Average	Number	Average
Airbus A319ceo	Arrival Rwy 04	57	85.4	52	84.6
	Arrival Rwy 22	100	88.8	60	87.8
	Departure Rwy 04	62	88.7	52	88.1
	Departure Rwy 22	100	88.0	60	87.8
Airbus A320ceo	Arrival Rwy 04	103	86.1	203	87.1
	Arrival Rwy 22	305	89.5	307	89.4
	Departure Rwy 04	126	89.3	231	88.6
	Departure Rwy 22	328	87.9	298	87.7
Airbus A320neo	Arrival Rwy 04	7	84.5	17	84.7
	Arrival Rwy 22	36	88.1	45	87.8
	Departure Rwy 04	16	85.2	23	85.2
	Departure Rwy 22	38	84.3	41	84.1
ATR 72	Arrival Rwy 04	307	83.4	126	84.4
	Arrival Rwy 22	407	86.8	356	87.8
	Departure Rwy 04	306	81.1	125	81.0
	Departure Rwy 22	386	82.5	323	82.9
Bombardier Dash 8	Arrival Rwy 04	146	82.3	-	-
	Arrival Rwy 22	200	85.3	-	-
	Departure Rwy 04	103	78.6	-	-
	Departure Rwy 22	160	79.0	-	-
Embraer E175	Arrival Rwy 04	52	83.8	-	-
	Arrival Rwy 22	83	87.3	-	-
	Departure Rwy 04	56	88.7	-	-
	Departure Rwy 22	63	87.1	-	-
Embraer E190	Arrival Rwy 04	77	86.4	91	86.2
	Arrival Rwy 22	215	88.3	129	88.2
	Departure Rwy 04	89	89.5	84	89.1
	Departure Rwy 22	207	89.0	116	88.7

Table A2.1: Measured Noise Levels used for Validation in 2022 and 2021

For each aircraft type there are four sets of measured results; arrivals and departures at each of the two monitors. As the monitors are not located symmetrically with regard to the runway the noise levels at each will differ and so they need to be considered separately. For the individual movements within a set there is some variation, so every arrival by an aircraft type does not produce exactly the same noise level. There are a number of factors which contribute to this, in particular the weather conditions.

The spread of results is illustrated in Figures A2.1 to A2.2 below. These show the distribution of measured noise levels from September 2021 to September 2022 for the most common operations, arrivals from the north and departures to the south, for the most common aircraft type in the summer period of 2022, the ATR 72.

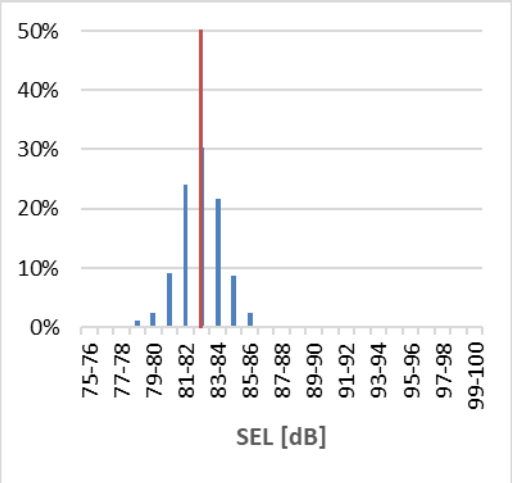


Figure A2.1 – ATR 72 Arrivals

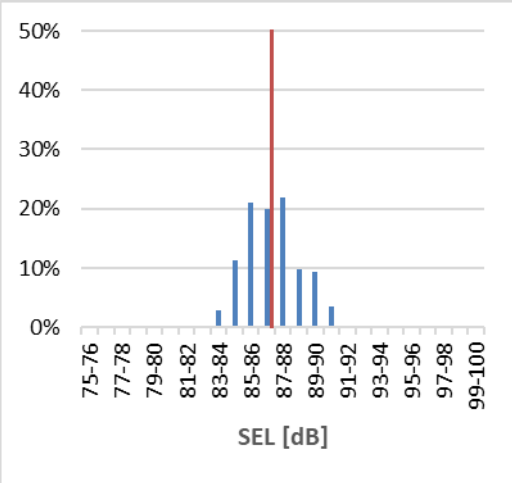


Figure A2.2 – Airbus ATR 72 Departures

The distributions have the large majority of measured noise levels closely grouped together around the averages, shown as a vertical red line on the figures, with a pattern that approximates to a normal distribution with a standard deviation of less than 2 dB. Such distributions of measured noise levels are commonly found at airport fixed noise monitors at a similar distance from the runway. From the distributions of measured noise levels for each of the aircraft types considered, the averages have been determined and compared to INM standard predicted noise levels. Table A2.2 gives the latest measured average noise levels for the seven aircraft types considered for validation in 2022.

Aircraft Type	Operation	2022 Validation Measured Noise Levels (SEL dB)		INM Standard Assumptions (SEL dB)	
		Number	Average	Type	Level
Airbus A319ceo	Arrival Rwy 04	57	85.4	A319-131	87.0
	Arrival Rwy 22	100	88.8		90.0
	Departure Rwy 04	62	88.7		87.9
	Departure Rwy 22	100	88.0		87.0
Airbus A320ceo	Arrival Rwy 04	103	86.1	A320-211	87.4
	Arrival Rwy 22	305	89.5		90.2
	Departure Rwy 04	126	89.3		89.4
	Departure Rwy 22	328	87.9		88.2
Airbus A320neo(1)	Arrival Rwy 04	7	84.5	A320-211	87.4
	Arrival Rwy 22	36	88.1		90.2
	Departure Rwy 04	16	85.2		89.4
	Departure Rwy 22	38	84.3		88.2
ATR 72(1)	Arrival Rwy 04	307	83.4	DO328	86.3
	Arrival Rwy 22	407	86.8		89.7
	Departure Rwy 04	306	81.1		82.1
	Departure Rwy 22	386	82.5		81.6
Bombardier Dash 8(1)	Arrival Rwy 04	146	82.3	SD330	82.2
	Arrival Rwy 22	200	85.3		84.5
	Departure Rwy 04	103	78.6		82.1
	Departure Rwy 22	160	79.0		81.6
Embraer E175	Arrival Rwy 04	52	83.8	EMB175	85.5
	Arrival Rwy 22	83	87.3		88.3
	Departure Rwy 04	56	88.7		87.8
	Departure Rwy 22	63	87.1		87.4
Embraer E190	Arrival Rwy 04	77	86.4	EMB190	86.6
	Arrival Rwy 22	215	88.3		89.0
	Departure Rwy 04	89	89.5		86.8
	Departure Rwy 22	207	89.0		86.0

(1) INM does not contain specific data for this type so alternatives used.

Table A2.2: Measured and Standard Predicted Noise Levels

Approach to Validation

The general approach to validation modifications has been to only change from the INM standard type when the measured results show clear divergence, i.e. an apparent prediction error in excess of 1.5 dB at a single NMT or an average error of over 1.0 dB across both NMTs. If the type has historically been modified from the standard type, then the approach has been to only change from the previous validation when there is an apparent prediction error or change in measured level in excess of 1.0 dB at a single NMT. Also, the approach seeks to determine any modification by aircraft type and aircraft operation, but not by runway used. This means one modification is adopted for all arrivals by an aircraft type, and one for all departures by an aircraft type.

Comparison of Measured and Predicted Results

Some changes have been made to the modifications compared to those used for the 2021 contours. The Airbus A319 has been factored up on arrival, whereas the ATR 72 has been factored down on arrival. The Bombardier Dash 8 and Embraer E175 have been included in the validation for 2022, but were not validated in 2021.

The final validation modifications are summarised below in Table A2.3. These have been used for the 2022, 2023 and 2024 contours.

Aircraft Type	INM Type	Modification to Movements Numbers	
		Arrivals	Departures
Airbus A319ceo	A319-131	A319-131 × 0.7	A319-131 × 1.2
Airbus A320ceo	A320-211	A320-211 × 1.0	A320-211 × 1.0
Airbus A320neo	A320-211	A320-211 × 0.6	A320-211 x 0.4
ATR 72	DO328/DHC6	DO328 × 0.5	DHC6 × 1.0
Bombardier Dash 8	SD330/DHC6	SD330 × 1.1	DHC6 x 0.5
Embraer E175	EMB175	EMB175 × 0.7	737500 x 1.1
Embraer E190	EMB190	EMB190 × 1.0	EMB190 × 1.8

Table A2.3: 2022 Validation Modifications

The need for modifications for the larger aircraft types in particular is not unexpected as they are available in a range of specifications with different engine types, sometimes from different manufacturers. This means that the actual type operated by the airline may differ to the one in the INM software.

The Airbus A319ceo has been modelled with the standard type but with departures factored up and arrivals factored down. The Airbus A320ceo, also using the standard type, is unmodified on both arrival and departure. The Airbus A320neo is a newer quieter version of the A320ceo and is therefore factored down on both arrival and departure.

For the ATR 72, modifications were needed to the INM type as the substitute type it suggests does not agree well with the measured departure results. On arrival the standard type was used, but with movements factored down.

For the Bombardier Dash 8 modifications were needed to the INM type as the substitute type it suggests does not agree well with the measured results. The validation finds that using the Dash 6 (DHC6) for departures and the Shorts 330 (SD330) for arrivals, with movement numbers factored, agrees well with measured noise levels.

For the Embraer E175, modifications were needed to the INM type as the standard type does not agree well with the measured departure results. On arrival the standard type was used, but with movements factored down.

For the Embraer E190, the standard INM type has been used, but with departures factored up.

Effect of Validation

The effect of the validation exercise on the predicted noise levels for the seven aircraft types is detailed in Table A2.4 which gives the differences between the measured noise levels and those predicted after allowing for the validation modifications.

Aircraft Type	Operation	Noise Levels (SEL dB)			
		Measured Average	INM Validated Prediction	Difference Predicted - Measured	Operation Weighted Average Difference
Airbus A319ceo	Arrival Rwy 04	85.4	85.5	+ 0.1	- 0.2
	Arrival Rwy 22	88.8	88.5	- 0.3	
	Departure Rwy 04	88.7	88.7	+ 0.0	- 0.1
	Departure Rwy 22	88.0	87.8	- 0.2	
Airbus A320ceo	Arrival Rwy 04	86.1	87.4	+ 1.3	+ 0.9
	Arrival Rwy 22	89.5	90.2	+ 0.7	
	Departure Rwy 04	89.3	89.4	+ 0.1	+ 0.2
	Departure Rwy 22	87.9	88.2	+ 0.3	
Airbus A320neo	Arrival Rwy 04	84.5	85.2	+ 0.7	+ 0.0
	Arrival Rwy 22	88.1	88.0	- 0.1	
	Departure Rwy 04	85.2	85.4	+ 0.2	+ 0.0
	Departure Rwy 22	84.3	84.2	- 0.1	
ATR 72	Arrival Rwy 04	83.4	83.3	- 0.1	- 0.1
	Arrival Rwy 22	86.8	86.7	- 0.1	
	Departure Rwy 04	81.1	82.1	+ 1.0	+ 0.0
	Departure Rwy 22	82.5	81.6	- 0.9	
Bombardier Dash 8	Arrival Rwy 04	82.3	82.6	+ 0.3	- 0.1
	Arrival Rwy 22	85.3	84.9	- 0.4	
	Departure Rwy 04	78.6	79.1	+ 0.5	- 0.1
	Departure Rwy 22	79.0	78.6	- 0.4	
Embraer E175	Arrival Rwy 04	83.8	84.0	+ 0.2	- 0.2
	Arrival Rwy 22	87.3	86.8	- 0.5	
	Departure Rwy 04	88.7	88.2	- 0.5	+ 0.2
	Departure Rwy 22	87.1	87.8	+ 0.7	
Embraer E190	Arrival Rwy 04	86.4	86.6	+ 0.2	+ 0.6
	Arrival Rwy 22	88.3	89.0	+ 0.7	
	Departure Rwy 04	89.5	89.4	- 0.1	- 0.3
	Departure Rwy 22	89.0	88.6	- 0.4	

Table A2.4: Measured and Validated Predicted Noise Levels

Table A2.4 shows that with the validation modifications there is good correlation between measured and predicted noise levels with differences of less than 1 dB when results from both NMTs are operationally averaged.

The effect of the validation exercises on the contours depends both on the modifications made and the contribution of those aircraft types to the overall noise. Changes to infrequent aircraft types are likely to have very little effect on the contours.

SUMMARY

The validation of noise contours at George Best Belfast City Airport has been continually improved, more recently by checking predictions against the results obtained from GBBCA's noise monitors. This has demonstrated that without validation the standard INM assumptions would be less accurate.

The latest contours have taken into account almost 5,000 individual aircraft noise measurements at GBBCA between September 2021 and September 2022. This has identified the need to modify the standard INM assumptions for six aircraft, the Airbus A319ceo, Airbus A320neo, ATR 72, Bombardier Dash 8, Embraer E175 and Embraer E190.

GBBCA will continue to collect further detailed information from the fixed noise monitors at Nettlefield Primary School and in Kinnegar, which will be used to regularly validate future GBBCA contours. This is in line with the EiP Panel's advice on contour validation.