Development of South Australian Building Standard for Aircraft Noise Intrusion – Ministerial Building Standard – 010 (MBS 010)

Darren Jurevicius (1), Jenna MacDonald (1), Lachlan Newitt (1) and Jingyuan Tan (1)

(1) South Australian Division, Resonate Consultants, Adelaide, Australia

ABSTRACT

For the first time in South Australia, a newly implemented building standard provides a deemed-to-satisfy protocol for the mitigation of aircraft noise for affected residential constructions in general accordance with AS 2021:2015. With the implementation of the Planning and Design Code in South Australia, residential developments are required to adhere to building requirements outlined in the Ministerial Building Standard – 010 (MBS 010), in which aircraft noise intrusion has been introduced. Implementation of these updated methods in MBS 010 is aimed to simplify the assessment of aircraft noise intrusion and reduce the costs associated with the development application process for residential homeowners. This paper details the methodologies, aircraft noise modelling and general development of the deemed-to-satisfy and performance protocols outlined in MBS 010. This includes development of the Aircraft Noise Reduction (ANR) contour which describes the predicted maximum noise level from aircraft movements surrounding the subject aerodrome, deemed-to-satisfy construction assumptions and the constraints of this new assessment methodology.

1 INTRODUCTION

Exposure to environmental noise such as noise propagated by road, rail and air traffic has been proposed to contribute to an increased risk to human health (Hatfield et al., 2001). Therefore, guidelines are essential to avoid health risk noise intrusion, which create a simpler standard aimed to help ensuring mitigations to reduce environmental noise intrusions are incorporated more efficiently and consistently.

Ministerial Building Standards have replaced existing Minister's Specifications due to the new planning system being implemented within South Australia. The Ministerial Building Standard – 010 (MBS 010) integrates the existing Minister's Specification SA 78B (SA 78B), which outlined noise attenuation measures for residential buildings affected by road and rail noise, and now includes an additional protocol for buildings affected by aircraft noise in general accordance with Australian Standard AS 2021:2015 'Acoustics – Aircraft Noise Intrusion – Building Siting and Construction' (AS 2021:2015).

This background paper provides the assumptions and reasoning around the modelling and calculations used in defining the aircraft additions within MBS 010. The authors advise that this paper is to be read in conjunction with the MBS 010, as well as the Guide for relevant authorities and applicants 'Applying the MBS 010'.

2 Application of MBS 010

The methodology presented in MBS 010 provides deemed-to-satisfy constructions and a simpler performance solution option for residential developments, which are required to undergo an aircraft noise intrusion assessment. MBS 010 follows the intent of AS 2021:2015 and specifies the same maximum internal noise level criteria of 50 dB(A) for sleeping areas and 55 dB(A) for habitable areas.

MBS 010 is solely applicable to residential developments, and as such, non-residential developments are not considered. The scope of MBS 010 is such that residential developments will potentially benefit most from a deemed-to-satisfy methodology, as the standard removes the need for homeowners or developers to engage an acoustic consultant. This allows them to follow a simplified and more cost-efficient application process.

Similar to AS 2021:2015, the methodology to determine if a residential development is affected by aircraft noise is based on the relevant Australian Noise Exposure Forecast (ANEF). The ANEF provides a forecast of the noise exposure level surrounding the subject aerodrome. The ANEF levels consider the intensity, duration, frequency and the time of day of the aircraft movements. If a residential development falls within an ANEF level of 20 or higher, the provisions in MBS 010 apply.

Table 1 shows the application of the ANEF for AS 2021:2015 and MBS 010. The terminology used in AS 2021:2015 is referred. The *Acceptable* category indicates that the buildings' constructions do not require any further upgrade for the purpose of aircraft noise attenuation; *Conditionally Acceptable* implies an acoustic assessment is to be conducted to determine what building constructions are required to ensure internal noise levels are acceptable; *Unacceptable* indicates that the land in this zone is not compatible with residential development.

Table 1: AS 2021:2015 & MBS 010 ANEF comparison

	Acceptable	Conditionally Acceptable	Unacceptable
AS 2021:2015	≤ 20 ANEF	20 < ANEF ≤ 25	25 < ANEF
MBS 010	≤ 20 ANEF	20 < ANEF	Not explicitly stated

The internal noise criteria, which are inherited from AS 2021:2015, required the aircraft noise intrusion to be quantified as a maximum noise level in decibels (L_{Amax} dB). Given that the required building constructions are determined based on the L_{Amax} dB level at the dwelling facade, an ANEF value at the dwelling was not directly suitable. The ANEF is simply a planning trigger for a deemed-to-satisfy construction in accordance with MBS 010. To determine the applicable deemed-to-satisfy construction requirements, once triggered, a different contour map needed to be developed, which was subsequently named the Aircraft Noise Reduction (ANR) contour map. The development of the ANR contour map is discussed in the following sections.

3 Aircraft Selection and L_{Amax} Noise Levels

Within the new standard, a maximum noise level event is used to determine the required building façade construction, similar to AS 2021:2015.

The selection of aircraft type and applicable noise levels in MBS 010 differ from AS 2021:2015. AS 2021:2015 methodology requires that façades achieve an internal noise criteria based on the maximum noise level (L_{Amax}) produced by the noisiest aircraft movement at the proposed dwelling location. This L_{Amax} level is then determined by reviewing relevant aircraft types specific to the subject aerodrome. The L_{Amax} of the selected aircraft is then derived from the applicable table listed in AS 2021:2015; Tables 3.4 to 3.24. Multiple distance inputs, which are measured from the subject site and the nearest aircraft runways are required to identify the specific L_{Amax} value.

In practice, the building of residential façades to attenuate the noisiest aircraft movement is not always practical. In these cases, acoustical practitioners have often considered the frequency of flights for each aircraft type in comparison to the noisiest aircraft. Furthermore, façade constructions that are similar in perceived acoustic performance to the human ear, yet practical to construct, have also been specified. This practice is most likely underpinned by the logic that it is not reasonable or feasible to design a dwelling to protect against a low number of the noisiest aircraft movements in comparison to the dominant aircraft movement. While this methodology is not strictly in-line with AS 2021:2015, it has nevertheless been accepted by land use planning authorities in the authors experience. Within MBS 010, the aircraft and the applicable L_{Amax} are pre-determined and documented via a contour map for each relevant aerodrome in South Australia. These contour maps are known as the ANR contour. A user is then only required to locate their property on the relevant ANR contour map, located using the SA Property and Planning Atlas (https://sappa.plan.sa.gov.au) to establish the applicable ANR (L_{Amax} dB).

4 Development of the Aircraft Noise Reduction (ANR) Contours

In South Australia, a single Aircraft Noise Reduction (ANR) contour was developed for each aerodrome with an ANEF. The ANR value directly identifies the required noise reduction performance of a proposed dwellings façade, rather than the maximum noise level at the facade. The ANR level was chosen in preference over presenting a maximum noise exposure level, which was thought to potentially give rise to unnecessary alarm or not be understood as readily by the wider community. The ANR was designed to indicate the noise reduction, in dB(A), required by a façade to achieve a compliant internal noise level of 50 dB(A), i.e. $L_{Amax} - 50 = \text{ANR}$. It is expected that the ANR for each aerodrome will require review and updating upon revision of the ANEF. For simplicity, a single ANR contour was also preferred to having multiple contours for each aircraft type and/or movement.

4.1 Selection of Indicative Aircraft

With each airport or airfield having a single applicable ANR contour, a number of aspects were weighed, such as:

- a suitable noise spectrum representative of all aircraft types.

- flight paths, profiles and elevations of all aircraft movements that were considered in the development of each ANEF.

To assist this process, the authors gained access to the Integrated Noise Model (INM) inputs for each relevant aerodrome used to develop the current ANEF's. The intent was to determine an indicative aircraft that matched the weighted average L_{Amax} exposure for all aircraft operations, for each aerodrome. For example, the chosen aircraft and associated calculated weighted average L_{Amax} for Parafield Airport is presented in Table 2 below.

Table 2: Calculation of the weighted average L_{Amax} for Parafield Airport

Aircraft	Annual Movements	Percentage of Total Movement	Average L_{Amax}, dB
BEECH 1900 Airliner	61	0.02 %	63.4
CESSNA Citation V 560	827	0.25 %	70.8
DASSAULT Falcon 20	16059	4.85 %	83.3
GATES Learjet 25	48	0.01 %	77.3
BEECH Baron 58	66156	Selected 19.97%	70.3
1985 1-ENG FP PROP	243017	73.36 %	61.9
1985 1-ENG VP PROP	5112	1.54 %	67.1
		Weighted Average L_{Amax}, dB	71.4

The Beechcraft Baron 58 is selected as the indicative aircraft for Parafield Airport, which is predicted to account for nearly 20% of the airport's annual movements in 2037 and the average L_{Amax} is within 1 dB(A) of the calculated weighted average. Whilst the Cessna Citation V 560 matches the L_{Amax} value more closely, its selection is not preferred due to its relatively low presence in annual movements. With a 73.4% of total movement, 1985 1-ENG FP PROP was not chosen due to the large discrepancy in its L_{Amax} and the weighted average L_{Amax}. The average L_{Amax} of the selected aircraft is considered as a conservative estimate of the noise experience of the average aircraft movement surrounding the airport, given the majority of movements, 94.9%, are performed by quieter aircraft. As such the selected aircraft, Baron 58, is a compromise of noise level and movement frequency. This selection methodology was performed for each aerodrome to establish an indicative aircraft for modelling purposes. The selected indicative aircraft for each aerodrome and respective weighted average L_{Amax} is summarised in Table 3.

Table 3: Calculation of the weighted average L_{Amax} for Parafield Airport

Aerodrome	Weighted Average L_{Amax}, dB	Selected Aircraft
Adelaide Airport	83.9	Boeing 737-800
RAAF Edinburgh	83.9	Boeing P-8 Poseidon
Parafield Airport	71.4	Beechcraft Baron 58

4.2 Modelling Methodology

Initially the noise levels documented for each indicative aircraft in AS 2021:2015 Tables 3.4 to 3.24 were reviewed and plotted into a contour. The L_{Amax} noise contours were produced using a rudimentary Microsoft Excel model, for each specific aircraft and runway configurations. These values were transformed into an XY co-ordinate system, which referenced the Geocentric Datum of Australia (GDA 94), and the contours were generated in QGIS software from the grid of L_{Amax} values. This simple model was however deemed impractical given the contour combination process was labour intensive. There were also limitations with modelling of curved paths, lack of elevation data and limited data points.

To have an improved alignment with current practice and to produce a more precise result, the final L_{Amax} noise contours for each aerodrome were modelled using the Aviation Environment Design Tool (AEDT 3c). AEDT 3c was recommended by Airservices Australia to produce aircraft noise contours. AEDT is the current industry standard for aircraft noise modelling, and is the tool used to generate ANEF contours. The software uses the Base of Aircraft Data (BADA), which provides more detailed noise data than the L_{Amax} tables in AS 2021:2015, including numerous arrival and departure profiles for aircraft. This improved the accuracy and coverage of the model.

4.3 Modelling of the ANR contours

The movement of the indicative aircraft, i.e. BEECH Baron 58 for Parafield Airport, combined with flight track data from the relevant aerodrome's Master Plan (and associated ANEF), was used to generate L_{Amax} contours for the relevant aerodrome in AEDT 3c. Further processing of the L_{Amax} contours was completed in QGIS 3.12.
For each aerodrome, the indicative aircraft was paired with the aerodrome's overall weighted average maximum noise level for final modelling purposes. This meant that the selected aircraft type would dictate the sound level's spectral shape, the flight profiles and elevations over each flight path. The sound source was then scaled to be in line with the determined overall weighted average for the aerodrome. This was done to ensure the final L_{Amax} was equal to or higher than 95% of all aircraft movements within each specific aerodrome.

The final L_{max} contour maps were produced with a 4 dB(A) contour resolution to line up with the deemed-to-satisfy resultant mitigation constructions (refer MBS 010). Figure 1 illustrates the final ANR contour map for Parafield Airport.

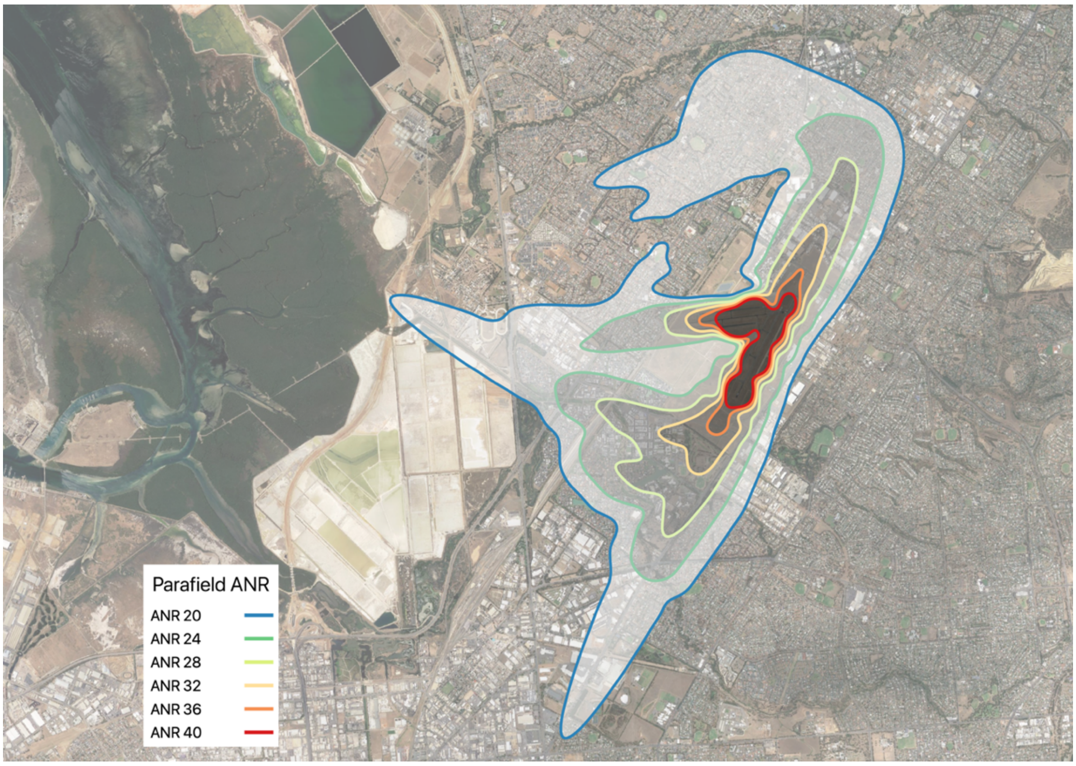

Figure 1: Parafield Airport ANR 4 dB(A) contour map

5 Determining Deemed-To-Satisfy Constructions

MBS 010 provides defined Sound Exposure Category (SEC) levels that have been adopted and marginally refined from SA 78B, with each SEC level corresponding to a set of deemed-to-satisfy constructions. For simplicity, it was desired to fit the deemed-to-satisfy constructions developed for road and rail sources to also mitigate against aircraft noise. To confirm this, various external L_{Amax} noise levels intruding into a typical sleeping area and habitable space were modelled. A sleeping area was assumed to be 4 metres long, 3 metres wide and 2.7 metres high while the habitable space was modelled as 6 metres long, 4 metres wide and 2.7 metres high. In all cases, the ceiling and roof were assumed to be 100% exposed to the external noise source, i.e. does not have a storey above it, and two of the space's four walls are exposed to the external noise source.

This typical layout was used to iteratively model the internal noise level from aircraft with differing window sizes and external noise levels using a Sabine Room Correction. The applicable window and door constructions previously outlined in SA 78B were dependent on window to floor area ratios allowing this new calculation process to keep the physical room sizes constant with little impact to the final internal noise level. Varying the room sizes when considering window size as a percentage of floor area, only altered final internal noise levels by approximately 0.5 dB(A) per doubling of floor area. i.e. the difference in predicted internal noise levels between the assumed 12 m^2 floor area and a potential 48 m^2 is 1 dB(A). As this difference is not perceivable to the human ear, and does not impact the final recommended construction, the floor area was kept constant throughout calculations. The impact of varying ceiling heights was also considered. With every doubling of ceiling height, the internal noise level decreased by 2 dB(A). Given ceiling heights within residential dwellings will very rarely exceed 5 meters, and the resultant noise level would be lower resulting in a more conservative construction, ceiling heights were also kept constant at 2.7 meters.

Using the deemed-to-satisfy constructions allocated to each SEC level one through four established as part of MBS 010 were fitted to the aircraft noise levels. An increment of 4 dB(A) was used between each aircraft noise level, as this was found to be the required decibel change to warrant a step up in construction requirements (Jurevicius D, 2013). An indicative aircraft spectrum, which was determined as part of a performance solution option, discussed later in this paper, was used for these calculations. Tables 5 and 6 below show the predicted internal noise levels for a sleeping area and habitable space respectively. The presented internal noise level is the result of each space implementing the constructions outlined in MBS 010 for the stated SEC across varying window sizes. Note the red highlighted box indicates the values that are applicable to what is documented in MBS 010 'deemed-to-satisfy'. The resultant internal noise levels have been colour coded to show how close they achieve the defined internal noise goal of 50dB(A) and 55dB(A) within a sleeping area and habitable spaces respectively. Refer Table 4 for colour code legend.

Table 4: Colour Code Legend for use with Table 5 and Table 6

Colour	Description
(blue)	More than 6 dB(A) below prescribed goal
(pale green)	Within 6 to 4 dB(A) below prescribed goal
(light green)	Within ±4 dB(A) of the prescribed goal
(green)	Within ±2 dB(A) of the prescribed goal
(orange)	More than 4 dB(A) above the prescribed goal

Table 5: Resultant Internal Noise Levels within a Sleeping Area

Window to Floor %	Aircraft Noise Level dB(A) L_{max} / Applied SEC Constructions							
	64 / *SEC 1*	68 / *SEC 1*	72 / *SEC 1*	76 / *SEC 2*	80 / *SEC 3*	84 / *SEC 4*	88 / *SEC 4*	92 / *SEC 4*
5%	31.3	35.3	39.3	42.1	44.3	45.0	49.0	53.0
10%	34.3	38.3	42.3	45.1	47.3	48.0	52.0	56.0
15%	36.1	40.1	44.1	46.9	49.1	49.8	53.8	57.8
20%	37.3	41.3	45.3	48.1	50.3	51.0	55.0	59.0
25%	37.1	41.1	45.1	47.2	49.8	49.4	53.4	57.4
30%	37.9	41.9	45.9	48.0	50.6	50.2	54.2	58.2
35%	38.6	42.6	46.6	48.7	51.3	50.8	54.8	58.8
40%	39.2	43.2	47.2	49.2	51.9	51.4	55.4	59.4
45%	37.8	41.8	45.8	48.3	50.8	46.8	50.8	54.8
50%	38.3	42.3	46.3	48.7	51.3	47.3	51.3	55.3
55%	38.7	42.7	46.7	49.1	51.7	47.7	51.7	55.7
60%	39.1	43.1	47.1	49.5	52.1	48.1	52.1	56.1
65%	38.0	42.0	46.0	48.2	50.6	48.4	52.4	56.4
70%	38.3	42.3	46.3	48.6	50.9	48.8	52.8	56.8
75%	38.6	42.6	46.6	48.9	51.2	49.1	53.1	57.1
80%	38.9	42.9	46.9	49.1	51.5	49.3	53.3	57.3
85%	37.6	41.6	45.6	47.4	51.7	49.6	53.6	57.6
90%	37.8	41.8	45.8	47.7	52.0	49.9	53.9	57.9
95%	38.1	42.1	46.1	47.9	52.2	50.1	54.1	58.1
100%	38.3	42.3	46.3	48.1	52.4	50.3	54.3	58.3

Table 6: Resultant Internal Noise Levels within a Habitable Space

Window to Floor %	Aircraft Noise Level dB(A) L_{max} / Applied SEC Constructions							
	64 / SEC 1	*68 / SEC 1*	*72 / SEC 1*	*76 / SEC 2*	*80 / SEC 3*	*84 / SEC 4*	*88 / SEC 4*	*92 / SEC 4*
5%	36.1	40.1	44.1	46.0	48.7	50.0	53.8	57.8
10%	39.2	43.2	47.2	49.0	51.8	53.0	56.8	60.8
15%	40.9	44.9	48.9	50.7	53.5	54.7	58.6	62.6
20%	42.2	46.2	50.2	52.0	54.8	56.0	59.8	63.8
25%	41.0	45.0	49.0	51.8	53.8	55.0	58.7	62.7
30%	41.8	45.8	49.8	52.6	54.6	55.8	59.5	63.5
35%	42.4	46.4	50.4	53.2	55.3	56.5	60.2	64.2
40%	43.0	47.0	51.0	53.8	55.9	57.1	60.7	64.7
45%	42.4	46.4	50.4	52.5	54.8	55.2	58.6	62.6
50%	42.8	46.8	50.8	52.9	55.3	55.6	59.1	63.1
55%	43.3	47.3	51.3	53.3	55.7	56.0	59.5	63.5
60%	43.6	47.6	51.6	53.7	56.1	56.4	59.9	63.9
65%	42.1	46.1	50.1	52.6	54.8	52.7	55.1	59.1
70%	42.5	46.5	50.5	52.9	55.1	53.0	55.5	59.5
75%	42.8	46.8	50.8	53.2	55.4	53.3	55.8	59.8
80%	43.0	47.0	51.0	53.5	55.7	53.6	56.0	60.0
85%	41.8	45.8	49.8	52.1	53.9	53.9	56.3	60.3
90%	42.1	46.1	50.1	52.4	54.1	54.1	56.5	60.5
95%	42.3	46.3	50.3	52.6	54.4	54.4	56.8	60.8
100%	42.5	46.5	50.5	52.8	54.6	54.6	57.0	61.0

The above final combination of treatment versus external noise levels was refined over multiple iterative processes. And as with any process which attempts to simplify continuous data into categories, there are some combinations which are slightly above or below the targeted level. The final combination of building constructions versus external aircraft noise level aimed to ensure no combination was more than 2 dB(A) above the internal noise goal. However, this means that some combinations with very small window areas at the lower aircraft noise levels resulted in internal noise levels up to 10 dB(A) below the prescribed goal, see values highlighted in blue in Tables 5 and 6 above. While it is acoustically beneficial to have such low internal noise levels, it may be considered an over design. Nevertheless, the deemed-to-satisfy constructions were not considered to be too onerous, given the low level of treatment associated with these scenarios i.e. these treatments would typically be required for a Building Code compliant dwelling regardless of acoustics. The final aircraft maximum noise levels and corresponding SEC level are summarised in Table 7.

Table 7: SEC Construction Alignment with Aircraft Noise Levels

Sound exposure category (SEC)	Aircraft L_{max} Noise Level at Building Façade, dB(A)	Aircraft Noise Reduction of Building Façade, dB(A)
1	$70 \leq L_{max} < 74$	20 ≤ ANR < 24
2	$74 \leq L_{max} < 78$	24 ≤ ANR < 28
3	$78 \leq L_{max} < 82$	28 ≤ ANR < 32
4	$82 \leq L_{max} < 86$	32 ≤ ANR < 36
5	$L_{max} \geq 86$	ANR ≥ 36

6 Performance Solutions

In addition to providing a deem-to-satisfy methodology for mitigating aircraft noise intrusion, MBS 010 also provides a 'performance solution' methodology. This option has been provided to accommodate constructions which fall outside of the prescribed deemed-to-satisfy requirements, or for those who wish to undertake a more detailed assessment of the dwelling façade. However, unlike the deemed-to-satisfy approach, a performance solution can only be completed by an acoustic consultant.

The methodology used to determine the required construction treatments in this section closely follows the methodology used for an assessment against AS 2021:2015. However, aircraft noise levels and spectrums are determined using the levels, contours and aircraft spectrums developed for the MBS 010 deemed-to-satisfy methodology. Following the performance solution defined in MBS 010, the applicable external maximum aircraft noise level is determined by confirming the subject's dwelling location on the applicable ANR contour map. The result ANR value plus 50 gives the external L_{Amax}. This in conjunction with an indicative aircraft spectrum is then used to determine applicable constructions using the same calculations and techniques already used for assessments against AS 2021:2015. This aims to help simplify the assessment process and provide a more cost-effective solution for residents given a weighted aircraft noise level is used for assessment rather than the noisiest aircraft.

6.1 Indicative Aircraft Spectrum

To determine the appropriate construction requirements for MBS 010, a spectral adjustment level is required to be applied to the determined L_{Amax} level incident on the subject building facade.

Numerous attended measurements of common passenger planes were averaged and then compared to confirm if the sound level spectrum across common aircraft changed significantly enough to warrant specific consideration. Figures 2 and 3 illustrate the plotted normalised spectrums for a plane landing and taking off respectively.

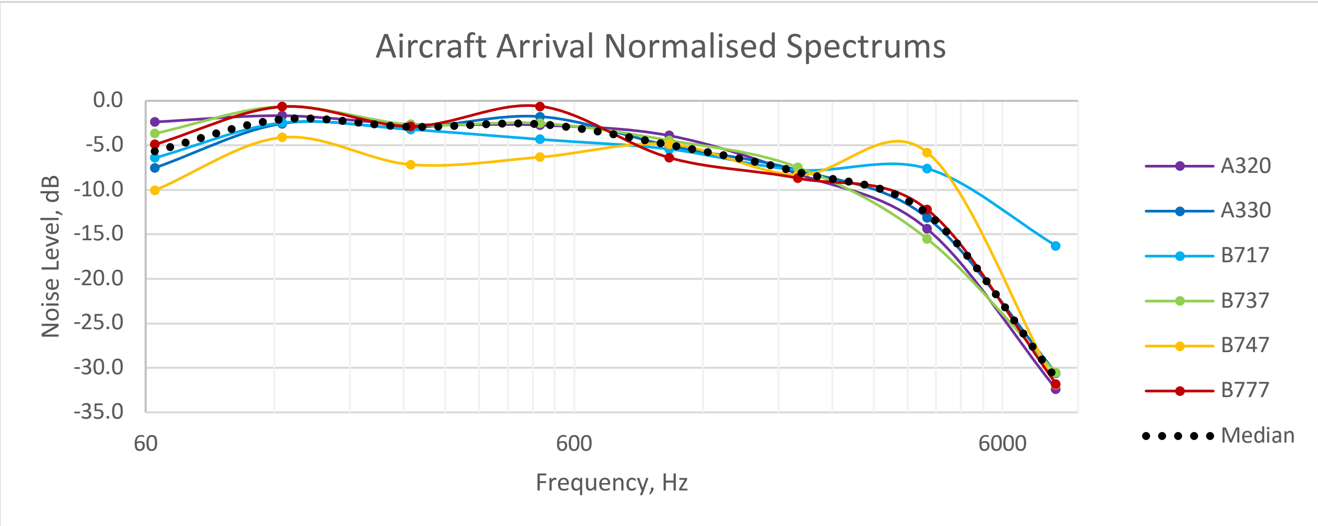

Figure 2: Aircraft arrival normalised spectrums

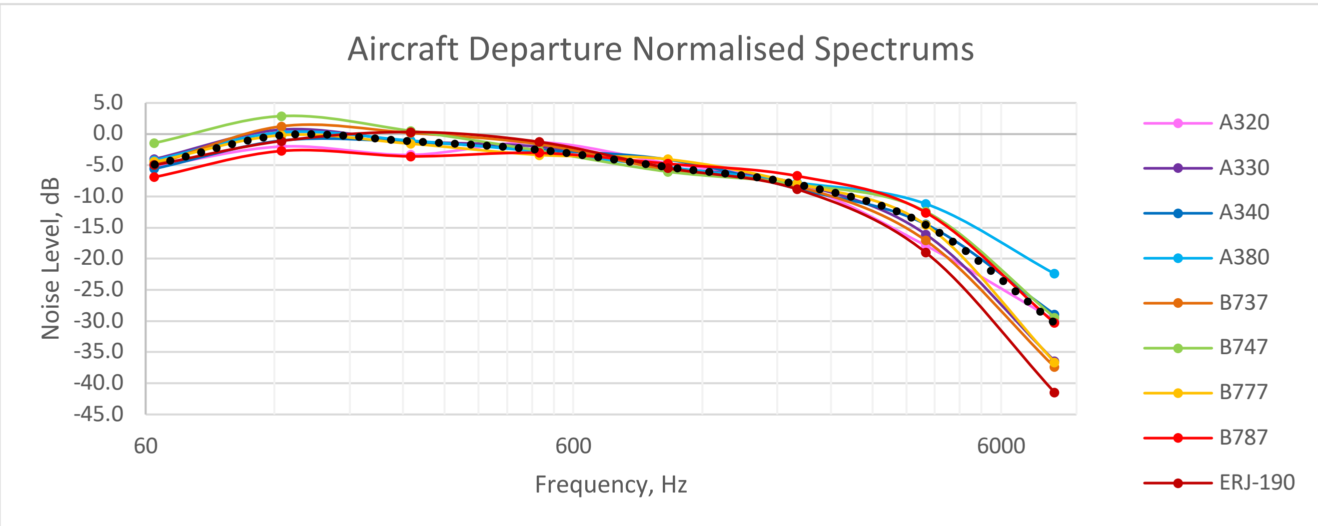

Figure 3: Aircraft departure normalised spectrums

It was found the spectral shape of each passenger aircraft was not significant enough to change the final recommended construction. Given this, a median of all the aircraft take-off and landing spectrums were derived and used as the governing aircraft spectrum. This final spectrum is presented in Table 8 .

Table 8: Final normalised aircraft spectrum, dB

Frequency, Hz	63	125	250	500	1000	2000	4000	8000
Noise level, dB	-5.2	-2.0	-3.3	-1.3	-4.7	-8.1	-17.9	-29.8

7 CONCLUSIONS

In South Australia the MBS 010 has been developed to ensure that buildings in areas considered to have consequential levels of noise impacts are appropriately addressed at both the planning stage, and in the design and construction stage. This paper provides technical insight to the inclusion of a deemed-to-satisfy and performance solution approach within the recently released MBS 010 for the mitigation of aircraft noise. In general, MBS 010's inclusion of aircraft noise is aimed to simplify the approach and reduce the costs associated with the development application process for residential homeowners through the provision of a deemed-to-satisfy pathway. A key benefit of the deemed-to-satisfy pathway is the ability for a developer to determine the potential construction costs prior to purchasing land. The intent of this paper is to assist other jurisdictions should they wish to adopt a similar approach.

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