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Review of International Research on Community Reaction to Aircraft Noise: <u>Report 2</u>: Socio-Acoustic Research in the U.K.

Andrew J Hede
Professor Emeritus, University of the Sunshine Coast, Australia
Director, Hede Consulting, Sydney

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Sydney Airport Community Forum (SACF)

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This research report was commissioned by Sydney Airport Community Forum *(SACF).* The views expressed in the report are those of the author and may not represent the opinions of SACF. This is Report 2 of an anticipated five reports in a comprehensive International Review of Aircraft Noise. The full list of proposed reports is:

- Report No.1: Aircraft Noise Metrics (c.f., report completed);
- **Report No.2: Socio-Acoustic Research in the U.K. (i.e., current report);**
- Report No.3: Socio-Acoustic Research in the EU and Canada (report to be commissioned);
- Report No 4: Socio-Acoustic Research in the U.S. (addressing U.S. report on new study due in 2018; report to be commissioned);
- Report No.5: Implications for Australia of Recent International Research (report to be commissioned).

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- Rebecca Cointin, Manager, Noise Division, Federal Aviation Administration, USA
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Hede Consulting

– Social Survey Research – Psychological Services –

25th May 2018

John Alexander OAM MP
Chair, Sydney Airport Community Forum
c/- Department of Infrastructure and Regional Development
GPO Box 594
CANBERRA ACT 2601

Dear Mr Alexander

Letter of Transmittal re International Review of Aircraft Noise Research

I am writing further to your letter of 3rd November 2017 following your original letter of 2nd August 2017 requesting my advice on: *"the status of any international studies recently completed or currently underway which may provide new evidence on the continued effectiveness of the 1982 National Acoustic Laboratories (NAL) study and the Australian Noise Exposure Forecast (ANEF) system."* SACF records will show that I replied to that letter on 18th August 2017 and to your letter of 3rd November on 15th November 2017.

On further reflection I realised that a project as large as the proposed international review of aircraft noise research would be best conducted in five separate stages as follows:

1. **Report 1: Aircraft Noise Metrics (Report completed);**
2. **Report 2: Socio-Acoustic Research in the U.K. (Report herewith submitted);**
3. **Report 3: Socio-Acoustic Research in the EU and Canada (Report to be commissioned);**
4. **Report 4: Socio-Acoustic Research in the U.S. (to address the anticipated report on the new U.S. study due in 2018) (Report to be commissioned);**
5. **Report 5: Implications for Australia of Recent International Research (Including the issue of a new NAL survey) (Report to be commissioned).**

I have undertaken the first two of the proposed five research review stages and hereby submit the accompanying report (No.2 as per above) for consideration by SACF.

For your consideration
Yours sincerely

Andrew J Hede PhD
Professor Emeritus, University of the Sunshine Coast
Director, Hede Consulting, Sydney

215/301 Galston Road, Galston, NSW, 2159, Australia
Ph: +61 [0] 416 168 281 andrewhede@totalcalm.com.au

Sydney Airport Community Forum

Dr Andrew Hede
Emeritus Professor, University of the Sunshine Coast
Director, Hede Consulting
andrewhede@totalcalm.com.au

Dear Dr Hede

The Sydney Airport Community Forum (SACF) met on 1 September 2017 and discussed your letter of 18 August 2017 regarding recent research on aircraft noise.

You indicated in your letter you would be willing to undertake a review of international noise studies. SACF seeks your advice on the scope and cost of the services in your letter. Whilst we are seeking this information from you, it should be noted there is currently no Government funding available for noise studies at this time, however SACF may be willing to lobby the Minister for Infrastructure and Transport about this work.

Should you be in a position to assist SACF by providing this information, I would be grateful for your reply by 15 November 2017. This would allow sufficient time for SACF members to review your advice prior to the next meeting which is scheduled for 24 November 2017.

Yours sincerely

John Alexander OAM MP
Chair
3 November 2017

Review of International Research on Community Reaction to Aircraft Noise: Report 2: Socio-Acoustic Research in the U.K.

Andrew J Hede

Executive Summary

If Australia were to look for direction from recent international research on aircraft noise, then the U.K. is clearly a key 'comparator' country as it has been on many issues of public policy for more than a century. This report reviews the recent U.K. socio-acoustic research with a view to deriving guidance on aircraft noise rather than simply borrowing their results and hoping they apply 'downunder'. The U.K. has a history of major socio-acoustic surveys on aircraft noise dating from the 1960s, including more recently: *Aircraft Noise Index Study* (ANIS – 1980-2), *Attitudes to Noise from Aviation Sources in England* (ANASE – 2003-5) and *Survey of Noise Attitudes* (SoNA – 2014-17) each of which comprised a survey of approximately 2,000 residents.

The U.K. adopted their current 'equal energy' aircraft noise metric (LAeq, 16hr) after rejecting their previous metric (Noise and Number Index – NNI) on the basis of the findings of the ANIS survey in 1980. Their main concern at the time was that *"the NNI expression places too much weight on the number of aircraft heard"* [a primary determinant of residents' reaction as in 'supplemental' metrics] (Brooker *et al.,* 1985, p58). A closely related finding was that the best-correlated metric for predicting community reaction in the U.K. does not require any time-of-day penalty weightings. This is in contrast to Australia and its comparators (U.S., Canada and the EU, all of which use time-of-day weightings similar to Australia).

The current report reviews the results of the ANASE study (2005) including the surprising public debate in Britain over its methodology and its findings. But most attention is here paid to the U.K.'s most recent socio-acoustic study (SoNA) which was published in 2017. The U.K.'s primary metric (LAeq,16hr) was found to be more highly correlated with community reaction than the EU's metric (Lden) and two supplemental metrics, N70 and N65 (see Hede, 2018a for comparative analysis of aircraft noise metrics). Perhaps the most important finding arises from a comparison of dose-response relationships over time. Independent reviewers concluded that between ANIS in 1982 and SoNA in 2014 respondents were found to be more sensitive to aircraft noise and that this was a "robust outcome of the study and can be relied upon". If such a situation exists in Australia, it would mean that the dose-response curve from the NAL study in 1980 and applied in the Australian Standard and elsewhere, could be seriously inaccurate when used for noise impact assessment and land-use planning. There's only one way to determine whether this is the case, that is, via an update survey.

A major 'take-home' recommendation from the researchers on the SoNA study relates to the frequency of socio-acoustic surveys, namely, *"that future surveys be undertaken more frequently"* (CAA, 2017, p66). One can only wonder what these British experts with their three major aircraft noise surveys in 34 years (viz., 1980, 2003 and 2014), make of Australia's single national survey (viz., NAL in 1980) with no plans for a long-overdue update.

2. Aircraft Noise Socio-Acoustic Research in the U.K.

2.1 Background

The Chair of Sydney Airport Community Forum (SACF), John Alexander OAM MP, invited the researcher to provide advice:

> ***"on the status of any international studies recently completed or currently underway which may provide new evidence on the continued effectiveness of the 1982 National Acoustic Laboratories (NAL) study and the Australian Noise Exposure Forecast (ANEF) system."*** (SACF Letter dated 2nd August 2017).

In response, the researcher recommended focusing on studies published since 2000 from four countries, namely, U.K., U.S., Canada and the European Union. These countries can be considered appropriate 'comparators' for Australia as they share many of our cultural and socio-political characteristics. In particular, the U.K. and U.S. have long been used by Australia for information and guidance on important public policy matters. This report focuses on aircraft noise research in the U.K. Because of the complex links among the different U.K. studies, this review commences with the 1961 study but focuses on more recent research.

2.2 Initial Phase of Socio-Acoustic Research in the U.K. (1961-1985)

The first major socio-acoustic study of aircraft noise in the U.K. comprised a social survey in 1961 of 1,731 interviewees plus noise measurements around Heathrow Airport. This study was integral to the work of the Wilson Committee (1963). The main outcome of this study was the U.K.'s adoption of the NNI aircraft noise metric (viz., Noise and Number Index) which is formally defined as follows:

$$\text{NNI} = L + 15\log N - 80$$

Only a few years after the Wilson Committee reported in 1963, another U.K. survey was conducted in 1967 *"to investigate whether the findings of the 1961 study remained valid in 1967" (*Brooker *et al.,* 1985, p7). It is notable that less than two decades after the introduction of the NNI in the U.K., this metric was being called into question on a number of grounds. For example, the NNI was considered *'out of date'* as compared with people's reactions to modern aircraft (especially, jet aircraft). Also, the NNI was declared *'out of line'* with the metrics of other countries (including a mention for Australia). And further, *“the noise level and number* [within the NNI metric] *are not averages from all aircraft but only those above a noise ‘cut-off’ ”* [in other words, all overflights below 80 PNdB are disregarded in NNI] (Brooker *et al.,* 1985, p2; *comment added*).

Some years later in 1980, another U.K. survey (labelled as ANIS – *Aircraft Noise Index Study*) was authorised specifically to assess the validity of the NNI metric in comparison with an alternative, LAeq. The main justification for this new survey was the claim that: *“Because of the length of time since these studies* [viz., in 1961 and 1967, respectively], *doubts have arisen as to the validity of the NNI”* (Brooker *et al.,* 1985, p5; *comment added*). It is worth noting that the elapsed time between the U.K.’s 1961 survey which resulted in the adoption of the NNI metric, and the Government’s subsequent authorisation of the ANIS study in 1980, was less than two decades.

This 20 years elapsed time between the original adoption of the NNI metric in the U.K. (Wilson Committee, 1963) and its re-evaluation and subsequent replacement by the LAeq metric following the 1980 ANIS survey, contrasts with Australia’s almost 40 years since the NAL survey of 1980 (which led to Australia’s adoption of its current aircraft noise metric, ANEF). Not only did the U.K. conduct two major surveys in the 20 years up to the 1980s, it conducted two further socio-acoustic surveys since 2000 (viz., ANASE in 2003-5 and SoNA in 2014-17 – see reviews below). Of course this raises the question of how long is long enough between aircraft noise national social surveys.

When the ANIS survey was initiated in the U.K. in 1980, the first task was to select the sample. Five airports were selected (Heathrow, Gatwick, Luton, Manchester, Aberdeen) though as per statistical representation, Heathrow dominated the overall sample comprising 20 of the 26 survey areas and a comparable proportion of the 2,097 interviews conducted (Brooker *et al.,* 1985).

The main finding of the ANIS study was confirmation that the metric LAeq was more suitable for assessing aircraft noise exposure than the previous NNI metric. According to the final report: *“The major conclusion … is that the use of the NNI expression places too much weight on the number of aircraft heard”* (Brooker *et al.,* 1985, p58). A closely related finding was that the best metric for predicting community reaction in the U.K. does not require any time-of-day penalty weightings. As the ANIS report concludes:

> *"Thus, for example, the USA uses Day-Night Sound Level (Ldn) in which all night movements are counted as 10dB higher than measured, because it is argued that night movements are more disturbing. The study results do not confirm the need for such major weightings; movements at night appear, if anything, less disturbing than daytime or evening movements (i.e., require a negative weighting)."* (Brooker *et al.*, 1985, p59).

It is notable that in Australia, the NAL socio-acoustic study results published internationally (Bullen & Hede, 1983) a few years prior to this U.K. ANIS study (1982-1985) also concluded that the 10 dB night-time weighting used in the NEF metric was much higher than the 0 dB weighting indicated by Australia's only aircraft noise social survey (NAL – 1980-1982). Australia settled for uniform evening and night weightings of 6 dB (Bullen & Hede, 1983) and these have continued in the calculation of its official aircraft noise metric (viz., ANEF) until today (see Table 1a in Report No.1, Hede, 2018a).

2.3 Recent U.K. Socio-Acoustic Studies: ANASE Study (2001-07)

The next major study of aircraft noise in the U.K. was announced by the Government in mid-2001 and was labelled ANASE (*Attitudes to Noise from Aviation Sources in England*). The initial social survey was conducted in 2003 with further interviews in 2005 and with the main report published in 2007 (see Brooker, 2008a).

The most surprising feature of the ANASE study was the public controversy about its validity and reliability as exemplified by the fact that Government ministers openly voiced their criticism and the U.K.'s leading academic researcher published three articles in one year criticising various aspects of the study's methodology (see Brooker, 2008a, 2008b, 2008c). According to Brooker (2008a, p2): *"the report's 'quantitative findings were rejected as unreliable' [BBC] by the DfT [Department for Transport]".* When the ANASE report was released, a Government minister was quoted as declaring:

> *"The reason why it [ANASE] was delayed was that the scientists – the peers reviewing this major scientific study – said that it isn't up to standard… it isn't good enough for what the Government wanted, that is, to formulate Government policy"* (cited in Brooker, 2008b, p1).

The basic methodology of ANASE was to build on that of the ANIS study almost 20 years previously. In the case of ANASE, social surveys were conducted with residents at 56 sites around 9 airports with aircraft noise exposure ranging from 36 to 68 LAeq (Brooker, 2008b). The initial ANASE report made a number of what were described as *"dramatic claims"* (Brooker, 2008c, p224), namely:

Claim 1: *"For the same amount of aircraft noise, measured in Leq, people are more annoyed in 2005 than they were in 1982";*

Claim 2: *"The modelling work also showed that respondents were less sensitive to changes in sound level below 42 Leq and above 59 Leq, adding support to a logistic dose-response form. There was no threshold, or discontinuity, in the relationship between mean annoyance and Leq."*

Claim 3: *"The results from the attitudinal work and the SP analysis both suggest that Leq gives insufficient weight to aircraft noise numbers, and a relative weight of 20 appears more supportable from the evidence than a weight of 10, as implied by the Leq formulation."* (Brooker, 2008c, p223).

2.4 Recent U.K. Socio-Acoustic Studies: Peer Review Report on ANASE (2003-5)

The key paper evaluating the ANASE report was that submitted to the U.K. Civil Aviation Authority [CAA] by the 'Non-SP Peer Review Group'. This research group's stated objective was: *"to review the outcomes of the ANASE work with a particular focus on the findings regarding the responses to aircraft noise expressed primarily in terms of annoyance"* (Havelock & Turner, 2007, p5).

The first major issue about the ANASE study concerns the accuracy of the aircraft noise exposure estimates at the various social survey sites. The non-SP peer review report found that the ANASE estimates for the $L_{Aeq,16h}$ exposures in the Summer of 2005 in the specified residential areas, differed by up to 5 dB(A) from the official exposure values published by CAA/*DfT [Civil Aviation Authority and Department for Transport].* The peer reviewers noted that *"noise exposure levels become progressively less accurate below* 57 dB(A) $L_{Aeq,16h}$ *and the reviewers believe that any modelling results below* 54 dB(A) $L_{Aeq,16h}$ *… should be treated with due caution"* (Havelock & Turner, 2007, p11). The reviewers also raised a number of issues about the ANASE report's modelling of aircraft noise metrics, specifically, $L_{Aeq,16h}$ (U.K.'s then current metric) and NNI (the previous metric replaced in 1985) (Havelock & Turner, 2007, pp13-14).

In addition to the concerns about the accuracy of dose estimation (i.e., aircraft noise exposure), the non-SP reviewers reported that the ANASE social survey was subject to inaccuracies regarding community response (viz., annoyance). This section of their report highlights the difficulties in avoiding bias in social surveys particularly because of the interactions among the various competing effects. For example, the ANASE study aimed to assess not only the primary relationship between aircraft noise and annoyance, but also the monetary valuation of aircraft noise annoyance (see Carles *et al.,* 2013). For this latter objective, the investigators had to set up and calibrate audio equipment in each respondent's home and then play back recordings of aircraft overflights in order to measure individual reaction to controlled levels of noise.

It is worth noting that very few socio-acoustic studies worldwide have ever attempted to combine, as the ANASE study did, a major social survey (questionnaire responses) with a 'field experiment' (measurements of reactions at home under controlled conditions). The logistics of such a study are clearly complex – every design element that tightens the methodology comes at a cost, not only from increased expenses, but in terms of decreased data accuracy because of respondent bias. The non-SP reviewers for the ANASE study, for example, criticised the fact that in setting up the playback equipment, the field staff could not avoid revealing that the study was about noise (specifically, for areas directly under flightpaths, about aircraft noise) thereby causing potential bias in respondent replies (Havelock & Turner, 2007, p16).

The use of playback recordings at interview sites enabled the ANASE study to test for response bias by comparing aircraft noise reaction in homes where equipment was set up before the interview versus those that did not employ such equipment. The hypothesis was that respondents whose homes did not have playback equipment *"would have less opportunity to deduce the nature of the study and would, therefore, be less susceptible to response bias"* (Havelock & Turner, 2007, p20). The comparison of results showed that:

> *"mean annoyance is statistically significantly greater for respondents at sites where noise playback equipment was used. Far from diminishing the reviewers' concerns about response bias this analysis has reinforced them"* (Havelock & Turner, 2007, p20).

The overall conclusion from the non-SP reviewers' assessment of the ANASE report was that *"the reviewers would counsel against using the detailed results and conclusions from ANASE in the development of Government policy"* (Havelock & Turner, 2007, p28) which is the most damning assessment that could be given to any Government study.

2.5 Recent U.K. Socio-Acoustic Studies: Update Report on ANASE (2003-05)

However, further controversy arose a few years later when a leading noise consultant was commissioned by a group of local authorities around Heathrow Airport, to re-examine the ANASE study (Flindell *et al.,* 2013; note that Dr Flindell and another consultant on the 'update study' were self-declared to have been members of the original ANASE project team). The main conclusion of the ANASE update study was that:

> *"The findings of the government-commissioned 2005 ANASE study are more robust than the previous ANIS study of 1982. However, government policy continues to be based on the older study The ANASE findings are more up-to-date, reflecting the views of communities around 20 U.K. airports in 2005/6, whilst the research still being used to inform government policy obtained the views of residents in 1982, more than 30 years ago, when aircraft sound levels and numbers were very different to today."* (Flindell *et al.,* 2013, i).

The Flindell update report provides what it describes as *"our rebuttal"* (Flindell *et al.,* 2013, p2.1) to the concerns about the ANASE study as expressed in the non-SP report by Havelock and Turner (2007). The term 'rebuttal' here seems to indicate there was a confrontational rather than a collaborative relationship between the two parties. In the year before the ANASE study was released (i.e., from mid-2006 to mid-2007), a series of meetings was conducted between the original ANASE research team and the newly-appointed non-SP reviewers. It appears from the detailed list of research issues addressed in these meetings (see Havelock & Turner, 2007, pp7-10) that worthwhile improvements were made in the ANASE methodology as a result of this review. Although such a process accords with the best traditions of 'peer review' in scholarly research, it is unusual for the two sides to openly publish their contrasting views. Interestingly, the non-SP report (published on the same date as the ANASE report in October 2007) revisited issues that had already been settled during the review meetings. According to the update report:

> *"By and large, the meetings and discussions were helpful during which a number of minor errors were picked up and corrected and a number of other matters were clarified and resolved. The research team, however, do not understand why the non-*

> *SP review group then included in their final report all those matters which had in fact been resolved along with the few outstanding matters where disagreement remained."* (Flindell *et al.,* 2013, p2.2).

Flindell asserts that there were only a limited number of issues that remained unresolved after the year-long discussions between the ANASE research team and the non-SP reviewers, the five outstanding issues being as follows:

a) *"'possible bias' in the design of the questionnaire;*
b) *"the use of loudspeakers during the interview;*
c) *"the use of noise monitoring equipment for calibrating aircraft noise calculation models in the areas where the interviews were taking place;*
d) *"the effect of public antagonism to the then current Government aviation policy; and*
e) *"differences between aircraft noise sound levels calculated for the ANASE study and subsequently calculated by the CAA using their proprietary aircraft noise model."* (Flindell *et al.,* 2013, p2.2).

The above issue of *'possible bias'* in the questionnaire raises the complex question of whether socio-acoustic studies should fully disclose the detailed purpose of an interview so that respondents are not biased towards providing the responses they guess are expected of them. The trouble with full disclosure (as faced by all social researchers) is that if potential respondents are told at the door the precise purpose of the study (in this case, aircraft noise), those who have low aircraft noise annoyance will be more likely to decline to participate (as the topic is less relevant to them) leaving those with high aircraft noise annoyance over-represented in the survey sample by subtle self-selection. This is the worst kind of response bias as it is completely undetectable in the data.

Thus, in the U.K.'s ANIS study two decades earlier in 1982 (and also Australia's NAL study in 1980), it was considered appropriate to avoid such response bias by starting an interview with broad contextual questions about neighbourhood matters prior to introducing the specific topic of aircraft noise (Flindell *et al.,* 2013; Hede & Bullen, 1982). Such a logical and ethical approach to avoiding biasing respondents needs to be distinguished from irrelevant and deliberately wasteful questions as used in some surveys and as criticised by Havelock and Turner (2007). Another aspect of response bias raised in the Flindell report is that the sequence of questions re aircraft noise in the 1982 ANIS study, had the effect of biasing respondents against the number variable. Specifically,

> *"Taking the design of the ANIS questionnaire into account, it is possibly not surprising that the ANIS study found that responses to aircraft noise were more strongly weighted towards sound level, relative to number of events, than had been found in the previous NNI study. Accordingly, the main conclusion of ANIS –subsequently accepted by government – was to reject the NNI and replace it with LAeq, which then had the effect of reducing the relative importance of the increasing numbers of aircraft in the assessment of aircraft noise "* (Flindell *et al.,* 2013, p2.3).

As for the other four unresolved issues identified in the ANASE update report (Flindell *et al.,* 2013) by way of rebuttal to Havelock and Turner's (2007) peer review report, they appear to indicate the adversarial nature of the relationship between the two opposing groups of researchers. Accordingly, it is worth revisiting the claim by Havelock and Turner (2007) as discussed in the previous section of this report, namely, that the ANASE study used inaccurate measurements of aircraft noise exposure. The peer review report declares that the reviewers used *"the results from the **published** CAA/DfT* [Civil Aviation Authority/ Department for Transport] *London Heathrow Summer 2005 (actual) aircraft noise exposure contours"* (Havelock & Turner, 2007, p11, *emphasis added*). In their rebuttal on this point, Flindell *et al.* (2013) point out that the *CAA/DfT* aircraft noise model was not *'published'* in the usual sense the word denotes, namely, publicly released with the official authority of the relevant government department/s. In other words, the acclaimed government model was far from an officially published standard.

Rather, the update study report (Flindell *et al.,* 2013) indicates that the ANASE study did not use idiosyncratic or inaccurate measurements in preference to the official CAA/DfT model as implied by the non-SP peer review report. Rather, the main study modelled aircraft noise exposure at the survey sites using the Integrated Noise Model (INM) first released by the Federal Aviation Administration in 1978 and then regularly updated until it was eventually replaced in mid-2015 by the Aviation Environmental Design Tool (AEDT; FAA, 2015). The FAA reported in 2007 that as of that year, the INM was being used by 1,000 organisations in 65 countries (FAA, 2007). Thus, contrary to the non-SP review report which fails to identify the use of INM in its criticism of the ANASE noise modelling, the ANASE study followed the *de facto* international standard for modelling of aircraft noise exposure. One must speculate whether such an unfounded allegation would have arisen if the independent reviewers had adopted a critical but non-adversarial approach to resolving methodological disputes.

From the above controversy regarding the ANASE study in the U.K. (2007-2013), we can ask what might be learned for future aircraft noise research in Australia? On the plus side, we must applaud the U.K. on its use of an independent review process whereby a non-aligned review team met regularly with the primary research team in order to identify and resolve any methodological issues. However, it appears from the above that the basic approach in the ANASE case was one of confrontation rather than of collaboration resulting in unresolved matters and outstanding methodological issues.

2.6 Recent Socio-Acoustic Studies in the U.K.: SoNA (2014-2017)

The most recent socio-acoustic study in the U.K. was conducted in 2014 and reported in early 2017 (CAA, 2017). This study (identified as SoNA – *Survey of Noise Attitudes*) aimed to investigate whether the U.K. aircraft noise exposure metric, $L_{Aeq,16hr}$, was still applicable after the two decades since its original adoption in 1990 (Jones & Cadoux, 2009; Critchley *et al.,* 1990) on the basis of the 1982 socio-acoustic study around six U.K. airports (ANIS – Aircraft Noise Index Study) which was published in 1985 (see Brooker *et al*., 1985).

Survey sampling is one of the most complex design issues in all socio-acoustic research but there is considerable variation in approach across countries. For SoNA in the U.K. in 2014:

> *"The objective of the study was to obtain a representative sample of c.2, 000 adults aged 18 and over and living in private dwelling in proximity to nine of the largest airports in England by aircraft movements, and where noise from aircraft is estimated to be over 51dB $L_{Aeq,16hr}$ during the summer months."* (Ipsos Public Affairs, 2015, p10).

The SoNA survey employed door-to-door sampling as did the previous U.K. surveys in 1982 (ANIS Survey) and 2003-5 (ANASE Survey). Different methodological issues would need to be addressed if telephone or postal interviewing were employed (as in the case of the current FAA study in the U.S. which is to be reviewed later in this report series). As with any socio-acoustic study, however, SoNA had to balance statistical precision in selecting survey addresses with the logistics and costs of conducting the door-to-door interviews. In other words, they had to resolve the issue of sample clustering. Clustered samples entail selecting groups of nearby addresses as in the NAL study which selected every third dwelling from random starting points within pre-mapped exposure areas (see Hede & Bullen, 1982, p26). Such sampling is cheaper but is somewhat less precise statistically. Unclustered samples, on the other hand, involve selecting individual addresses completely at random within each survey 'stratum' or noise exposure zone around each airport. Such clustered samples are only slightly more precise statistically but are much more costly; hence, the NAL compromise of selecting every third dwelling.

The U.K.'s SoNA study opted for a mixed sampling strategy employing clustered sampling for the vast low noise residential areas around the selected airports (viz., 51-54 dBA, which comprised one-third of the overall sample) plus unclustered sampling in the higher noise areas (viz., 54+ dBA, which comprised two-thirds of the overall sample) (see Ipsos Public Affairs, 2015, pp10-11).

The SoNA 2014 survey sample was stratified by airport which is methodologically appropriate to ensure that Heathrow Airport with three quarters of Britain's high noise exposure residences, didn't swamp the sample (Devine-Wright & Turner, 2017). The survey comprised 1,999 interviewees of whom 122 were not resident during the summer of 2014 yielding 1,877 valid responses (CAA, 2017, p62). There were a total of nine airports though the independent peer assessment concluded that *"Bristol, the tenth largest airport, was excluded due to the available sample size and a lack of noise data"* (Devine-Wright & Turner, 2017, p8).

One methodological limitation of the U.K. SoNA study is that respondents were asked to report on their noise experience during the previous summer period *[i.e., mid-June to mid-September, 2014]* although they were interviewed during the subsequent winter months *[Oct 2014 to February 2015].* The context of this questionnaire item is worth considering for it reveals the complexity of the task imposed on respondents for their critical ratings about aircraft noise:

> *(<u>SoNA Questionnaire Item</u>): "I would now like to ask more about noise specifically from large and small commercial and private aeroplanes. That means I would like you to ignore any noise you hear from any helicopters or from military aircraft, for this section of the interview. These questions are also specifically about your experiences during the summer. By summer I mean the period roughly from mid-June to mid-September 2014."* (CAA, 2017, p84).

In other words, the SoNA survey respondents were being asked to focus on their aircraft noise experiences in the summer which occurred between one and seven months previously depending on when they were interviewed and how they interpreted the stated definition of summer). The formal peer review for the SoNA study noted that:

> *"Although the use of retrospective recall was adequate for this study, ideally, subjective responses would have been obtained during the same time period as that covered by the noise exposure data"* (Devine-Wright & Turner, 2017, p8).

Reassuring though this peer assessment might seem, it is surprising that the SoNA reviewers here identify a potentially important methodological issue about the discrepancy between the period of interview (October 2014 to February, 2015) and the period of aircraft noise that was reported on (June-September, 2014), but then rule in favour of the researchers without any discussion let alone justification in terms of methodology. Issues such as variability in the time period being assessed as well as the complexity and demand characteristics of the question wording surely warrant consideration.

An important finding of the SoNA study was the following from the main report:

> *"The 57dB $L_{Aeq,16hr}$ contour was chosen as the threshold of community annoyance because it indicated a marked increase in some reported measures of disturbance, with 63 and 69dB $L_{Aeq,16hr}$ representing medium and high annoyance"* (CAA, 2017, p4).
>
> Note also the U.K. adoption of the following aircraft noise exposure levels:
> - 57 dBA = low annoyance,
> - 63 dBA = moderate annoyance, and
> - 69 dBA = high annoyance
>
> *(U.K. Government, 2013).*

2.7 Other Considerations re U.K.'s SoNA Study (2014-2017)

The U.K.'s SoNA study confirmed the $L_{Aeq,16hr}$ metric as providing the best predictor of the relationship between aircraft noise exposure and community reaction in Britain (CAA, 2017). Interestingly, this most recent British study compared only four (4) aircraft noise exposure metrics in terms of their ability to predict community reaction, namely, two primary ('equal-energy') metrics (specifically, the existing U.K. metric, $L_{Aeq,16hr}$, and also

L_{den}, the metric adopted in 2002 for European member countries (EP, 2002) (see details in Report No.1, Hede 2018a, Tables 1c & 1d). In addition to these two primary metrics, two supplemental metrics were examined in the SoNA study (viz., N70 and N65; see Southgate, 2000). It is worth commenting that these four SoNA metrics compare with the 1980 NAL study in Australia which assessed more than 50 metrics comprising 17 'equal-energy' and peak level metrics as well as 36 variations of time-of-day weightings added to the original NEF metric (Hede & Bullen, 1982).

As well as addressing only four aircraft noise metrics out of the many in use worldwide (e.g., the U.S. index DNL and Canada's metric NEF; see Report No.1, Hede, 2018a; Table 1a & 1b), the main U.K. report provides only restricted data on the four metrics examined (CAA, 2017). The official SoNA report specifies that the correlation between community reaction and the current U.K. metric ($L_{Aeq,16hr}$) is: $r^2 = 0.87$ (CAA, 2017, p6). But, instead of providing the specific correlations for the other three metrics (namely, L_{den}, N70, and N65) the report states that they are all in the range: $r^2 = 0.60–0.71$ (see CAA, 2017, p6). Significantly, by citing two unidentified correlations as end-points of the range, the report avoids recording the precise correlations for any of the three metrics in question. Importantly, the report failed to compare the primary versus supplemental metrics, a comparison which is of considerable interest in this context (viz., L_{Aeq} and L_{den} versus N70 and N65). According to the official report, the primary U.K. aircraft noise metric ($L_{Aeq,16hr}$) proved to have the best correlation with community reaction out of the four metrics assessed:

> *"Evidence was found that mean annoyance score correlated well with average summer day noise exposure, $L_{Aeq,16hr}$ (r^2=0.87). There was no evidence found to suggest that any of the other indicators $L_{den,}$ N70 and N65 (r^2=0.60–0.71) correlated better with annoyance than $L_{Aeq,16hr.}$"* (CAA, 2017, p63).

By way of confirmation of these results, the peer assessment report on the SoNA study stated that:

> *"the reviewers concur with the conclusion that the results of the study confirm that $L_{Aeq,16hr}$ is still the most appropriate indicator to use to estimate the annoyance arising from aircraft noise. There is merit, though, in considering the use of metrics such as N70 and N65 as supplementary indictors in understanding the noise impact".* (Devine-Wright & Turner, 2017, p10).

2.8 Discussion

We see then that the SoNA study (2014-17) confirmed the $L_{Aeq,16hr}$ aircraft noise metric as providing the most accurate predictor of community reaction in the U.K.. Out of the four metrics assessed in SoNA (2014-17) (viz., L_{Aeq}, L_{den}, *N70 and N65)*, the highest correlation obtained was $r^2=0.87$ for the metric, $L_{Aeq,16hr}$. In Figure 2.1 (below) as reproduced from the SoNA report (CAA, 2017, p50) there are four dose-response curves depicted using '% Highly Annoyed' to measure community reaction (in terms of the standard survey process; see ISO, 2003,) as predicted by aircraft noise exposure measured by the U.K. metric, $L_{Aeq,16hr}$. These comprise the three curves from the main U.K. socio-acoustic studies, namely: the ANIS 1982 study, the ANASE 2003-05 study and the SoNA 2014 study as well as the EU study by Miedema and Oudshoorn (2001).

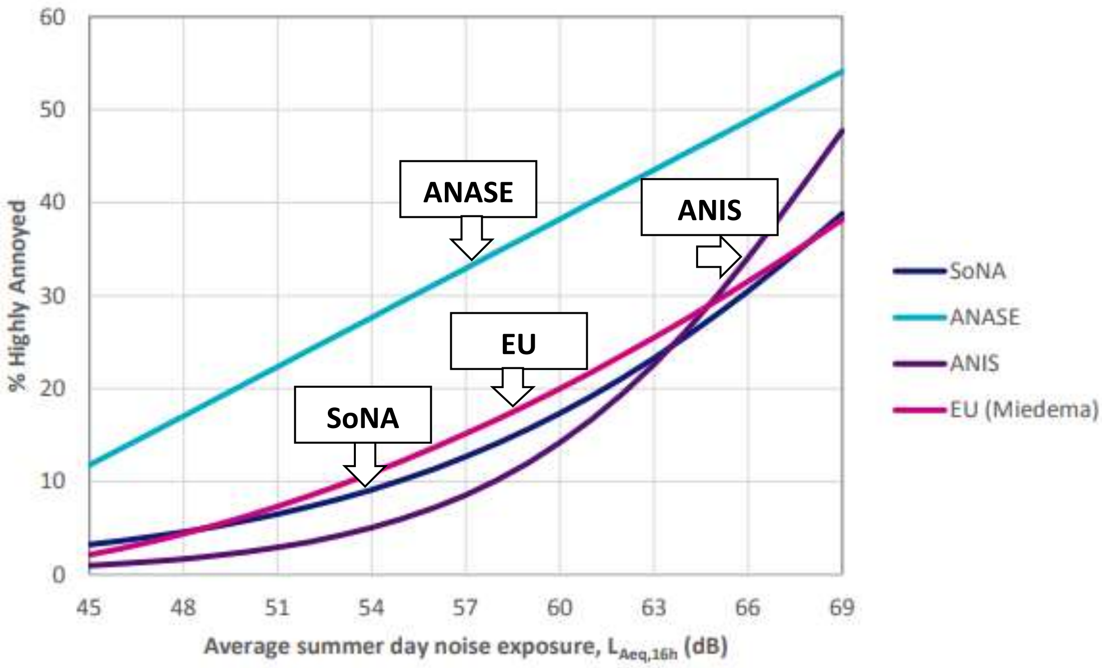

Figure 2.1: Comparison of % Highly Annoyed for three U.K. socio-acoustic studies *(viz., SoNA, 2014; ANASE, 2003-5; ANIS, 1982,* plus the EU study by Miedema & Oudshoorn, 2001); (Source: CAA, 2017, p50).

A key result of the U.K. SoNA study (2014) concerns possible differences over time in community reaction to aircraft noise. Table 2.1 below compares the dose-response in the SoNA survey in 2014 with the ANIS survey 32 years previously in 1982. The more recent survey report states that:

> *"The same percentage of respondents said by ANIS to be highly annoyed at 57 $L_{Aeq,16hr}$ now occurs at 54dB. Comparing with the results in Table 25 (= Table 2.1 above) the "Miedema dose response function (Miedema & Oudshoorn, 2001), predicts 12% highly annoyed at 54 dB and 16% at 57 dB."* (CAA, 2017, p50).

Average summer day noise exposure, $L_{Aeq,16h}$ (dB)	% highly annoyed	
	ANIS 1982	SoNA 2014
51	3%	7%
54	5%	9%
57	9%	13%
60	14%	17%
63	23%	23%
66	34%	31%
69	48%	39%

Table 2.1 in Current Report: Percentage highly annoyed as a function average summer day noise exposure, $L_{Aeq,16hr}$ (Ref: Table 25 from CAA Report, 2017, p50).

According to the independent peer reviewers of the SoNA report:

> *"The evidence from this study indicates that people are more sensitive to aircraft noise compared with the results of the ANIS study [1982]. The reviewers are satisfied that this is a robust outcome from the study and can be relied upon."* (Devine-Wright & Turner, 2017, p11).

As recommended by the independent reviewers, a full comparison of the two studies was included in the final SoNA report (see CAA, 2017, Table 25, p50) and is cited in the current report as Table 2.1 above. Examination of this table reveals that the differences in community response between 1982 and 2014 (ANIS vs SoNA) are not consistent but rather vary at different levels of aircraft noise exposure.

Thus, at the four lowest exposure levels from 51-60dB ($L_{Aeq,16hr}$, average summer day), the results for '% highly annoyed' were consistently higher in 2014 than in 1982 (viz., increases of 3-4 percentage points; see Table 2.1). However, at the medium exposure level of 63dB, community reaction levels were identical (viz., 23% 'highly annoyed') for the two-time measures of 2014 and 1982. At higher levels of exposure, however, (see 66 dB and 69 dB in Table 2.1 above), the relative differences in community response switch from showing an increase over time to a decrease between 1982 and 2014, such that at the highest exposure level of 69dB, the more recent response level was 39% 'highly annoyed' in 2014 as compared with 48% in 1982.

By way of insight into the socio-acoustic dynamics of U.K.'s SoNA study (2014), it's worth considering the distribution of the 1,877 valid respondents across the survey (CAA, 2017). Table 2.2 below shows the number of residents around each of the nine survey airports taking account of the distribution of the survey respondents exposed to the different aircraft noise measured in terms of the index, $L_{Aeq,16hr}$.

Summer average noise exposure $L_{Aeq,16h}$ (dB)								
Airport	**51-53.9**	**54-56.9**	**57-59.9**	**60-62.9**	**63-65.9**	**66-68.9**	**69-71.9**	**>72**
Birmingham	13,100	9,100	4,550	2,050	750	50		
East Midlands	600	550	200	200	100			
Gatwick	5,650	2,450	1,000	350	50	100	<50	
Heathrow	228,400	145,750	57,700	24,550	11,700	3,650	900	100
London City	12,600	10,950	4,450	3,050	350	<50		
Luton	2,200	2,100	1,750	750	350	<50		
Manchester	30,200	14,100	9,600	2,600	750	350	<50	
Newcastle	1,600	1,200	300	<50				
Stansted	2,200	1,350	350	100	50			
Total	**296,500**	**187,550**	**79,900**	**33,700**	**14,100**	**4,200**	**900**	**100**

Populations rounded to the nearest 50.

Table 2.2: Estimated population exposure in the vicinity of the nine largest airports in England as included in SoNA 2014 survey (based on annual movements and ordered alphabetically; see Table 1 from CAA Report, 2017, p15).

2.9 Conclusion

The initial series of socio-acoustic studies in the U.K. were conducted more than 50 years ago (1961, 1967) which led to the adoption of the Noise and Number Index (NNI). This index was subject to early criticism and was soon found wanting in the first of the modern socio-acoustic studies (ANIS, 1982) which subsequently replaced the NNI with the current U.K. aircraft noise metric, namely, $L_{Aeq,16hr}$.

Importantly, in the 36 years since the ANIS study in 1982, the U.K. saw fit to carry out two further full socio-acoustic studies (specifically, the ANASE study in 2001-2007, and also the SoNA survey which was conducted in 2014 and published in 2017) (CAA, 2017). Perhaps the most noteworthy factor about these three studies is that the ANASE study was subject to intense expert criticism which was most uncommon in the world of serious social research (as reviewed above).

If Australia were to look to *'the old Dart'* (a slang term referring to Britain) in relation to aircraft noise research, possibly the most important finding is that between ANIS in 1982 and SoNA in 2014 respondents were found to be more sensitive to aircraft noise. Further, independent reviewers stated that this was a "robust outcome of the study and can be relied upon" (Devine-Wright & Turner, 2017, p11). If such a situation exists in Australia, it would mean that the widely used dose-response curve from the NAL study in 1980 could now be outdated and consequently, seriously inaccurate when applied for noise impact assessment and land-use planning.

Another notable comparison between Australia and its British comparator is that the U.K. has carried out three socio-acoustic studies in the period of 38 years that Australia has made do with a single study. One of the most interesting conclusions from the official SoNA study was this:

> *"Noting the importance of non-acoustic factors identified that may be subject to greater variation over time,* ***it is recommended that future surveys be undertaken more frequently****"* (CAA, 2017, p66, *emphasis added*).

Presumably this means more frequently than the three U.K. surveys that have occurred in the past 34 years (viz., SoNA 2014; ANASE 2003-5; ANIS 1980). Does this mean that Australia should conduct its second socio-acoustic survey in the past 38 years (between 1980 and 2018)? It's clearly overdue would be the likely British advice.

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